Section I

Silviculture and Management

Sessions A and B

Inventories of Forest Resources
Inventaires des ressources forestières
Inventarios de Riquezas Forestales

Selecting Objectives and Methods of Estimating Forest Resources

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The establishment of an appropriate forest policy is possible only on the basis of a sound knowledge of the national resources of forest land and timber. The data necessary for the purpose must be gathered by means of inventory standards and methods that are adapted to provide the information wanted.

The selection of various methods is made to conform with the objectives expressed at the planning stage of the inventory. Three methods applicable to various objectives and circumstances will be discussed in the following.

Method A is useful in areas where the objective is to obtain information needed when planning the exploitation of accessible forest resources.

Here the primary objective is to procure explicit summaries of the present volume of accessible timber by stand types, species and sizes for the end purpose of establishing their value. An inventory by means of aerial photography appears to be the cheapest and most effective method in this case. Systematically spaced flight lines or randomly located sample plots provide information on the volume of growing stock (per hectare), its distribution by species and a rough estimate of age classes and sizes by technical means currently available. Frequently an estimate with a precision of $\pm$ 10 percent for the individual stand types may be considered satisfactory.

Method B is applicable in areas where the objective is to follow the development of the growing stock and the sustained utilization of the land for forestry purposes.

Survey methods of point sampling nature may be applied in this case either as a combination of aerial photography with certain field observations or as a field observation procedure only. In the first alternative the aerial photos provide dependable information on the volume of growing stock when supplemented by field observations. Point samples that are assumed to be applied on a certain fraction of the aerial photo material, constitute control data necessary for a determination of the accuracy of information obtained from the aerial photographs. Details that are impossible or very difficult to perceive in the aerial pictures are supplemented by the field observations. Point sampling may be arranged either systematically or randomly. In the first case, dependable estimates may be obtained by a rather small amount of data although the determination of the accuracy may meet with certain difficulties. In the latter case the determination of the limits of error is highly facilitated.

An estimate based on field observations only and obtained by systematic point sampling may be carried out either along regularly spaced lines or survey tracts, e.g., squares. Large distances between the lines are applied to reduce the cost of the survey. This requires rather dependable map material as a basis for the location of lines. Along the lines or the sides of the tract the site and timber conditions are usually recorded continuously. Sometimes the growing stock, too, is continuously measured by calipering the trees within a strip of certain width (strip survey). The latter task has lately been replaced by a registration of trees within sample plots located at even intervals along the survey line. The current measurement of the trees has sometimes been replaced by continuous ocular estimates occasionally supported by relascope observations along the survey lines. The method may be supplemented with regularly spaced sample plots to control and guide the ocular survey.

The method based on field observations only has been applied in the Nordic countries (Finland, Norway and Sweden) since the beginning of the 20's. The survey has been repeated at even intervals to provide current information on the development of the growing stock and to state the changes of volume that have occurred between the surveys. For reasons of organization the inventories were extended over several years (3-4 years in Finland; 10-15 years in Norway and Sweden). Thus, one or several provinces were surveyed annually to enable a presentation of partial results pertaining to administrative units. The accuracy was sufficient (standard error 2-3%) to be informative to the local authorities.

A total picture of the national resources was not obtained until the survey comprised all the provinces, and it was then a sum of results from a number of separate years. The exactness of the total result was dependent on the changes that have occurred in the partial results during the inventory cycle.

Method C is applicable in areas where the objective is to account for the balance between the timber depletion and the increment of current forest capital, and to register such occurrences that provide valuable information only if subject to an annual summary.

This method of survey is principally similar to that described under B for field observations. To reduce the cost, the requirements of accuracy with reference to the annual result in subregions must be abandoned. The accuracy must be adapted to certain main data regarding the total area. The survey can be carried out annually by first determining the location of survey lines and tracts for the whole 10-year period. Then one-tenth is systematically selected for survey during the current year at a cost not essentially higher than a tenth of the total.

The method is more expensive than that mentioned under B but it has certain advantages that will be discussed here.

Unlike the provincial surveys this method provides a synchronized picture of the whole area. The results presented for subregions after ten years certainly constitute averages of a ten-year period but they pertain to the *same* period of time in each of the subregions. The partial results may also be computed for the growing stock of the final year of the period, if the increment and the timber depletion are reported annually.

Since the account of the growing stock is synchronized and the annual cut and increment are recorded by certain years or periods, the changes of the growing stock can be studied for the area as a whole, or for subregions. At certain intervals it is possible to present a balance account showing the initial growing stock, the increment and the timber depletion on one side, and the final growing stock on the other side. The method also provides an opportunity to register certain occurrences of a given year.

First, the annual cut should be mentioned. If statistics of the felling operations in certain areas are not available in special reports, it is possible to procure information on the volume of timber cut during the previous year by a stump inventory in conjunction with the registration of growing stock. This inventory is carried out on plots where all stumps that originate in the cut of the previous year are tallied and measured. A sample plot spacing considerably closer than that used for the growing stock account is necessary for this inventory.

The cone production is another important occurrence deserving annual registration and localization. This will provide timely information on areas where the cone collection should be concentrated during the next winter.

A determination of increment and annual cut requires a number of sample plots in the field that is considerably larger than that necessary for an estimate of the growing stock. For this reason not much is to be gained by combining this field work with an aerial photography procedure that actually would support the estimate of growing stock only.

Discussion

What purpose then may a survey of large areas, e.g., the land and timber resources of a whole country serve? In this context this question will be answered only from a national point of view. Naturally the question also has a wider aspect since no nation should plan her forestry and wood industry independent of the conditions of other countries. The timber resources of the world is a matter that concerns every nation that depends on wood.

An inventory restricted to a presentation of the growing stock, occasionally distributed by stand types and sizes, may be considered sufficient on a short sight, if the purpose is to provide only a summary of the timber resources of a country with seemingly inexhaustible growing stock. However, information on the location of the timber resources in relation to transport lines available is very important. A general knowledge of the location of growing stock now available is a prerequisite when planning new road systems and establishing sawmills and pulp plants.

An approximate picture of the changes of the timber supply is obtained by repeating total inventories at certain intervals of time. However, estimates of this kind are rather inaccurate and only great differences can be ascertained. Higher standards are needed when a difference of about ten percent magnitude is to be established. On a long sight the need to plan the rehabilitation of the forests presents itself as a national matter.

The sustained yield of timber is effectively controlled only if the extent of clear-cut area is known. It is also necessary to collect information on the reserves of land that are suitable for timber production although they have previously been neglected. For this purpose the inventory of growing stock is often combined with a close account of the site conditions. If the investigation is carried out by means of aerial photos, relatively comprehensive field observations are needed as a supplement. Improved knowledge of the balance between the increment of the growing stock and the timber depletion (including natural mortality) is another condition for the maintenance of even yield. The increment depends, i.a., on the age composition of the growing stock and the kind of felling operations applied, i.e., thinning or final harvest. The inventory may be restricted to a statement on the increment accumulated during a certain period of time. Statistics, or some other sources, may be used to calculate the timber cut during a corresponding period with the addition of natural mortality estimated on the basis of empirical figures or other information available. The accumulated increment, that is, depending partly on the special climatic conditions and partly on the age composition of the growing stock, may be used to estimate the increment potential of the next period. A prognosis of the future cut of timber is producible by means of information on the distribution of the timber by classes of maturity and on the basis of the forest policy expected to be applied.

The various conditions of different ownership categories must necessarily be considered when establishing the forest policy. Privately owned small forest holdings, frequently in combination with farms, cannot participate in the same manner as that of large forests (state or industry) when the timber available for industrial purposes is estimated. Small holdings may often be excluded from the calculations since all their timber production is used for household consumption. Already in the planning stage of the inventory it is obvious that the forests should be classified by categories of ownership.

A division of the results of an inventory by different ownership groups means, additional costs if the accuracy of the estimates is to be kept within reasonable limits for the partial results. The following points may be considered when the costs are weighed against the importance of this separation of the material.

If the forests constitute such a national asset that knowledge of the size and composition of the timber is judged important, conditions usually exist for a legitimate need to follow the development and, if possible, to initiate measures for the improvement of the forestry practices. The forests are usually owned by the state as well as by communities, companies and individuals. To be able to undertake measures of promoting good forestry, or possibly to prevent continual destruction, it is necessary to know where the measures should be applied. The work may be designed in different ways depending on the ownership category concerned. Objectively collected data

then constitute a valuable instrument for the state or other organizations when planning the improvement of the forest status.

Under all circumstances inventories of this kind should be repeated at even intervals to enable a statement on the general development of the forest conditions. Simultaneously, it may also be desirable to know the standing of various ownership groups.

Particularly for technical resons, e.g., when it is generally difficult to employ trained personnel enough to carry out an annual inventory of the forest resources of a whole nation, the inventory is usually extended over a number of years. To maintain the continuity of the work, the inventory is carried out over the period of time that corresponds to the cycle planned for the survey work. Every year a geographical unit suitable from an administrative point of view is covered. The disadvantage has been discussed above: a synchronized status for the whole country is not obtained.

An Example

Partly for reasons discussed above, the national forest survey of Sweden has been changed after the completion of two surveys with annual reports for certain geographic units. According to the new system the whole country is surveyed annually since 1953 with a density one-tenth that of the previous surveys. The technical procedure is briefly described in *Unasylva* vol. 11, no. 1, 1957. The report states that the standard error of such an estimate of the growing stock per hectare amounts to only ±1.3 percent for the country as a whole in spite of the low sampling intensity. Simultaneously, certain data concerning the years 1953 and 1954 are presented. Here corresponding information is given with respect to the average of 2, 3, 4 and 5 years of survey.

A. Average Results

Table 1. Total growing stock according to the surveys of 1953-1957

	Total growing stock—millions of cu. meters				
	1953	1953-54	1953-55	1953-56	1953-57
Total	2,123	2,142	2,133	2,128	2,122

Table 2. Distribution of total growing stock by species

	Total growing stock—millions of cu. meters				
Species	1953	1953-54	1953-55	1953-56	1953-57
Pine	853	861	856	858	854
Spruce	945	953	946	942	940
Hardwoods	325	328	331	328	328
All species	2,123	2,142	2,133	2,128	2,122

Table 3. Distribution of total growing stock by diameter classes

Diameter	Total growing stock—millions of cu. meters				
class	1953	1953-54	1953-55	1953-56	1953-57
0-14 cm	619	611	609	607	604
15-24 cm	853	861	856	855	856
25+ cm	651	670	668	666	662
Total	2,123	2,142	2,133	2,128	2,122

Changes in the growing stock due to potential differences between timber cut and annual increment have not been considered.

The following approximate data of various years are also shown to elucidate the variation between the partial results.

B. Volume of Growing Stock

Table 4. Total growing stock according to the surveys of 1953-1957

	Total growing stock—millions of cu. meters				
	1953	1954	1955	1956	1957
Total	2,123	2,161	2,115	2,113	2,098

Table 5. Distribution of total growing stock by species

	Total growing stock—millions of cu. meters				
Species	1953	1954	1955	1956	1957
Pine	853	869	846	864	838
Spruce	945	961	932	930	932
Hardwoods	325	331	337	319	328
All species	2,123	2,161	2,115	2,113	2,098

Table 6. Distribution of total growing stock by diameter classes

Diameter	Total growing stock—millions of cu. meters				
class	1953	1954	1955	1956	1957
0-14 cm	619	603	605	601	592
15-24 cm	853	869	846	852	860
25+ cm	651	689	664	660	646
Total	2,123	2,161	2,115	2,113	2,098

Comments On the Example

An inventory extended over several years certainly is slightly more expensive than the method previously applied. At the time of change the increase in costs of the new national forest survey were calculated at 15 percent. This figure must be considered rather correct since the costs of inventory have varied within originally established limits during the past seven years.

What more has then been gained that justifies this raise of the costs? Here some concrete examples will be mentioned.

Formerly, the computation of the increment was to comprise a certain period (10 years), and an increment allowance for timber cut during the period must be added to provide a figure for the total increment of the period. Now the computations can be based on the increment of one year, and the allowance for increment on timber cut in the same year is reduced to a minor amount. Good information on the growth conditions of various regions is obtained if investigations are carried out in different parts of the country in the same year. This will enable a distinction of separate increment zones that probably are mainly climatically conditioned.

The extent of the timber extraction within the country was formerly known only from statistics based on industrial production supplemented with estimates of household consumption. Knowledge of the volume of timber cut is now gained by an inventory of the stumps. This task is tied directly to the survey, and the volume of timber cut is reported in the same unit of measurement as that used for the growing stock and distributed by species and diameter classes. This provides an opportunity to currently check the timber status of the country much more accurately and efficiently than ever. The special reports of products cut for industrial purposes still are valuable since they show the volume proportion used by the wood industry.

The cone inventory carried out annually in conjunction with the survey enables a summary of the areas where cone collection should be concentrated in the next winter. However, definite directions for the collection are not given until an investigation has shown the maturity and quality of the seed.

The following general advantages of the new method may be mentioned. Annually, the method can be supplemented with exploratory investigations of a nature similar to the cone production inventory. Likewise, a collection of certain data may be abandoned when the matter is found to be satisfactorily investigated, or lacking the importance initially assigned. Generally, the new method is more flexible in application especially for investigations that are intended to elucidate the conditions of areas, e.g., areas of industrial development, that initially were impossible to define. Areas of this kind would probably have been surveyed in separate years had the old method been used. Survey results based on the field work of several years may successively be renewed by substituting the most recent data for those obtained during the first years of the cycle.

In addition to being a guide for administrative authorities, a current inventory with detailed information on growing stock and site conditions may also constitute a good source of information for all forestry research. The results of the survey may thus be used to elucidate the magnitude of certain occurrences and the regional distribution of various problems.

RESUMES

Choix des objectifs et méthodes d'évaluation des ressources forestières

Les données nécessaires à l'établissement d'une politique forestière peuvent être fournies par des méthodes adaptées aux besoins et aux objectifs fixés pendant la phase préliminaire d'un inventaire. On examinera trois méthodes:

1° L'inventaire fondé sur la photographie aérienne semble la méthode la moins coûteuse et la plus efficace lorsqu'on veut obtenir un relevé sommaire du bois sur pied par type de peuplements forestiers et par espèces.

2° Il n'est fait un choix entre l'enquête fondée sur la combinaison de la photographie aérienne et des observations sur le terrain et la méthode de l'enquête sur le terrain que lorsque les inventaires doivent être répétés a intervalles réguliers dans le but de suivre la croissance du bois sur pied ainsi que l'utilisation régulière des terres à des fins forestières. Des raisons techniques obligent souvent à diviser le pays en régions géographiques avant de procéder aux inventaires. Il est nécessaire d'arriver à une grande précision (erreur relative 2 à 3%) pour déterminer les différences observables entre deux enquêtes consécutives.

3° Les inventaires annuels portant sur l'ensemble du pays, dans le but de réunir des renseignements sur le bois sur pied, son accroissement et son épuisement, nécessitent des observations directes sur le terrain. Chaque année, un dixième de la superficie totale est couvert d'un réseau de parcelles témoins réparties également, si l'on veut terminer l'enquête en dix ans.

La première méthode peut sembler suffisante à première vue si l'on se propose uniquement d'obtenir une image sommaire des ressources en bois d'oeuvre d'un pays dont le bois sur pied semble inépuisable. Il est indispensable de connaître les emplacements du bois sur pied existant lorsqu'on envisage la construction de nouvelles routes ou la création de nouvelles scieries et usines de pâte à papier.

La deuxième méthode devrait être appliquée dans les cas où les inventaires sont répétés dans le but de déterminer les différences de détail existant entre différents résultats (10% environ). Cette méthode offre une base utile aux prognostics sur les développements ultérieurs, dans les cas où la description du bois sur pied se fait par qualités. On complète l'inventaire par une enquête sur l'augmentation du bois sur pied et par des renseignements tirés des statistiques spéciales sur les coupes. Dès les travaux préparatoires d'un tel inventaire, on prévoit la nécessité d'un compte distinct pour chaque groupe de propriétés. Cette nécessité apparaît également lorsqu'on élabore des mesures pour l'amélioration du régime des forêts. Des renseignements réunis de manière objective sont alors très précieux.

Des considérations techniques, telles que le manque de personnel nécessaire à un inventaire annuel des forêts d'un pays entier font que ces inventaires s'échelonnent généralement sur plusieurs années. On couvre chaque année une unité géographique convenant du point de vue administratif. Le résultat global pour la totalité du pays se compose alors des données rassemblées au cours des diverses années. Ceci peut présenter certains inconvénients.

Si l'on a besoin d'un inventaire national véritable des forêts, plutôt que d'un certain nombre d'inventaires dans les provinces, il faudra mener l'enquête dans l'ensemble du pays en inspectant chaque année une certaine partie de la superficie totale. C'est là la troisième méthode mentionnée.

Une enquête de cet ordre a été entreprise en Suède depuis 1953. La première année, l'enquête a fourni des résultats partiels qui sont corroborés ensuite par une nouvelle évaluation effectuée l'année suivante.

Le tableau ci-dessous illustre une série de cet ordre:

Total du bois sur pied, en millions de mètres cubes

1953	1953-54	1953-55	1953-56	1953-57
2.123	2.142	2.133	2.128	2.122

Ce procédé est assurément un peu plus coûteux (15%) que la deuxième méthode mais elle fournit d'intéressants renseignements complémentaires tels que les rapports annuels sur l'épuisement du bois d'oeuvre exprimé en mètres cubes et réparti par espèces et par taille. Il fournit un relevé sommaire de certains phénomènes annuels tels que le rendement en cônes. Cette méthode permet en général de grouper aisément les renseignements et d'ajouter à l'enquête des tâches nouvelles ou d'en supprimer pendant n'importe quelle phase de l'enquête.

Selección de objetivos y Normas para Calcular las Riquezas Forestales

La información necesaria para adoptar una política forestal se puede obtener con métodos adaptados a lo requerido y los objetos que se expresan en la preparación de un inventario. Aqui se tratan los tres métodos siguientes:

1. El inventario basado en la fotografía aérea parece ser el método menos costoso y más eficaz cuando el objeto es el obtener un resumen de los árboles en desarrollo, distribuidos por arbolados y por especies.

2. Se escoge entre la investigación basada en la fotografía aérea en combinación con observaciones en el terreno y los estudios locales sólo cuando el inventario se ha de tomar a intervalos regulares a fin de seguir el desarrollo de los árboles en crecimiento y el uso constante del terreno para silvicultura. Por razones técnicas el inventario se debe tomar, con frecuencia, dividiendo al país en zonas geográficas. Se requiere alta precisión (error comun: de 2 á 3%) para cerciorarse de las posibles diferencias entre estudios consecutivos.

3. Los inventarios se deben tomar anualmente abarcando a todo el país a fin de obtener informes de los árboles en crecimiento, el incremento y los cortes, todo lo cual requiere observaciones directas en el terreno. La décima parte de toda la zona se estudia anualmente con un sistema de parcelas de muestra regularmente distribuidas, para hacer en diez años el estudio completo.

El primer método se puede considerar suficiente para corto plazo si el único objeto es el de tener un cuadro resumido de los recursos maderables de un país que tenga arbolado en crecimiento aparentemente inagotable. El conocimiento general de la situación del arbolado en crecimiento es prerequisito cuando se estudia un nuevo sistema de caminos o se fundan aserraderos y fábricas de pulpa.

El segundo método se debe sequir si los inventarios se repiten con el objeto de determinar diferencias menores entre los resultados (aprox. 10%). Este método proporciona buen fundamento

para pronósticos de desarrollo futuro si el arbolado en crecimiento se asienta según clases y condiciones. El inventario se complementa con estudios del incremento e informes obtenidos de estadísticas especiales de los cortes. La necesidad de cuentas aparte para cada grupo de propiedades se indica en la etapa preliminar de este inventario avanzado. La conveniencia de una cuenta para cada propiedad es también manifiesta al estudiar medidas para el mejoramiento de las condiciones del bosque. Los datos objetivamente compilados son, pues, de gran valor.

Debido principalmente a razones técnicas, tales como la falta del personal necesario para tomar un inventario anual de los bosques de todo un país, el inventario se toma generalmente en varios años. En cada uno se abarca una unidad geográfica adecuada desde el punto de vista administrativo. El resultado final se compone entonces de los datos compilados en los distintos años, pero esto puede tener ciertas desventajas.

Si se requiere un verdadero estudio de los bosques nacionales en lugar de inventario de diversas provincias, el estudio se debe llevar a cabo en todo el país anualmente abarcando determinada parte de la superficie total. Este es el tercero de los métodos que se tratan.

Desde 1953 se lleva a cabo en Suecia un estudio de esta clase. El primer año proporcionó un resultado parcial posteriormente completado con nuevos cálculos anuales.

El resumen siguiente muestra una seire de esta clase:

Arbolado total en cremiento, en millones de metros cúbicos

1953	1953 á 1954	1953 á 1955	1953 á 1956	1953 à 1957
2.123	2.142	2.133	2.128	2.122

Este método es, ciertamento, algo más costoso que el segundo (15%), pero se obtienen otros informes valiosos, tales como informes anuales de los cortes en metros cúbicos y distribuidos por especies y tamaños. También proporciona un resumen de ciertas ocurrencias anuales, como el rendimiento en conos. Este método presenta generalmente material fácil de agrupar y se pueden agregar al estudio nuevos aspectos, a la vez que se pueden excluir otros en cualquier momento en el curso del estudio.

Surveys Applicable to Extensive Forest Areas In the Asia-Pacific Region

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Over ten years ago the author presented a paper to the Third World Forestry Congress on aerial survey and photo interpretation in Australian forestry (Cromer, 1950). In retrospect, it is evident that few radical advances have been made either in survey technique or in aids to photo interpretation. True, the question of sampling methods has been further clarified by biometricians and by field tests; more varied first, second and third order instruments have become available; the use of punched cards and data-processing has been extended; but in the main the principles governing forest inventories have remained unchanged from those enunciated by Harrison (1950).

Happily, advances have been made in cognate fields, and this is reflected in certain phases of forest inventory, such as ground plot enumeration and volume computation. The most outstanding break-through, the angle-count or point sampling method of Bitterlich, was also presented to the Third Congress (Bitterlich, 1950). The method, which has not yet by any means been universally recognized or adopted, leads to considerable savings in the time required to assess temporary or continuous inventory ground plots. Electronic computers have likewise made it possible to prepare volume tables and stand volume tables from basic data by multiple regression techniques combined with significance testing of terms, using various variables, powers and combinations, which might prove useful, such as could not have been contemplated previously. Once established, these tables can be incorporated into inventory procedure for the calculation of plot volumes either by electronic processing or desk calculation.

Nevertheless, there remains an urgent need in the Asia-Pacific region for the development of an inventory technique for tropical rain forest, which is a much more difficult problem than that posed in temperate regions. In 1952 FAO's Asia-Pacific Forestry Commission considered the question, and recommended that a panel of technical experts be set up to recommend procedures, and that a regional study centre be established. In the meantime a committee was formed to examine the problem. These views were re-affirmed at the third session of the Commission in 1955, but the committee was disbanded on the understanding that the proposals would be given a high priority. In 1957 the Commission noted that the training centre in forest inventory was listed for the 1958 TAB programme and decided not to revive the working party on aerial photography and mensuration of tropical forests.

Meantime, missions have conducted surveys in Taiwan and the Ryukyu Islands, and an expert has been sent by FAO to advise Cambodia on forest inventory, but according to "A World Geography of Forest Resources" (American Geographical Society, 1956), few countries in the region have carried out an actual inventory, though many, such as Japan, have effected a number of estimates and compilations.

Apart from the activities outlined above, consideration has been given to the necessity for national forest inventories within the British Commonwealth. At the fifth Forestry Conference in London in 1947 it was resolved that every country should endeavor to complete a survey within ten years, using aerial photographs. Much has been done, but in only a few countries has the work been completed.

The writer proposes to use the terminology suggested by Carron (1956), which aimed at clarifying a good deal of current confusion, and to consider in more detail application in specific areas.

New Zealand

The National Forest Survey of New Zealand was initiated immediately after World War II and received impetus at the Fifth British Empire Forestry Conference. The date of completion was 1955 and the results were published two years later (Masters, Holloway & McKelvey, 1957). The survey covered the indigenous forest resources only, and a supplementary survey is now under way of the large exotic plantation asset established in that country. The area surveyed exceeded 7 million acres, of which 5½ million acres were mapped, and some 17,000 one-acre plots were assessed. The over-all costs of the survey amounted to 7.8 pence per acre.

A very realistic approach was applied to the survey design, viz, the intensity of the resource appraisal was varied according to the productivity potential of the forest itself. For forests of low potential, protection forest, etc., the method varied from a simple "walk through" reconnaissance, to random or systematic sampling, using any available forest map, both with and without supplementary air photographs, as circumstances warranted. For all forests of high production potential, however, a standardised procedure was employed, comprising the compilation of a detailed forest type map, and the assessment of the average volume per acre of each forest type by a line-plot sampling method.

A further feature of the New Zealand approach was the simultaneous collection of ecological and silvicultural information, which has already proved valuable, but which will involve many years of sifting and intensive work before the full benefit of the mass of data is exploited.

In brief outline the technical details are as follows:

Photography: Commercial 7″ x 9″, 8¼″ lens, R. F. 1:15, 840 with flight lines at right angles to topography.

Photogrammetry: Ground control points located in field and pin-pointed on photos. Slotted template assembly with some early work by radial line plotting. Transfer of detail by Multiscope or sketchmaster (where applicable).

Cadastral: Information transferred from Lands Department records.

Forest typing: Interpreted forest type boundaries marked on photos and checked in the field. Recognisable cover types subdivided into volume/acre and condition classes.

Sampling: Regularly spaced plots along survey lines parallel to the flight lines. Intensity varied from ¼ mile intervals x 1 mile apart to ½ mile intervals x 4 miles apart. 20-30 plots were measured for each forest type, but number increased when variability increased.

Line plots: Rectangular 5 ch. x 2 ch. All merchantable trees measured for d.b.h. and merchantable height, with deductions for visible defect and stem irregularity. All cull and dead trees tallied. Poles, saplings and seedlings tallied on smaller sub-plot.

Computations: Hollerith data processing was employed to compute plot volumes per acre by species and forest type, using standard volume tables for each species and region. The limits of error were calculated as if the sample were random for forest types, survey units and survey regions.

Australia

Australia has not yet completed a national forest inventory, possibly because of the independent nature of its composite States and the fact that forestry is not solely a Federal function. The only State with complete information at present is South Australia, which has no significant indigenous forest, but a large exotic plantation estate.

Nevertheless, the need for such an inventory has been recognized, much research has been carried out by the Federal Government, and all the remaining States have inventories in progress using aerial survey methods.

At an interstate conference convened in 1951, a plan for a national forest inventory was agreed upon, including a set of definitions and draft forms applicable to the project. Since that time a sample map sheet has been completed in Victoria (Carron and Hall, 1954) and an inventory of the Australian Capital Territory carried out (Rodger, 1953). These two surveys were very similar to the New Zealand prescriptions, i.e., slotted template assembly and transfer of detail by Multiscope. The essential differences were that the forests were stratified into stand size, height and density classes, and the plots were located at random within classes.

Concurrently, considerable progress had been made in Tasmania with aerial survey and photo interpretation. However, the policy adopted in that State aimed at the production of maps and assessment data at the management, rather than at the resource or national inventory level. Plans were drawn at 20 chains to an inch. Consequently, minimum interpreted areas were very much smaller and the rate of production correspondingly slower than at the inventory scale of 1 mile to an inch.

In essentials, however, the method closely followed the national inventory proposals, viz, stratification into stand size, height and density classes by interpretation of air photos, and random sampling. Details of the method and results have been published (Lawrence and Walker, 1954), including discussion on sampling errors, and elaborated in a later paper (Lawrence, 1957) which discussed the efficiency of photo-interpretation as carried out.

The Forests Department of Western Australia is also carrying out an inventory, which is nearing completion, and which likewise adheres fairly closely to the national inventory prescriptions (Nunn, 1959). Again, the methods used consist of slotted template assembly with transfer of detail by Multiscope and sketchmaster. Some further subdivision of height classes has been necessary in the jarrah (*Eucalyptus marginata*) forest, to reflect large changes in productive capacity with small changes in height.

Investigations in Australia into aerial survey methods have given attention to new developments in other countries and to their possible adoption, or adaptation to Australian conditions. One such of these was the "aerial volume table", viz, a table from which the volume per acre of a stand could be estimated from purely photomensurational data (i.e., without field observations). Unfortunately, almost the whole of Australia's forest resource consists of various species of *Eucalyptus* which have large spreading crowns, frequently fire-damaged, a

high percentage of defect both external and internal, and often the stand consists of a mixture of commercial and non-commercial sawlog species. This obviously leads to considerable difficulty in applying any volume figures to a photo-type even though total height and crown diameter (and/or density) can be measured.

In an attempt to adapt this technique to eucalypt stands, it was decided to measure "gross bole volume" as well as merchantable volume on all inventory ground plots, in the hope that an aerial volume table on this basis might prove feasible, and to which appropriate cull percentages could be applied. Gross bole volume is the total volume per acre of all live trees (over 12″ girth) from ground level to the base of the crown, without deduction for species cull, stump, stem irregularities, external or internal defect. Results in several localities over a number of years do, in fact, show a smaller sampling error for gross bole volume than for merchantable (saw log) volume, and in a specific stand type a relationship can be established (Carron and Hall, 1954) between gross bole and saw log volumes. Gross bole volume clearly represents the closest esimate of what the interpreter can measure. Nevertheless, it has not been possible yet to dispense with ground plots in eucalypt forest, and it appears unlikely that aerial volume tables will be used except for rough estimates. Any development must await further research.

In spite of the above, limited use has been made of the method by Dahl (1954), who determined plot pulpwood volumes by multiplying the average volume of five selected trees per plot by the number of trees. The volumes of the individual trees were obtained from crown diameter and height measurements by formula incorporating a pre-determined constant. The number of visible trees per plot was increased arbitrarily by 15% and an arbitrary deduction of 15% was made from the total volume for waste and tops.

The Commonwealth Forestry and Timber Bureau has given attention to photo-interpretation techniques (Aitken and Hall, 1951), the selection and training of photo-interpreters (Sims and Hall, 1955, 1956), and has ensured that for several years past all students passing through the Australian Forestry School have received a short course on the use of aerial photographs for forestry purposes. Another particular aspect which has been investigated is the presence on air photos of a "hot spot" or "shadow point" (Sims, 1954), leading to the production of tables showing when this phenomenon will and will not occur (Anon., 1955). If adequate interpretation is to be carried out, it is essential that flying be accomplished at such season of the year and time of day as will eliminate the presence of shadow point.

In contrast to photo interpretation of indigenous eucalypt forest, a technique has been described (Cromer and Brown, 1956) for the assessment of exotic coniferous plantations by the use of air photographs combined with point sampling. In this case, the limiting factor is the difficulty of accurately measuring the height of the trees by parallax methods, in order to classify stands into site index classes, in dense young stands when the ground can rarely be seen except along firebreaks. Large scale photographs (R. F. 1: 8,000 or less) are essential if such a classification is to be attempted. A significant feature of this angle count technique is that, following the initial survey, the computation of a stand volume table, in terms of basal area per acre and an expression of stand height, is possible. The latter can then be used for future surveys without the necessity of measuring sample trees, each plot only requiring the indirect estimation of basal area per acre, and the measurement of, say, top height. The time required to thus measure a plot with a wedge prism and a Haga altimeter is very short, and as the greater part of the total time required for this type of survey is occupied by traveling, it is possible to measure a cluster of point samples (angle count spots) and thus increase the precision of the estimate with but little extra effort.

An important step forward has resulted from the establishment in Sydney of IBM's Data Processing Centre, equipped with a 650 electronic computer, and the provision of training classes in "FOR TRANSIT" programming. The forest services of the Commonwealth, Tasmania, New South Wales and Queensland have already made use of this facility for inventory purposes. Tasmania has combined the sorting of punched cards containing tree and plot data with electronic computation of tree volumes (from previously computed regressions) and plot volumes. The programme provides for a prodigious output giving basal area, number of trees, gross bole volume, saw log volume, pulpwood volume, and cull, by species and by girth classes, with appropriate percentages, for each plot. Following re-sorting, the output becomes the input for a second run of the computer giving totals for all classes by sub-strata. A third run produces the inventory summary by strata, under all possible classifications likely to be required.

Less complicated programmes have been run by New South Wales and Queensland to furnish results for particular purposes. A usage which undoubtedly will continue to increase is the production of volume tables, and the improvement of volume tables as further sample tree data can be incorporated.

New Guinea

For some years the Department of Forests in the Territory of Papua/New Guinea has endeavoured to extract the maximum information from air photographs. Conventional keys to the identification of vegetation types from aerial photos, such as were produced during World War II, show examples of coconut plantations, sac-sac swamp, mangrove forest, shifting cultivation, and secondary growth. To the skilled interpreter the classification of these is easy, provided he has adequate photography. The real difficulty arises when differentiation of rain forest types is required.

Unlike the rain forests of Borneo, Sarawak and Malaya, where dipterocarps form a high percentage of the stand, those of New Guinea and much of Indonesia contain only a few desirable trees per acre, mixed with a large number of unmerchantable species which together form a continuous canopy. The requirement of the photo interpreter is to classify the stand with respect to merchantable volume, or otherwise stratify it so that volume may be determined by ground sampling.

There has emerged no solution to this problem to date. Admittedly, many rain forest species have characteristically

shaped crowns, and in virgin forest, if their crowns are level with, or slightly above those of their neighbours, this is sometimes reflected in the tonal pattern on vertical photographs. An example of this is *Anisoptera polyandra*. By painstaking interpretation it is possible to count the few mature crowns per acre of this species exhibiting the characteristic pattern. However, another dipterocarp occurring in the same stand (*Hopea* sp.) is not identifiable, and as the frequencies of the two vary from place to place, the merchantable volume cannot be predicted by interpretation, nor can the association present be defined.

It should be explained that photographs have not yet been taken with the latest European cameras, nor at a large scale. Perhaps the improved resolution now possible, and the photography of large scale sample strips in addition to smaller scale verticals for mapping, may change the existing situation. This appears to be a fruitful project for research in tropical areas.

In the region above the coastal rain forest belt occur stands of conifers (*Araucaria cunninghamii* and *Araucaria klinkii*) which form the basis of the plywood industry in New Guinea, at Bulolo. Hoop and klinki pines occur as pre-dominants in a mixed jungle containing only a few other merchantable species. On aerial photographs the characteristic crowns above the general canopy level are readily identifiable, and may be counted on random photo plots. The average number of trees per acre multiplied by the average volume per tree (derived from ground sampling) gives an estimate of the total volume per acre, with some allowance for invisible crowns. Such a project was in fact carried out, and a check instituted by random ground plots, located by photo reading and measured in the field. The comparison is not yet available, but it must be borne in mind that this is a special case and not generally applicable. Concurrently, a merchantable volume table was prepared in terms of girth (at breast height) and height to first green limb. This was computed by IBM's 650 machine, using in the first instance a regression analysis programme to determine the appropriate terms to be included, and finally by a specially-written programme. For this purpose the data were ranked in terms of the product of basal area and height and divided into a number of groups. Combined variable regression equations were calculated for each group and from these regressions the volume table was computed and printed out. It is unharmonised, but tests well against the original data. The production of this table was a co-operative effort between IBM, the Department of Forests, Commonwealth/New Guinea Timbers Ltd., and the Forestry and Timber Bureau.

General

In general, it can be said that sufficient guidance is already available, mainly in published form, to indicate the methods applicable to extensive forest areas in the Asia-Pacific region.

Until this region is more accurately mapped, reliance will have to be placed on the slotted template method with a minimum of ground control, since forest services cannot wait for topographical mapping by first order instruments, but must be content with provisional maps prepared as expeditiously as possible. For a similar reason, the transfer of detail will have to be effected by third and fourth order instruments, which are less expensive and require shorter operator training periods.

Within the temperate portions of the region, forests can readily be stratified in various ways according to particular requirements. In tropical areas, stratification of rain forest is more difficult and the determination of the most appropriate treatment awaits further research. In either case considerable latitude exists in the choice of the method of ground sampling within strata. Great savings in time and the elimination of errors can result from the use of punched cards or tape, and the processing of data by machines.

Caution is advised, when organising aerial photography, that shadow point be eliminated or minimised. The closer to the equator the more difficult this is to achieve and the more important it becomes that this undesirable effect is obviated. It is likewise highly important that forest administrations should satisfy themselves that persons engaged on photo interpretation have, in fact, adequate stereoscopic perception, and the ability to extract consistent information from the photographs.

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RESUMES

Méthodes de recensement forestier applicables aux vastes superficies boisées de la région Asie-Pacifique

La Commission Forestière de l'Asie et du Pacifique a insisté lors de ses trois dernières sessions sur le fait qu'il importe au plus

haut point d'établir dans la région un centre de formation pour le recensement forestier. Peu de pays ont effectué un recensement effectif dans cette région et le choix de la méthode à utiliser est souvent rendu plus difficile par le fait que la forêt humide y couvre de vastes superficies.

La Nouvelle-Zélande a toutefois terminé le recensement de ses forêts d'essences indigènes. Ce recensement a été effectué d'une façon très réaliste, c'est-à-dire que les ressources ont été évaluées en tenant compte du potentiel de productivité de la forêt elle-même.

Il s'agit ici d'une région pour laquelle il n'existe pas de bonnes cartes, et les décisions à prendre ne pouvant pas attendre l'existence d'une cartographie topographique précise, on a dû se contenter de cartes provisoires, établies par la méthode du gabarit à fente et à l'aide d'instruments de 3éme et de 4éme ordre pour le transfert des détails.

Des prescriptions quelque peu similaires à celles de la Nouvelle-Zélande ont été appliquées dans la plupart des états australiens, mais aucun recensement forestier national n'a encore été effectué. On a essayé d'établir des tables de volumes à l'aide de levés aérophotogrammétriques, mais sans grand succès, en raison de la présence dans les peuplements d'eucalyptus de diverses variétés défectueuses et inutilisables. Des progrès considérables ont été accomplis en ce qui concerne les techniques d'interprétation photographique grâce à la formation des interprètes photographiques et à l'étude des points d'ombre, y compris les moyens d'éliminer ces derniers en faisant procéder aux missions photographiques aériennes à des moments appropriés.

L'utilisation de la méthode de dénombrement par triangulation (échantillonnage sélectif) pour les recensements forestiers y est discutée et il y est fait mention de la disponibilité d'équipement pour l'interprétation des données en ce qui concerne les recensements et le construction des tables de volumes.

Le rapport met en lumière la difficulté qu'il y a de stratifier la forêt humide en types commerciaux et indique que ce problème exige des recherches plus approfondies. En dehors de cet aspect particulier, on dispose déjà, en général, de directives suffisantes pour formuler les méthodes applicables aux vastes superficies forestières de la région Asie-Pacifique.

Levantamientos aplicables a extensas áreas forestales de la región del Asia y del Pacífico

La Comisión Forestal para el Asia y el Pacífico ha señalado en sus últimas tres sesiones la necesidad de un centro de adiestramiento para inventarios forestales en esa región, donde sólo unos pocos países han efectuado un inventario efectivo y donde el problema de determinar qué métodos deben aplicarse se hace más difícil con frecuencia por la existencia de extensas zonas de bosques pluviales.

Nueva Zelandia, sin embargo, ha completado un inventario de sus bosques indígenas. Se aplicó a la labor un método muy realista, es decir, la intensidad de la evaluación de recursos fue variada de acuerdo con la productividad potencial del bosque mismo.

En una región donde los planos topográficos no son adecuados y donde las decisiones importantes no pueden esperar la elaboración de planos topográficos exactos, es necesario depender de planos topográficos provisionales, usando el método de patrón ranurado y empleando instrumentos de tercera o cuarta orden para ele traslado de detalles.

En la mayoría de los estados australianos se han usado métodos similares a los de Nueva Zelandia, pero aún no se ha completado un inventario nacional de bosques. Se ha intentado elaborar tablas de volumen aéreos sin mucho éxito, debido a la presencia de defectos y a la desigualdad de entresaques de especies en los bosques de eucaliptos. Se ha progresado mucho en las técnicas de interpretación fotográfica, en la prueba de intérpretes fotográficos y en la investigación de puntos de sombra, incluso el medio de eliminarlos haciendo que las misiones fotográficas vuelen en épocas y horas apropiadas.

Se discute el uso de la técnica de contar ángulos (muestreo de puntos) en inventarios de plantaciones y se menciona la disponibilidad de equipo para classificar datos para el cómpute de inventarios y cuadros de volumen.

Se subraya la dificultad de clasificar bosques pluviales según tipos de valor comercial y se sugiere la necesidad de ampliar las investigaciones sobre este problema. Aparte de este aspecto, ya hay, en general, suficiente orientación disponsible para indicar los métodos aplicables a los extensos bosques de la región del Asia y del Pacífico.

Surveys Applicable to Extensive Forest Areas In South America

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Modern development of aerial photo and sampling techniques has made it possible to perform in an efficient way surveys for extensive forest areas. For inaccessible regions and countries with few means of communication, the aerial photograph has opened the way for various kinds of accurate mapping from which, in the framework of this paper, the mapping of the general topography and the vegetation are the most interesting. These mapping possibilities enable the forester to apply modern sampling systems to his survey, whereas "at random" sampling and its modifications can be added to the well-known "selective" and "systematic" sampling systems.

Every survey is performed with a certain purpose. Mostly the aim is to obtain an estimate of the volume of standing timber from a certain d.b.h. and up. The aims for surveys of extensive forest areas are more complicated. At the moment, the Food and Agriculture Organization of the United Nations is assisting the Brazilian Government in the execution of two large-scale forest surveys, i.e., one in the Amazon Basin and one in the State of Santa Catarina, in the region where parana pine or *Araucaria angustifolia* occurs. The two surveys have entirely different aims. The purpose of the forest survey in the Amazon Basin is to obtain data about the composition of its mixed tropical rain forests to help provide a base for better economical activation. The survey of the parana pine forests is initiated because of a certain anxiety that they are overcut, so this survey has to find out what the actual situation is, and what can be done about a proved "overcutting."

The mixed tropical rain forests of the Amazon Basin cover an area of approximately 400,000,000 hectares. The region wherein parana pine originally occurred and where this tree still is found, either growing in groups

or singly, can be estimated at approximately 8,000,000 hectares. The first difficulty met in planning a survey for areas of this extension is: Where to start? Or in other words, which areas will have to be surveyed successively to make the survey, from the start, as effective as possible? At the time the survey of the Amazon forests was planned, two of the three forest experts who made an economic survey of these forests, as given in FAO report No. 171, were present and assisted in this planning. It was decided that a survey would be made of the central part of this forest area, located close to the Amazon River and its big tributaries navigable for seagoing vessels, starting with the plateau or "planalto" region south and southeast of Santarém (halfway between Belem and Manaus along the Amazon River). After having obtained, at present, survey data covering an area of approximately 17,000,000 hectares, it can be said that this first part surveyed is still one of the most promising. The first or "pilot" area of the parana pine region was selected by the Director of the Federal Forest Service, because in that area the most parana pine was cut, and because of its central location in the parana pine range in the State of Santa Catarina on the high plateau near Curitibanus.

A first essential for any kind of forest survey is a map. The minimum required is a controlled planimetric map. For most purposes, except of course for detailed inventory and management plans, scales of 1:50,000, 1:100,000 and 1:200,000 can be regarded as useful and convenient. Neither for the Amazon Basin nor for the parana pine region in the State of Santa Catarina were detailed planimetric maps available. These maps had to be made first. Since only maps made from aerial photographs are involved here, the best way to obtain them is to have these maps prepared by an aerial survey company. At the time planimetric maps were needed for the forest survey of the Amazon Basin, we could not order these maps through one of the Brazilian aerial survey companies, for reasons which will be explained shortly. At the start of the forest survey work in the Amazon Basin only trimetrogon aerial photographs taken by American flyers during the last world war were at our disposal. Trimetrogon aerial photographs are mostly taken for reconnaissance purposes. The survey plane uses three cameras, one in the middle for the vertical photograph (in this case mainly on scale 1:40,000) and two at the sides for the oblique pictures. The three pictures taken at the same time cover a stretch of the surface of the earth from horizon to horizon perpendicular to the direction in which the survey plane moves. It has not been common practice and it is fairly difficult to make detailed planimetric maps from trimetrogon aerial photographs.

To do this work for the Amazon Basin is the more difficult since this Basin is practically totally covered by dense tropical forests which conceal most of the natural topographical features of the region. Through previous experience, we knew that if the mapping of the topography from these pictures were done by people not accustomed to this special kind of photo-interpretation, we could at best expect a map of the smaller and bigger rivers visible on the aerial photographs. However, we wanted planimetric maps made from these trimetrogon photographs as detailed as possible, so it was decided to have them prepared in our own office by special trained personnel. All other maps made from vertical photographs were made by one of the Brazilian aerial survey companies.

Before the drafting of a map to be made from aerial photographs can start, its geographical base has to be provided for. The denser the net of geodetic or astronomic station points (which can be used for this base), the more exact will be the geographical location and the more accurate and uniform will be the scale of the map. For the mapping work of the Amazon region, only a few reliable astronomic station points were available. Sometimes the trimetrogon flight runs were too far apart, so it became difficult to tie them properly.

The most accurate parts of these maps are those parts for which we could use the geodetic maps, prepared by the National Brazilian Oil Company or Petroleo Brazileiro S.A., based on newly made astronomic station points. In view of the limitations of the precision of most of our Amazon maps, the final maps were produced on scale 1:200,000, which does not pretend to give a high accuracy in distances and directions, but presents an excellent overall picture of the country surveyed. For all our other maps, made from vertical aerial photographs, the aerial survey company which prepared them guaranteed their accuracy, based on reliable astronomic station points available or provided by their own geodetic service. These latter maps were all produced on scale 1:50,000.

After having obtained a network of triangulation points in which the single photograph can be fitted, the actual map can be drafted by photo-interpretation. Referring only to our map-making in Brazil, it can be said that the easiest parts of it are: (1) the mapping of the artificial topographical features; (2) the drawing of the water limits or the borders of the rivers and sea as long as they are not obscured by vegetation; (3) the borders between forest, agricultural and grasslands, and the borders between forest and scrub or grass savannah.

In reality these are all features or borders which can be observed directly in the stereoscopical view of the aerial photographs and for which the common photo-interpreter does not need special training. In our experience, the difficulties start always when the natural topographical features of the country are hidden by the vegetation. For example, in this case the borders between permanently or temporarily waterlogged areas and dry land cannot be observed directly but have to be deduced from the appearance of the vegetation canopy. When the country to be mapped is completely covered by dense forests, as is true for most of the Amazon Basin, even the mapping of the drainage system, i.e., the mapping of the rivers and creeks up to the gullies, cause considerable trouble and can be performed only by photo-interpreters who have had special training in this kind of mapping work.

Up to now all our maps were made as planimetric maps, i.e., maps without contour lines or indications about altitudes other than by way of form lines marking edges of plateaus or "planaltos" and tops of outstanding hills. Because the areas mapped in the Amazon region with the help of the trimetrogon photographs are practically flat, with differences in the plateau or "planalto" region of less than 150 meters, the oblique pictures could be used. This has to be regarded as an advantage, for in areas with

high and steep hills or in mountainous country, the hills and the mountains appear with their flanks on the oblique parts and hide all that is behind. Since the oblique pictures of these flight runs were often clouded or hazy, they could not always be used for the detailed mapping work. Furthermore, when the flight runs were too far apart, we had to leave some gaps in these maps here and there.

The planimetric maps are maps made to serve as *a* base for the sample to be taken from the forests under survey and as *the* base for the ultimate forest type map. It will be clear that, from the start, we tried to put, by way of pure photo-interpretation, as much information about the forests on these maps as possible. Through the demarcation of the areas flooded by sea water, areas temporarily and permanently waterlogged by river and/or rain water, and the dry land areas, the forests growing on these parts were automatically subdivided in formations, i.e., saltwater swamp, sweet-water swamp and marsh, and dryland forest formations. Up to now in the Amazon region only dryland forests have been surveyed. It is possible to separate, inside these dryland forests, the secondary forests and the savannah or caatinga forests.

According to our experience, both forest types can easily be identified on aerial photographs up to scale 1:45,000. In the secondary forest the pattern of the shifting cultivation fields can usually be recognized. At the border of the savannah or caatinga forests a gradual change can be observed from a coarse to a smooth crown canopy, contrary to the similar changes for the secondary forests, which are abrupt. The appearance of the savannah or caatinga forests amidst the common high dryland forests in the Amazon region is practically always paralleled with a change in soil, i.e., from loam, clay, or sandy soil into white sand soil covered by a thick layer of humus. In exceptional cases forests were found on soil on which the rain water lay stagnant because of a hard clay pan underneath. These forests are often found on top of or near the tops of watersheds. Their average total height of trees is around 20 meters, and rarely do trees have a d.b.h. of more than 35 centimeters.

On the vertical photographs (1:25,000) from the parana pine region in the State of Santa Catarina, it is very easy to recognize the big parana pine trees. When these trees grow in closed stands they show an unmistakably clear pattern. When they grow in mixture with other trees, normally they emerge high above the others, and their typical disk-shaped crowns can easily be spotted. When they grow singly on grass savannahs (campos) or are left on agricultural areas, they can always be recognized with certainty by their crowns and/or their shadows. Therefore, at the time the planimetric maps needed for the first survey of the parana pine region in the State of Santa Catarina were ordered, the aerial survey company was asked to subdivide the dryland forests on these maps into easily and surely identifiable parts. It came out that, from the stereoscopical view of the pictures, it was possible to divide these forests into the following types: (1) pure parana pine stands; (2) broadleaf tree stands mixed with parana pine; (3) broadleaf tree stands; (4) secondary forests; (5) devastated forests from which most of the parana pines were cut; (6) grasslands or savannahs with scattered growth of parana pine trees.

In this summing up of what can be achieved by pure photo-interpretation for the Amazon region and the parana pine region, one of the main problems of the photo-interpretation for forestry purposes in tropical countries has been touched upon. In the survey of the parana pine region, it is the only conifer growing mixed with broadleaf trees, or in pure stands, or as a light-demanding tree emerging above the broadleaf species or growing up in the open. We were therefore able to identify with some certainty the areas where parana pine occurs.

Using only the stereoscopical view of the aerial photographs, it is very difficult to identify forest types in the real tropical rain forests. The exceptions are: (1) the salt water swamp forests, with only the species *Rhizophora mangle* and *Avicennia nitida;* (2) several marsh and swamp forests, with only a few species in their upper story which have distinctly shaped crowns, as, for example, *Hura crepitans* and *Virola surinamensis;* (3) some patches of dryland forest dominated by one tree species, as, for example, *Eperua falcata;* and (4) dryland forests with clearly visible concentrations of *one* species in the upper story, so it is possible to name at least one of the components of its composition. After five years of experience in the field, we are not yet able to give the highly mixed dryland forests of the Amazon Valley a forest type name through pure photo-interpretation. The naming of concentrations of an upper story tree, which often was possible in Dutch Guiana, could here be done only for angelim pedra (*Hymenolobium petraeum*) and is questionable for massaranduba (*Manilkara huberi*).

For the planning of an aerial survey for forestry purposes these facts are extremely important. For example, the possibilities of seeing more of the smaller parana pine trees on the aerial photographs by changing the scale from 1:25,000 to 1:10,000 or even to 1:5,000 are practically unlimited. Especially for detailed surveys and management planning, these changes can be very useful. In practice, such changes will have to stop where the savings in supplementary outdoor and sampling work will be less than the increase in expenses for the larger scale photographs compared with the costs of the smaller scale pictures, consideration being also given to the growing expenses for the more time-consuming photo-interpretation and mapping work.

For the survey of the highly mixed tropical rain forests we use mostly aerial photographs of scale 1:40,000, and a few on scale 1:25,000 and 1:45,000. Scale 1:40,000 is sufficient to map the general topography and, consequently, also sufficient to divide the forests into formations.

When making a proposal for an aerial survey of these forests with larger scale photography, it is necessary to have a very sound reason to do so, since in general the value of these forests is not yet high, as long as only a few tree species are exploited. If, through direct observation in the stereoscopical view of the larger scale pictures, the trees to be exploited can be located with certainty, it is also possible to draw a stand map which can be used directly for management purposes. If, through observations made during previous exploratory surveys, it is known that certain valuable forest types coincide with the occurrence of a palm tree visible between the upper story trees, larger scale photographs offer a very good

chance to map these forest types accurately and quickly, i.e., by way of indirect observation in the stereoscopical view of the photographs. The larger palm trees of the genera *Mauritia* and *Maximiliana* are clearly visible on photographs at scale 1:20,000, and the smaller palm trees of the genus *Euterpe* on photographs at 1:10,000. For the justification of the higher cost of aerial survey, it has to be considered that in the very inaccessible parts of these forests, i.e., the swamp and marsh forests, the outdoor sampling work is very expensive and can never be done as well as similar work in the dryland forests. In these swamp and marsh forests the surveyor and his laborers can hardly move without having to overcome extreme physical difficulties. It can be expected that the data obtained through pure photo-interpretation are, in these cases, more reliable than those obtained through the common amount of outdoor sampling work.

Based on experience in photo-interpretation and observations made in the field, it can be assumed, for the time being, that for the Amazon Basin it is impossible to identify species in the highly mixed dryland forests through observing only their crown patterns under a stereoscope. From our experience with the clear and cloudless oblique parts of the trimetrogon flight runs of the Amazon region, we know that the subdivision of these tropical forests into formations is very good, possibly up to the center part of the obliques. From the bottom of the obliques up to the horizon the scale of the picture changes gradually parallel with the flight direction and is, near the center, more or less 1:70,000, provided that the scale of the vertical is 1:40,000. In view of these facts, the possibility exists that aerial photographs on scale 1:70,000 can do this job also, i.e., the mapping of the forest formations and the general topography. When the financial means will permit it, the intention is to make an experiment in this regard for an area already covered by one of our exploratory surveys, so that the results can be compared. The justification for this experiment is based on two very important reasons: (1) the cost of the aerial survey per square kilometer will be less than half compared with a survey on scale 1:40,000; and (2) the *few cloudless days* per year suitable for survey work in the Amazon Basin will give a much bigger photocoverage.

For the parana pine region we were also able to subdivide the area on which this tree grows into several density types. In the stereoscopical view of the vertical photographs on scale 1:25,000, the big parana pines were counted in squares of one hectare. The types separated are: (1) *type 2,* consisting of the pure parana pine stands with an average crown density of 15 or more crowns per hectare; (2) *type 1,* consisting of the more mixed parana pine forests (mostly mixed with embuja-Phoebe porosa) with an average crown density of 5-14 crowns per hectare; and (3) *type 0,* consisting of broadleaf forests with scattered growth of parana pine with an average of more than zero and less than 5 crowns per hectare.

The planning of the sampling work and the choice of the sampling system always depends on former experience and the information obtained from the aerial photographs about the forests to be surveyed. At the start of our inventory work in the Amazon Valley, very few qualitative descriptions based on quantitative observations or *so-called* samples were available for the Amazon forests in general and none for the forests in which the survey had to start. The valuable parana pine forests are, of course, much better known, but reliable quantitative data were few. Even volume tables for the standing timber of the virgin trees had to be constructed first.

The objective of the survey of the Amazon forests is to get as quickly as possible information about their composition and their accessibility, in order to be able to select the most valuable parts, suitable for modern management, with a high degree of certainty. This selection can be done for direct use, but the main purpose will be to preserve these parts for the future by transforming them into national forest reserves. Therefore, the sampling system chosen was an exploratory survey with the accent on the exploring part.

The objective of the survey of the parana pine forests, which are practically all privately owned, is to find out if they are overcut or, in other words, if they are disappearing. Looking at the statistical data of sawn parana pine timber over the years 1954-1958, as given in the following table, we see that a large quantity of that timber is cut annually and comes from four States of the United States of Brazil.

Table 1. Sawn parana pine timber data obtained from *Anuario Brasileiro de Economia Florestal,* Ano 11, No. 11, 1959. (Added is a comparison for the equivalent of standing timber with bark.)

Name of State	Quantity of sawn parana pine timber (in cubic meters)				
	1954	1955	1956	1957	1958
São Paulo	——	2,640	4,750	5,010	5,040
Paraná	1,182,072	1,286,227	1,138,999	895,487	1,000,744
Santa Catarina	1,340,173	1,492,489	1,293,115	1,294,335	1,424,210
Rio Grande do Sul	665,207	611,975	429,355	500,007	449,006
Total	3,187,452	3,393,331	2,866,219	2,694,839	2,879,000
Approximate equivalent of standing timber with bark (in cubic meters)					
Total	12,750,000	13,600,000	11,450,000	11,800,000	11,500,000

Because of the widely scattered activity in woodcutting, it is necessary to have recently taken aerial photographs for this survey. Without former knowledge of how to execute such a survey and the time it would take to accomplish it, it was thought inadvisable to start the survey for the whole parana pine region at once, but to perform first a "pilot" or experimental survey. In the State of Santa Catarina, where the most timber is cut

(see table), a comparatively small area of 550,000 hectares was selected for this experiment, to be performed with aerial photographs (scale 1:25,000) taken in the middle of 1957. The work for this survey started at the end of 1958 and has just been finished.

After having chosen the sampling system, it is necessary to plan the actual sampling work in the field in such a way that an unbiased sample is obtained. For both the pure exploratory and the pilot surveys it is not necessary to know beforehand how big the sample has to be in order to achieve a certain degree of accuracy in estimate, whereas it is one of the aims of this kind of survey to provide data about sample size.

The Amazon maps gave only the location and the extent of the dryland forests. In the field we had to find out: (1) how to enter and penetrate these forests; (2) what is their composition; (3) can these forests be subdivided into types; and (4) what is the best method to perform more detailed surveys? Entering an *unknown* forest type, as we always have to do during our exploratory surveys, and enumerating a sampling unit at the point of entrance, this sampling unit will be *unbiased,* but when the second sampling unit is taken without following a prearranged plan, *it can be biased.* Therefore, before our field trips started, the transects to be cut perpendicular to the topography of the country were more or less regularly spaced along the rivers we assumed could be entered, and attention was paid to regular distribution over the area to be surveyed. The sampling units of one hectare each were taken along the transects at planned intervals. Over the length of one kilometer the trees with a d.b.h. of 25 cm. and up were enumerated five meters left and right from the center of the transect. The sampling density of the exploratory surveys is about or less than one-hundredth of one percent.

For the parana pine forests, the planimetric maps with the vegetation types and the photographs with the crown density types gave us their exact location and extent. The only thing we had to find out in the field, by way of sampling, was the volume of standing timber and the diameter distributions. Before the planning of the sampling work could start, a very interesting difficulty came up. The parana pine grows practically everywhere, on grasslands used for cattle grazing, on agricultural lands, etc. On those places the trees are also cut by sawmills.

Since the areas outside the forest types mapped are nearly three times as big as those occupied by these types, it was thought possible that these areas could produce a considerable amount of timber. Therefore, these areas were included in the sampling procedure. On the planimetric maps of the whole area was drafted a network of east-west running lines, two kilometers separated from each other. The starting point of the network was chosen at random. If all these lines were surveyed in the field and all parana pines were enumerated that fell within five meters of this survey line, this network could provide an unbiased sample of 0.5 percent for the whole area. It could give in reality 2,800 kilometer transects or 28,000 sampling units of one-tenth of a hectare each, which was considered to be a sampling density which could cope with exceptional variabilities in volume distribution. The actual sample taken was enumerated in five groups. This separation was made to be able to make an analysis of variance, i.e., to be able to find out if the parana pine type called "type 2" at the eastern side of the area can be regarded as belonging to the same or "homogeneous" type as that at the western side of the area.

All parana pines, including seedlings and saplings, were enumerated along the transects in sampling units of 0.1 hectare. This small sampling unit was chosen since some very small patches of parana pine had to be crossed. The strip system was applied, owing to the very heavy undergrowth of these forests. On one occasion, a transect had to be cut through an unbroken patch of bamboo for a length of five kilometers. More than 600 kilometer transects were cut, giving more than 6,000 sampling units, or a sampling density of a little more than 0.1 percent.

During the sampling work and after its conclusion, the results were evaluated with the help of statistics. Especially for the Amazon region, a considerable amount of experimental work has been done, in which we were assisted by the Statistics Department of the Central Organization for Applied Scientific Research for the Netherlands. Hereafter some of the results will be shortly summarized.

A. For the Amazon region, our data showed that not all the species have the same chance to grow up and survive. Groups of species were found which were enumerated constantly in big numbers; groups of species which were only locally enumerated in big numbers; and groups of species which were always enumerated in small and very small numbers. The conclusion is that the species of these forests do not appear "at random" but have a competitive power which differs substantially.

After having obtained, at present, more than 1,200 sampling units of one hectare each, spread out over a front of 1,600 kilometers, i.e., from the Rio Madeira to the Rio Maracassumé in the State of Maranhão, it can be said that the composition of these forests is very uniform. The occurrence of the abiuranas (*Pouteria* spp.) is practically constant from the Rio Madeira up to south of Belem, i.e., more or less ten percent of the number of trees enumerated, or 12 trees of a d.b.h. of 25 cm. and up per hectare, which can be regarded as a big number for this kind of highly mixed forest. Going to the eastern tip of the Amazon forests in the State of Maranhão, slight changes in composition occur, and the dominance of the abiuranas is taken over by the mata matas (*Eschweilera* spp.). Except for these latter forests, the others can be called abiurana forests belonging to an abiurana association. Inside these abiurana forests were found several types or facies (sub-types). Mainly in the understory appeared at once in abundance, a species not yet or only occasionally found elsewhere.

The division of these forests into types or facies was based on the occurrence of these species appearing in abundance, which characterized part of the abiurana forests. The borders of these types were defined by way of sampling. Only on one occasion could these borders also be defined with the help of aerial photographs, i.e., for the "planalto" forests types where borders coincided with the borders of the flat top of the plateau or "planalto." To obtain a picture of the composition of a forest type it is necessary to take a sample of 30 sampling units of one hectare each.

It came out that the trees of most of the species were fundamentally distributed at random and followed a Poisson distribution. The Poisson distribution was used because it deals with the occurrence of isolated events in a continuum of area. Applying this distribution to the data, it was frequently upset by one or more sampling units with a very large number of trees. The larger the average number of trees per hectare became, the more often this happened. This means, in reality, that the species of these forests have the ability to grow in clusters or in colonies. The species with the most outspoken ability to grow in colonies are the species which characterize one of the forest types or facies. A statistical rule could not be applied to the distribution of the trees of these species.

To get an estimate of the average number of trees per hectare for tree species (not character species) with an accuracy within 10 percent in 19 out of 20 cases, it is necessary to take an unbiased sample containing 400 to 500 trees. This is not difficult if a species appears at a rate of 5 to 6 trees per hectare, but becomes very difficult and expensive when a species appears only once on 20 hectares.

Also, it was calculated how many trees of one species have to be enumerated to obtain the same accuracy in volume estimate. These calculations were performed for 95 species. It came out that for 91 of these species, 400-500 trees were more than sufficient, and only for four species not sufficient. The calculations for these last four species were based on very few trees enumerated.

For the groups of valuable or so-called economic tree species, a sample of 200 hectares at maximum can give the same accuray in estimate as mentioned for the number and volume of the trees of the single tree species.

B. The evaluation of the sampling results for the parana pine forests, which seemed at first sight to be very similar to a survey of conifer forests in the temperate region, caused some very particular difficulties. Through the choice of the sampling unit of 0.1 hectare, we got, especially for the areas outside the forest types, large numbers of zero sampling units. The volume of standing timber without bark was calculated for trees with a d.b.h. of 20 cm. and more (paperwood limit), and for trees with a d.b.h. of 40 cm. and more (the legal limit for tree cutting) in tenths of a cubic meter. Through the omitting of the smaller diameters, the amount of zero sampling units increased once more. After several trials it came out that it is possible to transform the sampling series obtained into series following a Poisson distribution by grouping the units into volume classes. For example, from a certain part of secondary forest, outside the parana pine forest types, we have 549 sampling units, of which 464 are zero for the trees of d.b.h. 40 cm. and up. By grouping these units into volume classes of 6 cubic meters, the following distribution is obtained:

Volume class (Cubic meters)	Number of sampling units	Poisson distribution
0.0	464	461.8
0.1- 6.0	76	79.9
6.1-12.0	8	6.9
12.1-18.0	1	0.4
Total	549	549.0

The observed distribution (units found) is nearly a perfect Poisson distribution (P.D.) and has a chi-square of 1.28, between the 0.750 and 0.500 level. This means in reality that these volume classes are distributed at random throughout the area occupied by the parana pine forest types or the areas outside these types where the parana pine occasionally appears. Through this transformation, the calculations for the accuracy of estimate and sample size become easy and simple.

The survey work mentioned for the Amazon region is described in detail in the FAO reports Nos. 601, 949, 969, and 992, the report "Caeté-Maracassumé" (not yet released), the report "A 100% Survey in the Curua-Una" (not yet released), and an interim report in six parts (not yet released).

The survey work mentioned for the parana pine region is described in detail in Boletim No. 1 and Boletim No. 3 (not yet released) from the Inventory Section of the Federal Forest Service of Brazil.

RESUMES

Inventaires applicables notamment aux vastes étendues forestières

L'Organisation des Nations Unies pour l'Alimentation et l'Agriculture prête actuellement son concours au gouvernement du Brésil pour établir deux inventaires forestiers sur grande échelle, un dans le bassin de l'Amazone et un dans la région des pineraies du Paraná. L'inventaire du bassin de l'Amazone a été entrepris en 1953, et jusqu'à présent une région de 17.000.000 d'hectares environ a fait l'objet d'inventaires exploratoires. L'inventaire de la région des pineraies du Paraná a été entrepris vers la fin de 1958, et l'on vient de terminer la première exploration d'une région couvrant 550.000 hectares, à titre de région "témoin".

Les deux inventaires sont effectués à l'aide de photographies aériennes. Les photographies de la région de l'Amazone ont servi à dresser une carte topographique générale du pays et à tracer les lignes de démarcation des peuplements forestiers. Elles n'ont pas encore pu servir à donner aux essences constituant les forêts inventoriées des terres fermes leurs dénominations floristiques exactes. Les photographies de la région des pinearaies du Paraná ont servi à dresser une carte topographique du pays, de même qu'une carte des différentes essences et de la dessité des couronnes dans les forêts de pins de Paraná.

En ce qui concerne les forêts de l'Amazone, l'analyse des résultats de l'échantillonnage a montré que les diverses essences ne semblement pas être disséminées au hasard, mais suivent bien une certaine disposition définie, qui peut se trouver parfois modifiée par l'apparition d'un nombre appéciable de certaines essences, dont le peuplement caractérise certaines parties de ces forêts. Les arbres appartenant à ces espèces ont été en principe disséminés au hasard, mais ils ont tous démontré une tendance a s'assembler, autrement dit, à former une colonie. Afin d'obtenir un échantillon avec une approximation de 10% d'exactitude, et tenant compte d'une possibilité d'erreur de 5% dans l'évaluation du nombre moyen des arbres et de leur volume par hectare pour une seule espece, il est nécessaire de compter de 400 à 500 arbres. Pour obtenir la même exactitude d'évaluation due volume des arbres sur pied, en ce qui concerne les groupes des espèces de rapport, dites de valeur économique, il est nécessaire d'évaluer un échantillon d'un maximum de 200 hectares.

Du fait que le pin de Paraná croit pour ainsi dire partout, il est devenu nécessaire prendre des échantillons hors forêt. Attendu qu'on avait trouvé les forêts de pins de Paraná dispersées, en petits et meme en très petits groups (de 2 à 5 hectares), on a été obligé d'adopter une petite unité d'échantillonnage, c'est-à-dire représentant un dixième d'hectare. Il en a résulté, qu'une grande partie des unités d'echantillonnage prélevées etaient nulles. Les séries d'échantillonnages pouvaient être transformées en distribution de Poisson, en les groupant et en les classant par volume. Ce fait prouve, qu'à l'intérieur même des forêts, ainsi bien que dans les terrains non-forestières, les pins de Paraná sont disséminés au hasard, certaines étendues sont totalement

dépourvues de ces pins, tandis que d'autres en ont un seul, ou plusieurs, ou meme en grand nombre.

Comme c'est le cas pour tout inventaire forestier, les données obtenues par l'exploration peuvent être appliquées uniquement à la surface totale de la région étudiée. Attendu que l'inventaire obtenu par les recherches effectuées dans le bassin de l'Amazone à porté sur des régions étendues, les données ainsi recueillies peuvent servir à évaluer le potentiel total des forêts inventoriées et à prévoir avec exactitude le rendement probable de certaines parties données de la région étudiée.

L'inventaire "témoin", ou d'essai, de la région des pineraies du Paraná à indubitablement prouvé, par l'abondance des unites d'echantillonnage prelevées, que les types de densité des couronnes, répresentés sur la photographie aérienne a l'échelle de 1 : 25.000, indiquent des forêts de types homogènes. L'évaluation du volume de ces types de forêts peut être effectuée sur la base d'échantillonnages assez petits. C'est cet inventaire "témoin" qui a ouvert la voie à un inventaire d'ensemble, réalisable a relativement peu de frais, de toute la région des pins du Paraná, ou de certaines parties données de cette région.

Inventarios especialmente aplicables a las grandes areas forestales

La Organización para la Alimentación y la Agricultura de las Naciones Unidas está prestando asistencia al Gobierno del Brasil en la preparación de dos grandes inventarios forestales, uno en la Cuenca Amazónica y el otro en la región de pinares del Paraná. El inventario de la Cuenca Amazónica se comenzó en 1953 y hasta la fecha se ha cubierto una extension aproximada de 17 millones de hectáreas en una serie de inventarios exploratorios. El inventario de la región pinareña del Parana se inicio a fines del año 1958 y ahora acaba de terminarse el primer inventario experimental que ha abarcado una extensión de 550.000 hectáreas.

Ambos inventarios se llevan a cabo con la ayuda de la fotografía aérea. En la región amazónica las fotos se usaron para levantar un mapa de la topografía general del territorio y para determinar las formaciones forestales. Sin embargo, no han podido ser usadas todavía para dar a los bosques de suelo seco inventariados su nombre floréstico correspondiente. En la región pinareña del Paraná las fotos se emplearon para el mapa topográfico de la zona, para el de los tipos de vegetación y para el de los tipos de densidad copal de los bosques de pinos.

El análisis de los resultados del muestreo de los bosques amazónicos probó que las especies no están apareciendo "alazar," sino que siguen una pauta que puede ser modificada localmente por otras que aparecen en abundancia y caracterizan ciertas partes de estos bosques. Los árboles de las especies fueron distribuídos fundamentalmente alazar pero han mostrado tendencias a reunirse y formar colonias. Para obtener una muestra que tenga una exactitud de 10% con un 5% de oportunidad de error en el promedio numérico de árboles y de su volumen por hectárea, cuando se trata de una sola especie, es necesario enumerar de 400 a 500 árboles. Para conseguir la misma exactitud en los cálculos para el volumen de árboles en pie, por grupos de las llamadas especies valiosas o económicas, hay que enumerar una muestra de un máximo de 200 hectáreas.

Debido a que el pino del Paraná crece prácticamente en todas partes, fue necesario muestrear también las zonas no forestales. En lugares donde este pino crece muy disperso en parcelas que varían entre pequeñas (de 2 a 5 hectáreas), hubo que escoger una pequeña unidad de muestreo, esto es de una décima de hectárea. El resultado fue que en gran número de las unidades de muestreo éste acusó cero. Las series de muestreo fueron convertidas a la distribución de Poisson, poniéndolas por grupos en clases de volumen. Este hecho vino a demostrar que los lugares dentro de las zonas forestales y no forestales, sin pinos del Paraná, con ni uno, con uno solo, con unos cuantos, y con muchos, están distribuídos alazar en toda la región que ocupan.

Como sucede con cualquier clase de inventario forestal, los datos obtenidos mediante el inventario exploratorio se puede aplicar solamente al total del área inventariada. Los inventarios exploratorios de la Cuence Amazónica incluyen grandes extensiones y los datos obtenidos preden usarse en el cálculo de la potencialidad total de los bosques inventariados y dar una indicación sólida de lo que prede esperarse en partes selectas ed la zona estudiada.

El inventario experimental de los pinares del Paraná, merced a la abundancia de unidades de muestreo obtenidas, ha probado sin género de duda que los tipos de densidad copal observados en las fotos, a escala de 1: 25.000 son indicación de tipos forestales homogéneos. El volumen de estos tipos puede calcularse con muestras razonablemente pequeñas. Con este inventario experimental se ha abierto el camino para otro inventario general, relativamente poco costoso, de toda la región pinareña del Paraná o de partes selectas de ella.

Surveys Applicable to Extensive Forest Areas In North America

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Introduction

To introduce my discussion I'll outline the objectives and scope of a survey for an extensive forest area as I see them. I'll also list some criteria for evaluating survey designs. I hope these points will indicate that my orbit around this topic is approximately the same as that of my colleagues on this program. I also hope that my discussion will provide you with another representative view of useful survey designs—this one from North America.

Objectives. The objectives of a survey of an extensive forest area might be, in brief, to provide reliable estimates of those minimum facts on the forest resources of the area that are necessary for policy appraisals of the timber situation and for planning forestry programs and forest industry investments. Thus, there is need for such basic statistics on timber supplies as areas of forest by classes (cover type, stand-size, age, site and other conditions), and volumes, growth, mortality and cut of timber. Unless timberlands are held in one ownership, separate statistics by ownership class are needed. There is also need for data on timber demand and for information on parts of the forest resource beyond timber values, such as values for water, forage and recreation. For brevity in subsequent discussion, however, I'll ony refer to procedures for determining timber supplies, and will not discuss procedures for obtaining estimates by ownership class.

Scope. An extensive forest area, as I see it, is one in the magnitude of millions of acres or hectares, within a large economic region. This might be a political unit such as a state or country. Several broad inventory designs in general use in North America will be described and evaluated. The application of one specific design will be outlined.

Criteria. Several criteria useful in appraising the relative merits of a survey design are: (1) efficiency, permitting speed of operation at reasonable costs; (2) dependability, permitting computation of statistics for which confidence limits can be indicated; (3) suitability for reinventory, permitting comparable data to be obtained on initial and subsequent inventories (in effect a design for continuing inventory); and (4) flexibility, permitting incorporation of improved techniques as they are developed without significant sacrifice of the comparability just mentioned.

Various Useful Designs

Extensive inventory designs used currently or recently in North America can be grouped into several broad categories for convenience of discussion. Virtually all of these designs use aerial photography, at least as an aid for estimating areas of forests, for expediting field work and for referencing locations of field plots. Most of them also depend on supplementary studies to determine timber cut. This is usually determined from canvassing the products output of forest industries or from records of timber removed in logging. This output is then related back to the forest by applying utilization factors obtained on special studies to get an estimate of timber cut (or fellings).

Examples of application in the United States are by the Forest Service; those in Canada[1] by the Provincial Forestry Departments working under general inventory standards outlined in National-Provincial Forestry agreements; those in Mexico[2] by the Nacional Financiera, the official agency for promoting and financing industrial development of the country.

In discussing methods used in Canada and Mexico I may overlook important points, since I am not as familiar with procedures there as in the United States. I hope that persons who are more knowledgeable will advise us on such points during the discussion period.

1. Mapping for Area Estimates— Empirical Sampling for Other Estimates

This design requires production of a complete map showing forest classes (such as type, site, stand-size, height, age and stand density classes) prepared by a combination of photo interpretation and field checking. Planimetry (or other method of determining areas on maps, such as intensive dot counts) is used to provide estimates of areas of all forest classes. These estimates, in effect, are free from sampling error.

There may be significant errors in the technique of mapping, however. The accuracy of delineations in forest classes on a map varies with subjective decisions made by the mapper as he judges the "average" of a variable range in forest conditions over rather large areas.

Field plots provide volume, growth and mortality data. Plot locations are selected by the most experienced personnel to sample "typical" portions of the various forest classes. Data from all plots taken in each class give "average" statistics on volume, growth and mortality in that class. Sampling errors for these estimates sometimes are computed and expressed as if the plots were truly representative samples.

Variations of this design have been used in the Canadian Provinces of Alberta, Manitoba (accessible portion), Ontario and Saskatchewan (general forest zone).

2. Mapping for Area Estimates— Representative Sampling for Other Estimates

In this design, also, areas of forest classes are estimated from units delineated on maps, but estimates for other statistics are determined by representative field sampling of forest classes. The locations for plots are determined in a systematic or random manner without opportunity for personal judgment in selection. From these plots sampling errors are computed for average volumes, growth and mortality in a forest class. As you know, sampling errors of systematic samples are computed as though the sampling were random. Statisticians tell us that the estimate of sampling error so computed is likely to be greater, but that the real error is probably less, than that of a random sample of the same intensity.

To insure that representative samples are chosen, random or systematic choices may be made from a large number of possible locations defined by geographic coordinates on maps or by grids on aerial photographs.

In applying this design, the number of field plots to be taken (either total or number within each forest class) may, of course, be determined for any desired allowable standard error of estimate by assuming that variability of the timber is similar to that in another region where a survey has been completed. A preferable procedure is to estimate the variability (coefficient of variation) by taking a limited reconnaissance sample within the Survey Unit. If, after the survey is completed, the actual coefficient of variation proves to be significantly higher than that given by the reconnaissance, additional plots may be taken to reduce the standard error to that allowable.

In one variation of this design (used in the Canadian Provinces of Nova Scotia and British Columbia and in the United States on many national forest working circles) sampling has usually been stratified by forest class with more intensive sampling in heavy-volume stands than in low-volume stands. In another variation (used to inventory a large portion of Michoacán State in Mexico) sampling was distributed proportionally to total area of forest.

Sampling for Estimates of All Forest Statistics

The three following designs involve representative sampling by photo and field plots to estimate areas of forest classes and to estimate volumes, growth and mortality as well. Thus sampling errors may be computed

[1] From "Forest Inventory and Reforestation under the Canada Forestry Act," 1952 to 1956, Misc. Publ. No. 9, Department of Northern Affairs and National Resources, Forestry Branch, Ottawa, 1957.

[2] From "A Forest Inventory in Mexico" by Norberto Sanchez Mejorada, Abraham Escarpita H. and Louis Huguet. *Unasylva,* Vol. 12, No. 2, 1958.

for all statistics. Relatively large numbers of photo plots and relatively small numbers of field plots are taken. The photo sample is distributed essentially in a systematic pattern. The field sample is drawn from this pattern in a random or systematic manner.

Field plots are used to furnish details of information not determinable by photo interpretation and to adjust estimates made on the photo plots. Insofar as possible, each field plot is centered on the same point as a corresponding photo plot. Due to practical limitations, the dimensions of photo plots are usually different than those of field plots. Except with very large scales of photography, circular photo plots approximately an acre in size are generally used. Field plots are generally smaller regardless of their shape. One-acre circular photo plots may be paired with one-fifth-acre circular field plots or with variable-radius field plots (or point samples). In most applications at least part of the field plots also are referenced for relocation and remeasurement on a subsequent survey—as part of a continuing inventory system.

Time does not permit my discussion of procedures for determining the relative numbers of photo and field plots to be taken or of procedures for adjusting photo estimates by field estimates. Detailed discussions of these procedures, and formulae used, are given in several books, including the *Manual of Photo Interpretation*[3] and the *Forestry Handbook*.[4]

3. *Sampling Primarily By Field Plots*

In this design numerous photo plots (or points) are located by templets over aerial photos and are classified according to major land use (commercial and other forest land, agricultural land, waste land, etc.). Any plots falling on doubtful areas are noted so that these locations (or some of them) may be checked on the ground.

Next, a portion of the total number of photo plots falling on commercial forest land (or doubtful commercial forest land) is selected to approximate the number of field plots desired.

Specific locations for all field plots are determined by random or systematic selection from the universe of photo plots falling on forest land.

The photo sample is used only to estimate the total area of forest and other land use classes, after field correction of the photo tally for doubtful classifications on the photos, as necessary. The proportion of all photo plots classified as commercial forest when applied to the known gross area of the Survey unit gives the estimated acreage of commercial forest land.

The field plots give estimated proportions (and thus acreages) of various classes of forest and average volumes, growth and mortality of the timber.

This method is used in 12 southern states of the United States as part of the Nationwide Survey.

[3] American Society of Photogrammetry, 1960. *Manual of Photo Interpretation.* George Banta Publishing Co., Menasha, Wisconsin. (Chapter VII covers forestry applications, including compilation and use of photo volume tables and integration of photo and field estimates).

[4] Society of American Foresters, 1955. *Forestry Handbook.* Ronald Press, New York. (Section 1 covers forest measurements, including cruising and volume tables; Section 19 gives procedures for adjusting photo estimates by field work).

4. *Double Sampling*

In this design, also, areas of major land uses are estimated from numerous photo plots located by templet. In contrast with the previous design, however, the photo plots in commercial forest provide other information—such as cover type and stand-size, crown closure and volume classes.

The photo sample provides a preliminary basis for obtaining area estimates of classes of forest. Information from relatively few field plots is used to adjust this estimate for errors in photo classification. The photo sample also is the basis for stratifying the field plots in some significant respect. This procedure permits more accurate estimates of items determined in the field than if field plots were not stratified.

Photo stratification has generally been employed to increase accuracy of timber volume estimation. In such cases, the strata have usually been derived from photo interpretation of forest classes based on gross stand-volume, stand-size (or height), crown closure, or combinations of these classes. Photo interpretation, including measurements of photo images, of small plots is a more objective and accurate procedure for determining forest classes than are complete mapping procedures.

This method has been used in regions where the commercial forest covers a large proportion (well over half) of the gross land area and where forest composition is quite variable. In two applications of the method (on the Nationwide Survey in eleven northeastern states and in California) a stratification based on cubic-volume classes (per acre or per photo plot) is used. In three applications of the method in Canada (for New Brunswick, for the inaccessible area of Manitoba and for the settlement area of Saskatchewan) cover type, stand height, crown closure and volume classes have been used for stratification.

5. *Triple Sampling*

In this method—just as in double sampling—the first step is to take a very large number of photo plots to determine proportions of major land uses. In the second step—in contrast to double sampling—only part of the photo plots falling in commercial forest land are interpreted to estimate forest areas by subclasses and to subsequently stratify field plots. The third step is similar to the second step of double sampling. A sample of field plots is selected from the population of photo plots, but only from that part of the photo plots falling on commercial forest.

Triple sampling is believed to be somewhat more efficient than double sampling in regions where commercial forests cover a small proportion (generally less than half) of the gross land area, and where rather small scattered units of similar classes of forest occur throughout the region. It is being used on the Nationwide Survey of the United States in the North Central and Rocky Mountain states, except where inventory data for intensive management plans (such as those on national forests) are available.

Evaluation of Designs

To evaluate how well the foregoing designs meet the objective, we might consider the four criteria listed

earlier: (1) efficiency, (2) dependability, (3) suitability for reinventory and (4) flexibility.

Double and Triple Sampling Designs Are Most Efficient

For efficiency, the designs using sampling for all statistics appear to qualify better than the designs using mapping. Production of a rather detailed map is less rapid and more expensive than sampling for estimates of areas.

Greater use is made of relatively inexpensive photo interpretation to reduce expensive field work in the double and triple sampling designs. Thus, they appear to be more efficient than the designs relying on field plots for information which may be obtained reasonably accurately by photo interpretation. The extent to which photo interpretation can be substituted for field work depends, of course, on availability of suitable aerial photography, or costs for producing it specifically for a timber inventory.

Designs Which Sample for All Statistics Are Dependable

The mapping designs are not as dependable as the others. Errors of mapping cannot readily be evaluated; thus, confidence limits for area statistics derived from maps are difficult to set. The technique errors in mapping often are not compensating, and they cannot be appraised statistically without a very costly effort—such as the application of representative sampling for area estimates throughout the region in addition to mapping.

The least sound design is the one in which samples to estimate averages of volume, growth and mortality are selected by personal judgment and in which area estimates are based on mapping.

Sampling Designs Better Adapted to Reinventory

Under any design a number of measures can be used to foster comparability between inventories. One measure is the use of standard definitions or specifications for such items as land-use classes, forest classes (cover type, site, stand-size, etc.), and tree classes (merchantable, sawtimber, cull, or others)—provided there is no significant change in utilization practices between surveys. Identical volume tables and measuring procedures can be used on plots taken on initial surveys and reinventories. Field plots can also be permanently marked on the first survey with provision for remeasurements on resurveys.

Although those measures may be applied to the mapping designs, comparable area estimates are much more difficult to realize because of many opportunities for unknown errors in the technique of judging and delineating area classes. Each individual mapper also is likely to interpret written standards somewhat differently than any other individual.

For comparability of estimates between surveys, one of the three sampling designs is better than a design where area statistics are based on mapping.

Double and Triple Sampling Designs Are Most Flexible

A design for initial inventory should provide flexibility so that techniques developed later may be incorporated on a reinventory. Nevertheless, comparability of estimates between surveys should not be sacrificed to provide for unforeseen technological developments. Perhaps the best course is a compromise in procedures, to insure reasonable comparability and some flexibility in design throughout several resurveys, with an expectation of breaking the comparability cycle when a technological breakthrough occurs.

Over the years, comparability in design has been sacrificed to permit incorporation of new techniques offering greater efficiency. Without speculating on the exact nature and timing of future technology for inventories, we may agree that some of our presently favored techniques will be outmoded before long. Possibly the diameter tape, the relascope, the wedge prism and the helicopter—and almost certainly some of today's computing machines—will be obsolete within several decades. We can hope that certain principles of design—including satistically efficient sampling procedures, machine-methods for computing and aerial operations—will not become obsolete as rapidly.

For flexibility, fixed investments should be kept relatively low. Detailed complete mapping of forest classes and a large sample of permanent field plots are rather large fixed investments. Thus, the designs for double or triple sampling are more flexible than the others. Although a nucleus of permanent plots is remeasured on reinventories, the investment in field work is less than that for the other designs. Also other fixed investments of the double and triple sampling are relatively low.

A Recommended Design

General

If you agree with the criteria selected, we may conclude that two of the five general designs—double sampling and triple sampling—are preferable. Frankly, I have no strong preference between those two. That is one reason I've chosen to outline a specific design in the following section which has some aspects of both double and triple sampling. You will note, however, that some compromises have been made with those idealized designs for reasons peculiar to the particular region.

You may be interested to know that this question of the most efficient inventory design(s) is concerning the United States Forest Service to the extent that a special study is being started to arrive at an answer. Upon completion, that study should provide an answer based on a far more detailed and objective analysis of the question than the cursory examination attempted here.

Survey Design for Interior Alaska

The Problem and Objectives

An initial inventory of the forest resources of interior Alaska is needed, using a design which can be applied, at least in part, on a reinventory as much as two decades later. The survey, now in progress, was scheduled for completion within a period of approximately four years and within a fixed budget.

The region is vast and relatively inaccessible. The area of commercial forest is judged to be about 40 million acres (16 million hectares) distributed within a gross area more than 5 times that size. The forest pattern is very

broken, owing to numerous lakes and muskegs dotting broad glacial valleys, irregularity of the topography in many mountain ranges, and a history of severe forest fires.

Alaska is the least populous of any state in the nation. Roads, railroads and cities are few. Travel by light aircraft operating from small airfields, lakes or river bars is the most feasible mode of transportation throughout forest areas.

Small-scale topographic maps (1:250,000) and vertical aerial photographs (mostly 1:60,000 and 1:70,000) were available for the region prior to the forest survey. Although these aerial photographs are not suitable for detailed forest interpretation, they will be used in producing a generalized forest map.

As part of the Nationwide Forest Survey, the inventory is intended to furnish basic statistics on forest land areas, timber volumes, timber growth and mortality and timber cut; as bases for determining nationwide and regional forest policies and plans, and for orienting prospective industrial investments. Particularly needed are estimates of the amount and general location of commercial forest land, which is very largely in Government ownership.

Steps In Survey Procedures

1. *Production of Sampling Aerial Photography*

As a preparatory step, contracts were issued for strips of stereoscopic aerial photography at approximately 1:5,000 scale, on infra-red film with a minus-blue filter, with a camera having a 9 x 9-inch plate and a focal length of 12 inches (approximately 305 mm.). Tests indicated that this kind of photography was likely to provide the image detail needed for interpretation of commercial forest classes. The strips were flown at intervals of 30 miles (about 48 kilometers) across the region to provide a total of more than 11,000 linear miles (about 18,000 kilometers) of photography. Some large areas known to be nonforest—primarily large glaciers and ice fields—were excluded from the photography.

2. *Photo Plot Sampling*

Photo plots are located at intervals of about one-third of a mile along each strip of photography for a total of approximately 36,000 plots. By reference to available topographic maps, average photo scales are calculated for short sections of each strip, for use in applying photo measurements. These scales deviate from the average photo scale specified for the project (which permitted reasonable deviations in flight operations). A transparent templet centered over each photo plot location defines a rectangular plot area which covers about 1 acre (two-fifths of a hectare) of ground at the particular scale of photography.

Through stereoscopic study each plot is classified by land-use class. Each plot falling on commercial forest land is classified by such classes as cover type, stand-size and stocking. On plots in sawtimber and poletimber stands, photo measurements of stand height and percent crown coverage are also made. These are the bases for applying photo volume tables which are used to stratify subsequent field plots by gross cubic volume classes. When there is photographic evidence of mortality (as shown by groups of dead trees) the proportion of the stand that has been killed is estimated also.

3. *Visual Aerial Check of Photo Interpretation*

So far, the technique resembles double sampling. In Alaska, however, because of the high costs of travel, considerable restriction of the field-plot sample was necessary. At the same time, reasonably good estimates of area classes are needed. Tests indicated that a rapid check of a rather large number of photo plots could be made from low-flying aircraft to provide verification or adjustment, as needed, in the area estimates made by photo interpretation. About 10 percent of the photo plots will be checked by visual reconnaissance; in systematically selected segments of line all plots will be checked. This deviation from an idealized systematic sample (and the limitation of sampling photography noted previously) was taken to keep flying costs within a budget.

4. *Field Plot Sampling*

Since representative field plots in this region are very costly (estimated at $450 each), only about 100 one-acre field plots will be taken. These will be selected systematically from that part of the visually checked photo plots that are verified as falling in sawtimber and poletimber. Field crews will be transported by light aircraft or helicopter to the vicinity of each plot location.

This step (resembling the third step in triple sampling) provides the basis for converting photo estimates of gross volumes into net volumes (using cull factors determined from a special study). It also provides details on species not provided by photo interpretation of forest types. Five major commercial species are involved: white spruce *(Picea glauca),* black spruce *(Picea mariana),* quaking aspen *(Populus tremuloides),* balsam poplar *(Populus balsamifera)* and paper birch *(Betula papyrifera).* The field plots provide details on growth and mortality also. These plots will be permanently marked and together with the photo plots may be remeasured on a reinventory to foster comparability between surveys.

5. *Timber Cut Estimates*

The industrial establishments producing timber products will be canvassed, and a study will be made on logging operations to get utilization factors for translating this output into timber cut. Since timber fellings in Alaska are very limited this will be a minor job.

6. *Computing*

Most of the data obtained during all previous steps will be coded, sorted and computed by machines to provide tabulations of statistics needed in the Survey report. This is, of course, a very brief reference to a complicated but efficient process. I note, however, that modern machine methods for computing survey data will be discussed during another part of this program by a competent authority.

7. *Statistical Report and Map*

The objectives of any survey design are not realized, of course, until a useful report is produced. The design for Alaska should provide statistics on the forest resource to substantiate a reasonably thorough analysis of the timber situation. A map of forest classes will be produced also—not as a basis for computing statistics—but as a visual aid to the analysis and report presentation. This map will

be made in the office by using information recorded on photo and field plots as samples of conditions in other parts of the region, and by using the small-scale photography and topographic maps mentioned earlier.

Conclusion

The purpose of this paper has been to demonstrate certain desirable principles in selecting and applying a design for a survey of an extensive forest area.

In this brief discussion of five broad designs (and one specific example) used in North America, my emphasis upon the advantages of sampling for determining all statistics may suggest that forest maps are relatively unimportant. Certainly, maps can play an important role. I suggest, only, that they be separate graphic productions (in any detail wanted) and not be used in the procedures for computing statistics.

If this discussion has suggested greater use of double or triple sampling, part of my purpose will have been achieved. No specific survey design, of course, is useful in every situation for all objectives. Thus, if I have also underlined the need for careful consideration of the design in terms of the survey objectives and the situation, the other part of my purpose will have been achieved.

RESUMES

Types d'inventaires qui conviennent plus particulièrement aux terres forestières étendues

La présente communication fait état de cinq méthodes générales d'inventaires telles qu'elles sont appliquées aux vastes forêts de l'Amérique du Nord et examine leurs mérites relatifs. Elle fait mention de l'application de ces méthodes dans l'un au moins des pays de l'Amérique du Nord. Le but principal d'une étude de cette nature doit être de fournir des données statistiques fondamentales dignes de foi quant aux ressources en bois d'une région importante comprenant des millions d'acres ou d'hectares de terres forestières. Parmi les données nécessaires, on compte les classes de forêt (type de couvert, dimension des arbres des peuplements, âge, site et autres conditions) ainsi que les volumes, l'accroissement, la mortalité et l'exploitation du bois.

Trois de ces méthodes utilisent des unités d'échantillonnage choisies soit au hasard soit systématiquement sur la totalité de la forêt et permettent d'élaborer des statistiques complètes; elles sont jugées supérieures aux deux autres qui se basent sur des cartes forestières pour obtenir en surface forestière.

Les méthodes utilisant des unités d'échantillonnage sont plus efficaces (elles permettent des opérations rapides a un prix raisonnable) et rendent possible le calcul de renseignements statistiques sûrs. Elles permettent également de comparer plus facilement les évaluations statistiques fournies par des études répétées (ou inventaires continus) dans une région donnée.

Encore que les cartes forestières soient utiles à la présentation graphique des renseignements obtenus, les erreurs techniques commises au cours de la préparation des cartes sont très difficiles à évaluer et souvent, elles ne se compensent pas. De cette manière, le classement par régions des diverses catégories de forêts telles que les présentent les cartes peut ne par être sûr.

Les méthodes de double ou triple échantillonnage qui utilisent l'interprétation de photographies pour arriver à des évaluations, semblent plus souples et d'un meilleur rendement que toutes les autres méthodes d'échantillonnage utilisant des unités d'échantillonnage prises sur le terrain qui doivent fournir toutes les statistiques à l'exception des catégories d'utilisation des terres (telles que terres forestières et exploitations agricoles).

Dans le cas du double échantillonnage (utilisé dans certaines parties du Canada et des Etats-Unis) on examine un grand nombre de placettes qu'on repère au moyen de gabarits sur des photographies aériennes et d'une manière essentiellement systématique. En procédant à une interprétation photographique de ces placettes, on évalue les catégories d'utilisation de la terre et les différentes classes de forêts. L'interprétation photographique sert également à stratifier les placettes et permet ainsi d'obtenir des évaluations plus précises que celles obtenues par un échantillonnage non-stratifié sur le terrain. L'emplacement du nombre limité de placettes est déterminé au hasard ou par un choix systématique parmi le très grand nombre de placettes photographiques tombant sur des terres d'exploitation forestière. Les placettes prises sur le terrain servant à rectifier les évaluations fournies par les placettes photographiques et à évaluer les détails intéressant le bois qui ne sont par fournis par l'interprétation photographique.

Dans le cas du triple échantillonnage (utilisé dans certaines parties des Etats-Unis), on détermine d'abord l'utilisation des terres en procédant à l'interprétation d'un grand nombre de placettes photographiques réparties de manière systématique. On détermine ensuite les classes de forêts selon un échantillonnage systématique de la totalité des placettes photographiques initiales. La combinaison de ces deux phases du travail correspond dans une certaine mesure à la première étape du double échantillonnage. La troisième étape correspond dans une certaine mesure à la seconde étape du double échantillonnage; on prélève un échantillon des unités d'échantillonnage prises sur le terrain soit systématiquement soit au hasard parmi les unités photographiques se trouvant dans des zones d'exploitation forestière.

Il semble que le double échantillonnage convienne mieux à l'étude de régions dans lesquelles les forêts occupent la plus grande partie des terres, tandis que le triple échantillonnage convient mieux aux autres régions.

La communication renvoie à deux ouvrages (Manual of Photo Interpretation et The Forestry Handbook) pour plus amples details sur la manière de déterminer le nombre relatif de placettes photographiques et de placettes prises sur le terrain nécessaires ainsi que sur les méthodes de correction par les unités d'échantillonnage prises sur le terrain des évaluations fournies par l'interprétation photographique.

La communication fait enfin état dans ses grandes lignes de l'inventaire forestier actuellement en cours en Alaska pour illustrer par un exemple précis certains des aspects du double et du triple échantillonnage. Il a été nécessaire d'apporter certaines modifications à ces méthodes idéales pour les appliquer aux objectifs particuliers de l'inventaire, dans les limites imposées par les difficultés d'accès de la région. Ceci souligne le fait qu'une méthode d'inventaire doit toujours s'adapter à des objectifs et à des conditions définies pour offrir un maximum d'efficacité.

Estudios aplicados especialmente a vastas regiones forestales

En este articulo se describen y evalúan los méritos relativos de cinco procedimientos generales aplicados para inventaries extensivos de vastas regiones forestales de la América del Norte. Se hace referencia a la aplicación de dichos procedimientos en por lo menos una de las naciones de la América del Norte. El objetivo principal de tales inventarios es la obtención de estadísticas básicas seguras sobre los recursos forestales de una extensa región que abarca a millones de acres o hectáreas de terrenos forestales. Las estadísticas que se requieren comprenden información sobre la clase de bosque (tipo de cubierta, cantidad de existencias, edad, ubicación y otras condiciones) y volumen, crecimiento, mortalidad y corte de madera.

Tres métodos de inventario en los cuales parcelas de muestras representativas, ubicadas al azar o sistemáticamente a través del bosque proporcion an cálculos de todas las estadísticas que se consideran superiores a los que se obtienen per medio de otros dos métodos, en los que se usan mapas forestales completos para preparar cómputos estadísticos sobre la región. El empleo de muestras representativas resulta más eficaz (permite acelerar la operación a costos razonables) y permite el cómputo de información estadística segura. También fomentan el cotejo de cómputos de estadísticas obtenidas en estudios periódicos (o inventarios continuos) de una región.

Aun cuando los mapas forestales son útiles para la presentación gráfica de información, los errores en la técnica de su preparación son muy difíciles de estimar y a menudo no compensan el esfuerzo. Por este motivo, no puede confiarse mayormente en la clasificación de áreas forestales basada exclusivamente en mapas.

Los métodos de muestras dobles o triples, en los que la interpretación de fotografías proporciona muchos de los cálculos estimativos se consideran más flexibles y eficaces que los demás

sistemas de muestras en los que se utilizan parcelas para obtener todas las estadísticas, con excepción de las que se refieren a la utilización del suelo, (como ser tierras forestales y agrícolas).

En el procedimiento de muestras dobles (aplicado en algunas regiones de Canadá y de los Estados Unidos) se colocan los patrones de numerosas parcelas pequeñas sobre las fotografías aéreas, siguiendo una distribución esencialmente sistemática. Mediante la interpretación fotográfica de estas parcelas, se establecen cómputos sobre aprovechamiento de la tierra y de las distintas clases de bosques. La interpretación fotográfica también se usa para estratificar las parcelas de muestra en el terreno, haciendo posible así efectuar cómputos más exactos del terreno que los que se obtienen cuando se usan muestras no estratificadas en el terreno. La ubicación para el número limitado de parcelas en el terreno se determina al azar o por selección sistemática del conjunto de fotografía que corresponde a tierras forestales comerciales. Las parcelas de campo se usan para verificar los cómputos provenientes de las fotografías y para efectuar cálculos estimativos sobre la madera, que no pueden obtenerse por interpretación fotográfica.

En el sistema de muestras triples (que se utiliza en algunas regiones de los Estados Unidos) el primer paso consiste en determinar el aprovechamiento de la tierra, interpretando numerosos planos fotográficos distribuidos sistemáticamente. En el segundo paso se determina la clase de bosques en una muestra sistemática del conjunto de los planos fotográficos iniciales. La combinación de ambos procedimientos equivale más o menos al primer paso del sistema de muestras dobles. El tercer paso de las muestras triples se asemeja un poco al segundo paso del sistema de muestras dobles; de los planos fotográficos correspondientes a bosques comerciales se toma, al azar o sistemáticamente, una muestra de las parcelas de muestra en el terreno.

El procedimiento de muestras dobles parece ser el más adecuado para el estudio de regiones en las que la mayor parte de la tierra está cubierta de bosques comerciales, en tanto que el procedimiento de muestras triples se adapta mejor a otras regiones.

En el "Manual Of Photo Interpretation" y "Forestry Handbook" se detallan con mayor amplitud los procedimientos para determinar los números relativos de planos fotográficos y parcelas de muestras que deben tomarse, como así también los métodos para ajustar los cálculos de interpretación fotográfica por medio de parcelas.

Se hace mención del estudio sobre bosques que se está llevando a cabo en el interior de Alaska, con el fin de ilustrar un procedimiento específico con algunos aspectos de muestras dobles y otros de muestras triples. Se hicieron modificaciones de estos procedimientos ideales para satisfacer los objetivos particulares del estudio, dentro de las limitaciones impuestas per las dificultades de acceso a la región. Esto pone de relieve que para lograr una eficacia máxima, un método específico de estudio debe responder a objetivos y situaciones específicas.

Application of Aerial Photography to Forest Management In the Tropics

(Southeast Asia—Pacific Region)

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Introduction

The basis of organised forest management lies in the preparation and availability in the first place, of acceptable forest inventories. F.A.O. (1950) has rightly stressed the vital necessity for the collection of statistics for the preparation of forest inventories in a systematic and orderly manner in order to obtain sufficient and accurate information on 'the location, extent, nature, condition and productive capacity of a nation's forests'. Such information can well serve not only in the preparation of Working (Management) Plans but are necessary for overall land-planning, especially in the demarcation of areas to be retained or planted in forest. The factors underlying such reservation, namely the location of forests which are essential for soil and moisture conservation or shelterbelts and/or those to be earmarked and developed for sustained commercial production of timber will have to be evaluated simultaneously.

The ecological approach to the survey of forest resources is naturally the most desirable and useful, as without a proper understanding of the complex factors which make up the entire *ecosystem* (Tansley, 1935) or *biogeocoenosis* (Sukachev, 1941), the planning of organised and intensive management of forests can only be a question of guesswork or even pure and simple opportunism or expediency. As such, it is not out of place to briefly review the state of our knowledge of the ecology of tropical forests, with special emphasis on rain forest, which is generally admitted to be the most productive and useful and also the most complex and advanced development of forest in the world. Of the vast extent of rain forest still remaining — for instance, about 1¼ million square miles in the Amazon basin alone (De la Rue, Bourliere and Harroy, 1957) — only very restricted areas, especially in the Indo-Malaysian and Equatorial African region, have been brought under intensive forest management or even exploitation.

Rain Forest Sociology

In the first place, there is disagreement in the very fundamentals of rain forest sociology. While many of the foremost foresters and botanists accept the existence of discrete sociations (or associations of tree species) in tropical rain forest, others flatly deny the existence of such sociations. These conflicting views of scientists were discussed in a recent Unesco Symposium (1956) on tropical vegetation and have been reviewed by the writer (de Rosayro, 1958b). The extension of the methodology employed in temperate countries has limited usefulness in this respect.

The fact remains, however, that whatever system has been used, studies in rain forest for purely ecological purposes have been confined to the use of individual plots, ranging from one to a few sample plots of varying size, from as small as 10 sq. metre quadrats used by Mangenot (1958) to plots of 1—2 hectares as used by Richards in British Guiana (Davis & Richards, 1933-34), Wyatt-Smith (1958), etc., in Malaya and elsewhere. Such studies have often been supplemented by charts of vegetation showing the horizontal and vertical spatial relationships of the three layers as exemplified by the now well known profile diagrams derived from Richards (1933-34), (with Davis, 1936), and used extensively by other workers (notably Beard, 1946) occasionally with included plots of the shrub and field layers, including the regeneration of tree species (e.g., Holmes, 1958). Van Steenis (1958) quotes Meijer Drees (1935) as coming to the conclusion from an examination of somewhat uniform rain forest on poor soils in Banka, that "in that type the practical ('qualitative') minimum plot area should be at least about one quarter of a hectare . . . The 'quantitative' minimum area," he says, "is so large that it is quite impractical to use it in phytosociological investigations." "In cauda venenum"! The last statement involuntarily reveals wherein lies the real deficiency in our studies of rain forest. The 'quantitative' minimum area, that is, the minimum extent which is ascertainable by the application of methods of sampling involving modern statistical design and analysis, is stated to be impracticable for adoption in phytosociological investigations. Assuming for the moment that this is an insurmountable difficulty, our views on the existence of association relationships of species and the nature of the climax will perforce be coloured largely by our limited experience supplemented by that minimum of 'practical' statistical data.

In most studies of tropical forests, especially rain forest, the data obtained from a few scattered and not necessarily representative plots has been the meagre 'quantitative' basis around which has been built up the entire knowledge of tropical forests supported by varying degrees of purely subjective observations on the structure and composition of the forest. The apparently most generally accepted statement that the so-called 'mixed tropical rain forest' (Richards, 1952) does not exhibit any well-marked differentiation into associations, perhaps accords with our current seriously inadequate knowledge of rain forest in many countries of the humid tropics, where limitations imposed by inadequate taxonomic knowledge, inaccessibility or other practical difficulties of initiating such studies preclude the use of acceptable sampling procedures. In Ceylon, as recently as 1950 (Ceylon Year Book, 1950), rain forest was regarded as of a very mixed nature in which little or no distinction into well-marked communities of a specific nature could be recognised.

Admittedly, such sampling procedures can seldom be undertaken in the study of the vegetation *per se,* but are generally undertaken for the introduction of some form of practical forest management ranging from the earliest stage of purely commercial exploitation to the more advanced stage of intensive operations based on the principle of sustained yield management. For this purpose, prior to the introduction of aerial photography, many more advanced tropical Forest Services such as in India, Malaya, Ceylon, Indonesia and British colonies in Africa adopted sampling procedures involving enumerations as a means of obtaining information on the composition of the forests. These enumerations have been confined to the tree species and further restricted in most cases to 'merchantable 'tree species and sizes. In a few countries such as in India (Griffith, 1945), Uganda (Dawkins, 1956) and in Ceylon (de Rosayro, 1953, 1955), fairly extensive and statistically acceptable sampling procedures have been adopted comprising the entire range of distribution of all tree species above a practicable diameter limit (normally 4 inches diameter or 1 foot girth). This information can be and has been used by the analysis of data of individual plots to establish the actual occurrence of discrete associations of species based on the recognition of dominants in the tree layer. On the basis of such sampling procedure, provided a sufficiently high intensity of enumerations is adopted (e.g., 5 per cent, as in Ceylon), even preliminary mapping of the vegetational types (stockmapping) based on such species—associationships (forest types)—can be and has been made. The associations of rain forest in Ceylon in particular have been entirely distinguished on this basis and their ecological relationships and successional stages have been recognised and described with added information on the regeneration complex as obtained from systematic sampling in milliacre quadrats. These vegetational types have been described in earlier papers by the writer (de Rosayro, 1943, 1953, 1954, 1955, 1958).

Special reference was made at the Unesco Symposium of 1956 to the advantages of aerial survey in the following terms: "Aerial survey as a method of getting the fullest information in the shortest possible time is one which merits universal adoption. An added advantage is that periodical surveys will indicate fully the changes in vegetation trends induced either artificially or by natural causes. Photo-interpretation is itself a specialised task; its extension to tropical studies for ecological purposes will necessitate expert knowledge not only in the technical field of photo-interpretation but also in the ecological background which will enable one to recognise the boundaries between ecological types and correlate the photographic information with ground studies. The techniques most suitable for this purpose, especially the extent and methods of sampling which should be adopted, are being studied in some countries but no precise and acceptable methods have yet been found which can be readily applied to a variety of tropical conditions." (de Rosayro, 1958).

The present paper is an attempt to survey the application of aerial survey to forestry with special emphasis on the ecological delineation of vegetational types in recent years in Tropical Asia. The most recent developments in this field in Ceylon are considered in some detail, as they represent considerable advances in the mapping and intensive study of tropical forest types, especially in virgin rain forest, where very strong correlation has been obtained by methods combining subjective photo-interpretation with objective field studies by sampling procedures. Experience in mapping and sampling in the dry evergreen, moist semi-deciduous and montane types also brings out similar correlation, but as smaller scale photography is adopted for these types, this is on broader lines.

Brief Review of the Application of Aerial Survey In the Tropical S.E. Asia-Pacific Region[1]

The development of aerial photographic methods in tropical countries has lagged behind that achieved in temperate countries in Europe and America chiefly because of the inherent difficulties in the identification of forest strata [2] and the inadequate knowledge of the heterogeneous composition, running into hundreds of species which are found in the tropics, particularly in tropical rain forest. In some countries, e.g., in Sarawak (Browne, 1958), the taxonomy of rain forest is still to be completely worked out. Identification of individual tree species in the field is restricted to the commoner species or those of economic importance only.

Aerial photography in the first instance proved invaluable in the mapping of uncharted country in many of the relatively undeveloped British colonies, especially for the preparation of suitable topographic maps (Miller, 1957). Concurrently with this first phase in the introduction of air photography, small scale photography was initially adopted from the photographs taken originally for military purposes in many of the British dominions and colonies for generalised land use mapping and agricultural purposes (Sisam, 1947; Miller, 1957). Many tropical countries have now complete air-photo cover at scales varying from 1/30,000 to 1/50,000. On the basis of such cover, studies have more recently been directed towards the generalised interpretation of forest types on a quasi-ecological basis.

Among the countries in S.E. Asia and the Pacific, perhaps India was the only country where the initial need for air-photo cover was not felt, for the reason that the development of both suitable topographic maps and intensive forestry based on Working Plans had reached a high pitch. The latter involved the collection of suitable statistics of composition and stock by enumerations. Even as recently as 1957, Mathauda (1957), in an official report to the Seventh British Commonwealth Conference, states that aerial photography has only a limited scope for Indian forestry, as the experience gained indicated that it was not possible to distinguish their tropical tree species or even the various forest sub-types on the aerial photographs.

From the use of aerial photography for reconnaissance surveys for forestry purposes, a more intensive use of aerial photography (with the availability of high quality photographs) has been towards more precise classifications of closed forest. In the first instance, such classifications have been purely empirical and not related to proper sampling procedures in the field.

In North Borneo, Francis and Wood (1955) used 1/50,000 scale photography for the preparation of maps showing drainage patterns and 16 vegetational types which can be readily and precisely determined from the photographs. These consist, firstly, of types with different commercial possibilities based on variations in the crown size and site and, secondly, of vegetation which has been more or less permanently altered by man. Somewhat similar work has been carried out in Sarawak by the staff of the Colonial Air Survey Centre (Miller, 1957), but more recent developments described by Browne (1958) include stratification on the basis of forest types and apparent changes in quality.

The earliest recorded development in the S.E. Asia-Pacific region towards the more intensive application of aerial photography for the preparation of forest inventories is for Indonesia by Hannibal in 1952[3]. Detailed studies of 5 carefully selected experimental plots (each 9 to 4 hectares in extent) were made involving the study of form factors, crown-diameter/bole-diameter relationships. It has been demonstrated by such studies that for tropical countries only a very rough estimation of volume is possible by a combination of crown measurements and count of trees in aerial photographs. In this study, several scales of photography, varying from 1/55,000 to 1/10,000 were adopted, and initial stock mapping into broad ecological types was done on scales of 1/50,000 to 1/20,000.

Preliminary studies for rain forest in Ceylon by Merritt and Ranatunga (1958), using enlargements ten times the original scale of 1/15,840, confirm the impracticability of direct measurements of crown diameter. The combination of the two factors of crown density (using standard crown density scales) and average crown diameter (determined indirectly from crown counts and crown density) gave a reasonably good empirical relationship with basal area.

A broader field sampling procedure, but with inferior photography and without stockmapping, was carried out for the U.S.-controlled Ryukyuan Archipelago (Cunningham, 1952). In the U.S. study the scale of photography was small (not specified) and the study directed mainly to the volume estimation of the stock. Sampling was made in stereo-computation for generalised land classification. Ground examination was confined to 200 selected circular plots, each one acre in extent, in which trees over 44 cms. d.b.h. were enumerated. The information so obtained by enumeration and height measurements were converted to volume estimates by the use of a generalised volume table used in the East Central U.S. for hardwoods, and adjustments were made on volumes calculated from the photographic stem-interpretations by regressions derived for each volume class by ground check. The examination of the figures provided in this study show that wide and irregular variations exist between estimated volumes and ground checks. The estimates have, however, been used in determining the allowable cut.

Taylor and Stewart (1958) have described a more comprehensive approach to land-mapping based on the ecological distinction of vegetational types. The study is being conducted in the Australian territories of Papua and New Guinea by a land resources survey team of the Land Research and Regional Survey Section, Commonwealth Scientific and Industrial Research Organisation. The scale adopted is 1/40,000. Mapping of the major vegetational types covering mature rain forest, secondary

[1] For a fuller review the writer's recent paper (de Rosayro, 1959) may be consulted.

[2] The use of the word "strata" is in a specialised sense, viz, the patterns of vegetation recognised by air-photo interpretation and should be distinguished as such from "strata" in the ecological sense applied to the separate tree layers identifiable in tropical forest.

[3] Incorporates an earlier article "Interpretation of aerial photographs in virgin forest complex, Malili Celebes" by K. Paijmans, *Tectona,* October, 1951.

forest, grassland, swamp and other edaphically controlled communities are correlated with field reconnaissance studies of vegetation along selected ground traverses.

A more acceptable statistical approach in the preparation of a forest inventory in tropical forest has recently been applied to the teak-bearing forests of Northern Thailand by Loetsch (1956, 1957) under the FAO extended technical assistance programme. The scale of stockmapping adopted was 1/48,000. The strata recognised below an altitude of 1000 metres are: (a) mixed deciduous teak-bearing forest, (b) semi-evergreen forest, (c) dry Dipterocarp forest; and above 1000 metres: (d) inaccessible hill evergreen forest or savanna. The main object of the study is to obtain a reliable and statistically acceptable estimate of the growing stock in the individual strata, concentrating in particular on a reliable volume estimate for teak. Towards this end, a system of restricted random sampling has been adopted for both the selection of photographs for the purpose of ground study and for the actual field sampling procedure. As such, stock maps covering the entire range of forests examined do not appear to have been prepared, stratification and the estimation of the area of strata being on a percentage basis, the degree of sampling being arrived at after preliminary investigation. The field sampling procedure has been specially designed to obtain the maximum dispersion of plots with proportionate reduction in the required sampling intensity. The enumerations cover all tree species, (72 individually, the balance collectively) and the figures so obtained are coded for use in punch-card calculations. The data reviewed are for basal area (obtained directly by the use of Bitterlich's 'Tarifmesswinkel') and merchantable volume with additional data on regeneration, whether from seed or coppice origin. For the different strata, sampling error is calculated by the analysis of variance. For 5000 sq. kilometers of teak-bearing deciduous forest, a sampling error of plus or minus 4 percent can be obtained, which is considered satisfactory. In the determination of growing stock, the limit of plus or minus 10 percent for stock up to one million cubic metres and plus or minus 5 percent for stock up to 10 million cubic metres has been obtained, which conforms satisfactorily with standards adopted in the U.S. and Sweden.

Studies of Rain Forest In Ceylon

In 1957, the Sinharaja forest reserve, an area of 24,000 acres, situated in the southwest region of Ceylon, was selected for special study in collaboration with the Canadian Photographic Survey Corporation under the Colombo Plan. This is one of the best known of the virgin forests of Ceylon; it was till recent years (Baker, 1937) unexplored and, on account of its comparative inaccessibility, had not been examined and brought under a Working Plan. Two preliminary reconnaissances of the area and the region had been made by Decamps and the writer and later by Wright, also of the Forest Department (de Rosayro, 1954). These reconnaissances confirmed that the reserve itself was largely virgin and in its species composition closely related to the other virgin forests which have been intensively examined and described (de Rosayro, 1943, 1953, 1955).

The forest lies between an altitudinal range of 330 to 4000 feet in a geographically distinctive region of strike ridges composed of the Khondalite—Charnockite Saries of Archaean gneisses, the more resistant Charnockite igneous rocks coinciding with the ridge crests. Recent or sub-recent gravels, sands or clays, generally of fluvial origin, cover the strike valleys and inter-montane basins (Wijayapala, 1938).

The scale of photography used for this study was 1:15,840. The recognition of distinctive photo-patterns based on a combination of features brought out in stereo, viz, tree height, crown size and appearance, density of stocking, variation in texture and tone, etc., was the basis of stratification. The ecological significance of the stratification was investigated by empirical methods of field sampling, largely based on the 'selected line' method used in Canada (Seely 1955, 1959). Although true randomisation is to be preferred, it is not practicable to adopt it in closed forest communities in the tropics, on account of the difficulty of locating sampling points accurately on the ground. The final mapping was done after the results of the sampling had indicated the nature and significance of the strata. A total of seven forest strata were recognised, including two secondary forest types and five virgin forest types.

The stratification obtained by air-photography was found to have a close relationship to previously recognised ecological types, chiefly the *Mesua—Doona—Shorea* climax community and its softwooded faciation (the *Cullenia—Palaquium—Doona congestiflora* community). Both types have been recognised with single species dominants and were designated the 3 ND (Na-Dun) type in which *Mesua ferrea* predominates and the 3 T (Tiniya) type in which *Doona congestiflora* predominates. The tendency in these types is towards an extreme form of gregariousness. Between these two extremes, intermediate and mixed types have been recognised, designated the 3 U (Utility) and 3 TS (Tiniya and Softwooded Species) types. The former is a more mixed type with the hardwood *Mesua, Doonas* and *Shoreas* predominating and is the largest and most widely distributed type covering approximately 70 percent out of the total area of 17,000 acres of virgin forest. The latter is also a mixed type but with the softwooded elements (chiefly *Doona congestiflora* with *Calophyllum, Cullenia, Palaquium* and *Myristica* species) predominating.

The ecological relationships of the major types were investigated. The evidence of the spatial distribution of the chief species in relation to regeneration, especially of *Doona congestiflora* appears to give support to the possible occurrence of a cyclical or recurrent spacetime pattern in the region (see Aubreville, 1938; Watt, 1947). There is also a strong correlation between the presence of certain specialised types, the 3 MR (Medium Ridge) and 3 HR (High Ridge) types, the 3 H (Hora- *Dipterocarpus zeylanicus*) and the 3 F (Alluvial Flats) types (the two latter types being only sparsely represented) and the peculiar geological features of the region. The 3 H (Hora) and 3 F (Flats) types are clearly associated with a senile stage in the drainage pattern.

The intensity of sampling varied from 0.25 to 3.0 percent for individual strata. The distribution of transects was mainly with the intention of getting as wide a disper-

sion of plots as possible. The results, however, give acceptable limits of error for each major stratum in the calculation of the total stock in terms of basal area (in lieu of volume) as well as in numbers of merchantable trees. In the larger types (3 U, 3 ND), acceptable results have also been obtained for each category, viz, hardwoods (two quality classes), softwoods, i.e., light hardwoods (two quality classes) and fuel, into which the species have been grouped in management practice. The following table adapted from Merritt and Ranatunga (1959) summarises the results for the major forest types:

Stratum or forest type	Percent of area sampled	No. of one-acre plots	Aver. basal area per acre (in sq. ft.)	No. of merchantable stems per acre	Percent standard error at 95% probability, plus or minus					
					Total basal area	Tree layers				No. of merchantable stems
						Hd. 1	Hd. 2	Sf. 1	Sf. 2	
3U-Mixed (Utility) Type	0.25	33	149	12	7	26	17	19	–	15
3ND-*Mesua-Doona-Shorea* (*Mesua ferrea* predominating)	3.0	33	174	17	7	13	–	–	–	13
3MR-Medium Ridge	1.1	13	123	7.4	6	–	20	–	–	35
3T-*Doona congestiflora*	1.7	11	159	13.4	11	–	–	13	–	28
3TS-*Doona congestiflora* and light hardwoods	1.3	11	119	11.2	13	–	24	15	–	40

Hd.1 = Hardwood, Quality 1.
Hd.2 = Hardwoods, Quality 2.
Sf.1 = Light Hardwoods, Quality 1. (Softwoods).
Sf.2 = Light Hardwoods, Quality 2.

This study has been dealt with in full in two papers, one by Merritt and Ranatunga (1959) and the other by the writer (1959). In the latter study, for each type, tables are given of the distribution of the principal species by Percentage Occurrence, Stem Numbers and Basal Area classified into three main diameter classes (4-12 ins., over 12-20 ins., over 20 ins.) and showing both the average and maximum figures (by number and basal area) recorded in the type. In addition, figures of recorded regeneration of the principal species for each type are tabled. Both papers are fully illustrated with maps, diagrams and reproductions of representative stereo-pairs.

The Application of Aerial Photographs to Dry Evergreen and Moist Semi-Evergreen Forest

As early as 1947, Chapman, using approximately 1/9,000 and 1/7,200 scales of photography, attempted to study the ecological value of aerial photography in Ceylon by sporadic field sampling of the main vegetational types, comparing these results with the actual photographs of the areas so sampled. He supplemented the vegetational lists so prepared by information on the soil types and profile diagrams of the plots actually studied on the lines of Richards' original method (Richards, 1936) with estimates of heights and crown diameter. His work is useful in indicating that the following main types and sub-types of these formations can be recognised:

1) Moist Tropical Semi-Evergreen Forest
2) Tropical Savanna
   (a) Moist savanna community (*Anogeissus-Careya-Cymbopogon-Imperata* association)
3) Southern Tropical Moist Deciduous Forest
4) Tropical Dry Evergreen Forest
   (a) *Manilkara* community
   (b) *Manilkara-Hemicyclia* community
   (c) *Manilkara-Hemicyclia-Chloroxylon* community
   (d) *Manilkara-Chloroxylon-Eugenia-Vitex* community
5) Southern Thorn Forest
   (a) *Hemicyclia-Euphorbia* semi-desert scrub
   (b) *Acacia* thorn scrub

The first intensive study of the Dry Evergreen and Moist Deciduous forest types was made by the Photo Survey Corporation of Canada (under the Colombo Plan) in collaboration with the Forest Department (Merritt and Ranatunga, 1959). The area selected was the Kirindi Oya (River) Basin covering 459 square miles in the southeast of Ceylon, embracing a very varied type of forest and land-use pattern from the montane zone (over 5000 feet elevation) to sea-level. From the experience gained in this study, the statification of dry evergreen and moist semi-deciduous types is found to be relatively simpler than for rain forest, on account of the more homogeneous character of the vegetation and the occurrence of fewer tree species, often with well pronounced emergents in the tree layer. These factors make for easier photo-interpretation and relatively less intensity of field sampling. In the Kirindi Oya study the photo-interpretation of sub-types was correlated with sampling on the purely reconnaissance level. The following sub-types have been recognised and mapped and the principal species comprising the communities have been listed. Forest land is allotted the symbol 7 in accordance with the international system of land-use classification.

7 A — Savanna
7 B1 — Highland riparian forest (Montane type)
7 B2 — Lowland riparian forest
7 C — Dry evergreen forest
divided into *five* sub-types on quality classes, site factors and predominance of the principal species such as *Chloroxylon swietenia, Berrya cordifolia,* etc.

7 D — Thorn scrub
7 E — Abandoned shifting cultivation
7 F — Forest plantations
7 FG — Beach dune forest
7 H — Sub-montane dry evergreen forest
7 J — Intermediate (i.e., moist semi-deciduous) forest containing a mixture of typical dry evergreen and rain forest species
7 K — Coastal forest

A similar mapping-out of forest types based on an intensive study (practically amounting to transects) in a hitherto unexplored region, the Knuckles region of Ceylon —an isolated group of mountains to the north of the main central massif—was successfully carried out using 1:40,000 scale photography. The results of this study have been described in considerable detail elsewhere (de Rosayro, 1958a). The following vegetational types were mapped and correlated with field studies:

1. Formation type—Lowland tropical wet semi-evergreen forest
   1A — Tropical wet semi-evergreen forest—Climax type
   1B — Low jungle—Sub-seral type
   1C — Riparian forest—Faciation or location
2. Formation type—Sub-montane tropical wet semi-evergreen forest
   2A — Sub-montane semi-evergreen forest, dry faciation
   2B — Sub-montane semi-evergreen forest, wet faciation
   2C — Sub-montane grassland—sub-sere or disclimax
   2D — Sub-montane savanna—sub-sere or disclimax
   2E — Sub-montane scrub forest—sub-sere
3. Formation type—Montane tropical wet evergreen forest
   3A — Montane wet evergreen forest, dry faciation
   3B — Montane wet evergreen forest, wet faciation
   3C — Low forest—montane thicket (Beard, 1955)
   3D — Elfin forest—elfin woodland or mossy forest (Beard)
   3E — Pigmy forest—comparable possibly to paramo (Beard)
   3F — Montane grassland—preclimax, disclimax or sub-sere
   3G — Bamboo brake—sub-sere
   3H — Palm brake—lociation

Aerial Survey of Forest Resources

The further survey of the primary natural resources in Ceylon has been undertaken by the Photographic Survey Corporation of Canada under the Colombo Plan, comprising the entire field of geology, geophysics, hydrology, soils, land-use and forestry (Andrews, 1960), the unit of study being the principal river catchments.

The Forest Survey of the Island (Ceylon) was planned in conjunction with the Forest Department. Photographs on the scale of 1/40,000 for the whole Island and 1/15,840 of the south-western (rain forest) section were taken in 1956, and semi-controlled mosaics on the 1:31,680 scale were prepared from these. The experience of the work already described has been the basis for stockmapping and the preparation of composite forest inventories.

The typing of the photograph was carried out continuously by Canadian specialist foresters in advance of field work. On the 1:40,000 scale, only broad types are recognised, such as non-productive, low, medium, and high-productive, for each of the major forest formations: rain forest, dry evergreen and moist semi-deciduous. In the major section of the rain forest zone, photographed on the 1/15,840 scale, the typing is on the lines already described for the Sinharaja forest. These are essentially management types but bear in most cases a close relationship to previously recognised ecological types. In some instances, the typing is modified as necessary after field check and sampling. The identification of individual species even on the 1/15,840 scale is not possible except *Dipterocarpus zeylanicus* and *Doona congestiflora* in gregarious stands. Emergents in the dry evergreen and moist semi-deciduous forest types can be picked out, but identification can only be confirmed after field check.

On the results of the initial mapping, the largest and most important forest reserves or forests selected as future reserves were examined by field sampling. The extents examined under the principal forest types are as follows:

1. Rain forest, including montane rain forest	112,000 acres
2. Dry evergreen forest	1,055,000 acres
3. Moist semi-deciduous forest	36,000 acres
4. Teak plantations previously not taken on to a Working Plan	1,500 acres

The main objective of stockmapping is the use of an acceptable, yet economic and rapid system of field sampling. For this purpose, the most recent developments in the methods of "plotless cruising" were studied, especially the "variable plot radius" method originally introduced by Bitterlich (1947, 1948) in Austria, with a specially designed instrument, the relascope. Pioneer work on this method has been carried out in several countries, and considerable literature on this subject is now available, including comparisons with the usual areal methods adopted in forest sampling (Lindsey, Barton and Miles, 1958). The very satisfactory and acceptable results by the Bitterlich method which had been demonstrated in this study and elsewhere (e.g., Kendall and Sayn-Wittgenstein, 1959; Dixon, 1958) indicated that it might be worth while to try out this method under tropical conditions. Accordingly, in 1959, the wedge prism (3.03 diopters, i.e., with an exact basal area factor of 10), which is a simplified and convenient modification of the original relascope, was tried out under diverse conditions in Ceylon and found to be entirely acceptable for use in field sampling even in dense rain forest. The sparse undergrowth normally found in both the wet and dry forest types in Ceylon facilitates its use. This method has, therefore, been universally adopted by the Forest Department. Its rapidity and convenience allow for a wide dispersion of plots, a condition which has been shown to be essential for obtaining statistically acceptable results.

The method of sampling roughly follows the "selected line" method used in Canada (Seely, 1955, 1959) in which the principal forest strata recognised in the photographs are sampled up to acceptable limits of error. In order to obtain as wide a dispersion of plots as possible, individual plots are located at 10 (sometimes 5) chain intervals along these lines. With this method, however, it is impossible to state accurately what percentage of the total area has been sampled. All trees falling "within" the plot are enumerated by species, diameter (over 4 ins.) and *merchantable length* of bole. The information is

transferred onto "punch-cards" designed for electronic computation, one card per tree. In addition to the basal area per tree, the cards also provide for the computation of volume. This has been possible for the utilisable species by preliminary research into the determination of form-factors for the merchantable bole, derived from special studies undertaken by the Forest Department Research Division for this purpose. The basic results obtained by this sampling are estimates of basal area per acre. The method is being extended to obtain volumes of each species for each diameter class per acre; although theoretically this method is not strictly correct, for practical purposes it suffices (see Kendall and L. Sayn-Wittgenstein, 1959, p. 17). A correction is also made in the field for slope.

In a period of 10 months (up to May 15th, 1960), including an initial fortnight of training of the Forest Department field staff, the preliminary field work has been completed. 7,806 plots have been enumerated, 3,433 in rain forest (including montane rain forest), 3,796 in the dry evergreen and 577 in the moist semi-deciduous types. Although no accurate area statement is possible, the intensity of sampling by area would approximately be 0.33 percent for rain forest, 0.03 percent for dry evergreen and 0.15 percent for moist semi-deciduous forest. The results of this data have not yet been analysed. The indications are, however, that even for the broad reconnaissance types, there will be considerable correlation possible with the main ecological types already recognised. The data of growth increment obtained from linear increment plots which have been laid down since 1951 in representative natural forest types are now being analysed. Using this data, which adequately covers the principal forest types and species, the first island-wide inventory of our forest resources will be completed by the middle of 1961, giving acceptable estimates of volume and prescribing the allowable cut based on the increment data.

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RESUMES

L'application de la photographie aérienne a l'aménagement forestier dans les régions tropicales (région de l'Asie du Sud-Est et du Pacifique)

Pour procéder à un aménagement forestier organisé, il est indispensable de disposer d'inventaires forestiers de qualité acceptable, à l'aide desquels on établit des Plans de Travail (ou d'Aménagement). Ces plans doivent de préférence tenir compte des conditions écologiques, de façon à permettre un aménagement rationnel pour la sylviculture et pour l'utilisation des terres. Des divergences de vues considérables existent en ce qui concerne les principes fondamentaux de la sociologie de la forêt de pluies, notamment pour ce qui est du concept des associations d'essences et de la phytocénose. Ceci est attribuable en grande partie au fait que la majeure partie de nos connaissances sur la forêt de pluies sont basées principalement sur l'étude approfondie de quelques parcelles isolées, complétée par des observations purement subjectives. On peut cependant utiliser, et l'on a en fait utilisé des procédures d'échantillonnage appropriées pour distinguer les phytosociétés de la pluvisylva.

Ce n'est que récemment que l'application de la photographie aérienne a été étendue à l'étude des forêts tropicales, et alors qu'elle ne servait au début qu'à l'établissement de cartes générales de végétation, elle est maintenant utilisée pour délinéer les types de végétation sur des bases écologiques réelles. Parmi les réalisations récentes, il nous faut mentionner la préparation de cartes de peuplement et d'inventaires forestiers basés sur la corrélation des types de végétation avec des échantillonnages au terrain, et l'utilisation de méthodes statistiques pour déterminer le degré d'exactitude atteint. On a constaté que de telles méthodes, basées sur une forme restreinte d'échantillonnage au hasard, peuvent être appliquées à la forêt semi-caduque (teck) de la Thailande en utilisant la photographie au 1/48.000.

Dans la *forêt de pluies* de Ceylan, on a pu vérifier que la stratification obtenue au moyen de photographies aériennes à l'échelle de 1/15.840 cadrait assez étroitement avec les types écologiques précédemment déterminés. Les essences de type grégaire avec une essence dominante, *Mesua ferrea* et *Doona congestiflora*, sont plus fortement marquées, mais il est même possible de reconnaitre des mélanges comme les phytoassociations *Mesua-Doona-Shorea*. Il a été possible d'établir qu'il existe d'importants rapports écologiques entre les essences extrêmement grégaires et celles vivant en mélange.

Avec l'intensité de l'échantillonnage variant de 0,25 à 3 pour cent pour chaque strate, des limites d'erreur acceptables pour chaque strate principale ont été obtenues pour le calcul du peuplement total, en termes de la superficie occupée par la base des arbres, ainsi que pour le nombre d'arbres de valeur commerciale.

En ce qui concerne la *forêt tropicale sèche toujours verte* et la *forêt humide semi-caduque* de Ceylan, des travaux effectués antérieurement ont démontré la valeur écologique de la photographie à grande échelle (1/9.000-1/7.200). Il est cependant possible d'utiliser des photographies à l'échelle plus réduits (1/20.000-1/40.000) en raison du caractère plus homogène et plus simple de telles formations. Les résultats de l'exécution des cartes montrant la composition floristique de ces forêts et des forêts de *montagne*, à l'aide d'études et de reconnaissances sur le terrain, ont montré qu'il est possible de distinguer les types principaux sur des bases écologiques.

Un inventaire aérien complet des ressources forestières de Ceylan est actuellement effectué à l'aide de photographies au 1/40.000 et au 1/15.840 et d'une détermination plus simple des types basée sur la productivité pour les photographies à échelle plus réduite. Les opérations d'échantillonnage sur le terrain en vue d'établir une estimation du volume de chaque strate et de prescrire le volume pouvant être coupé sont maintenant terminées. On a trouvé que la méthode du rayon de parcelle variable de Bitterlich pouvait être appliquée de façon satisfaisante à tous les types de forêts, humides et sèches, et un total de 7806 parcelles ont été inventoriées au cours d'une période de dix mois. Les données relatives à l'essence, au diamètre et à la mensuration du volume de chaque arbre sont transférées sur des cartes perforées et le calcul final du volume superficie des bases par acre sera effectué électroniquement. L'intensité de l'échantillonnage sera déterminé par les limites de l'erreur statistiquement acceptable.

Aplicación de la Fotografía Aérea a la Administración Forestal en los Trópicos (Asia del Sudeste—Región del Pacífico)

Las bases de la administración forestal organizada descansan esencialmente en la disponibilidad de inventarios forestales aceptables según los cuales sea posible preparar Planes de Trabajo o Administración. Esto debería hacerse, de preferencia, según las normas ecológicas que permitan el adecuado planeamiento para la silvicultura y otros usos de la tierra. Existe considerable desacuerdo en los mismos principios de la sociología de los bosques pluviales, especialmente sobre el concepto de asociación y el clímax. Ello se atribuye mayormente al hecho de que la mayor parte de nuestro conocimiento de bosques pluviales se basa, primeramente, en el estudio intensivo de un número de parcelas de muestreo muy limitado, suplementado por observaciones puramente subjetivas. Adecuados procedimientos de muestreo pueden y han sido usados para distinguir las comunidades de los bosques pluviales.

Es hasta ahora que la fotografía aérea se ha aplicado más al estudio de bosques tropicales y ésta ha evolucionado poco a poco de la vasta cartografía de la vegetación a la delineació de tipos vegetativos según las verdaderas normas ecólogicas. Lo más reciente ha sido la preparación de mapas de inventarios de reservas basados en la correlación de tipos vegetativos con el muestreo en el terreno y el uso de métodos estadísticos para determinar los límites de la exactitud. Tales métodos, valiéndose de la forma; restringida de muestreo al azar, se han considerado aplicables a los bosques semicaducos en Tailandia utilizando fotografía a una escala de 1:48.000.

En los bosques pluviales en Ceilán, la estratificación obtenida por la fotografía aérea a una escala de 1:15.840 demostró estar íntimamente relacionada con los tipos ecológicos reconocidos con anterioridad. Los tipos gregarios de especies dominantes, *Mesua ferrea* y *Doona congestiflora* se hacen resaltar más; pero aún los tipos mixtos tales como la Musua Doona-Shorea se pueden reconocer. Se han establecido importantes relaciones ecológicas entre tipos extremadamente gregarios y mixtos.

Con una intensidad de muestreo que varía de 0,25 a 3 por ciento para estratos individuales, los límites aceptables de error para cada estrato mayor se han obtenido en el cálculo de la reserva total en términos del área basimétrica y también y el total de árboles de utilidad comercial.

Respecto a *los bosques tropicales secos y siempre verdes,* así como a los *húmedos y semicaducos* de Ceilán, en trabajos anteriores se ha devostrado el valor de la fotografía en gran escala (1:9000-1:7.200) para delinear tipos ecológicos. Fotografías de escala más pequeña (1:20.000-1:40.000) pueden, sin embargo, adoptarse a causa del canácter más homogéneo y simple de tales formaciones. Los resultados de la cartografía vegetacional en éstos y en los bosques *montane* con estudios de reconocimiento del compo, han demostrado que los tipos principales pueden distinguirse según las normas ecológicas.

Un estudio aéreo completo de los recursos forestales de Ceilán está en progreso utilizándose para ello la fotografía a una escala de 1:40.000 y 1:15.840 y un sistema de clasificación más sencillo basado en la productividad respecto de la fotografía de menor escala. El muestreo extensivo de la estrata por estimado de volumen y la prescripción de un corte admisible se ha terminado ya. El método de parcelas de variable de Bitterlich aplica a todos los tipos de bosque, tanto seco como húmedo y en un período de 10 meses, un total de 7806 sitios se han enumerado. Los datos sobre especies, diámetro y volumen de cada árbol en particular, se transfieren en tarjetas de anotación automática y los cómputos finales de volumen area basimetrica por acre se hace en la máquina. La intensidad del muestreo se determinará por los límites del error estadísticamente aceptable.

Advances In Forest Survey Design and Procedure

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During the past ten years, design and procedure of forest surveys have greatly changed with regard to techniques. While prior to this time conventional opinions were supported, new methods of design and mensuration have now been developed, referring to both national surveys and forest condition surveys for forest management purposes. In a summary report, Prodan quotes 410 papers written on this matter within the past five years.

Regional Inventories

All regional inventories as yet made in Central Europe, such as the Austrian Forest Inventory (Waldstandsaufnahme), 1952-56, and the survey of the privately owned small-scale forests in Baden, Germany, have still shown the characteristics of classical forest management procedures. The objectives of these surveys differ in principle from those of Scandinavian inventories. These surveys were put into practice because of economic emergency which originated from overcutting during war and postwar times. In these cases, averages of large areas as obtained by regional inventories on a statistical basis are insufficient. Rather a survey of forest conditions of the smallest areas was required in order to take efficient steps in exhausted forests.

Because of these circumstances, as well as the multiplicity of site, stand, and ownership, a total survey has been necessary in Austria. The following modern resources have been employed: aerial photographs, angle-count sampling for determination of stand volume, and the punchcard system for evaluation of field data. Without the use of angle-count sampling, this inventory would have been simply a yield-table cruising. The applied method is characterized by the large number of units for which information is required (about 10,000), and by the numerous points of view by which these data are represented. Disadvantages are: large staff, high costs, and the impossibility of continuing the survey in the same way.

Inventories have been made also in Greece, the Netherlands, Spain, and Turkey. National inventories based on statistics are now projected in Belgium, France, Switzerland, and Austria.

In the Northern European countries, periodic inventories derived from line cruising and also designed by statistics have been carried out for decades.

The projection of the Third Swedish National Forest Inventory has to be quoted as the greatest advance in forest inventory techniques. It was Hagberg who could solve a great deal of important problems by changing the original method of successively made provincial surveys to an annual survey covering the whole country with one-tenth of the final number of sample plots, the grid of them being condensed each year. The periodic inventory turned into a continuous inventory by which essential results are provided already after a few years; not only growing stock and increment are determined, but also the real annual cut is found in an objective way. With aid of this inventory, balances of changes in the volume of growing stock can be made.

In Austria, a similar continuous national forest inventory, according to the Swedish model, is now projected, taking into account the specific conditions of mountain forests. Statistical sampling design is based upon the results of the "Waldstandsaufnahme" and takes advantages of the variance of stand volume per hectare (2.47 acres). New ways are intended to be followed with respect to volume, increment, and cut determination, as mentioned under "Basic Research." An objective estimate of the annual cut is projected by measuring the stump diameters of the stems felled within the previous cutting period. The presumable volumes of the single trees will be derived from data of so-called "twin trees," which

are nearly similar to those of the felled trees. The results will be recorded by wood quality, diameter classes, age classes, and cutting methods such as clear-cutting, thinning, etc. Between the National Forest Inventory of 1952/56 and the coming continuous inventory, relations have to be established which will allow application of the new results to smaller units.

General Objectives

Periodic surveys which, in general, will not provide results earlier than 10 to 15 years later no longer satisfy the increasing demands of national economy, since their results will be, in part, out of date at the time they are available. Because of integrating large economic regions, continuous inventories are requested rather than those mentioned above. Forestry of today needs inventories which show the trend and the future possibilities of production; in other words, inventories which ascertain current changes in forest conditions and which provide partial results possibly each year, in order to draw up interim balance sheets. With this, stand volume, growth, and the real volume of cut are the main problems which should be determined in the field objectively by tallying measurable characteristics. The individual tree has to be put into the spotlight, completely abandoning stand averages as well as the use of yield tables; its elements controlling volume and increment are to be determined as accurately as possible. In order to enable the drawing of true balances, comparisons of volume, increment, and cut have to be done in the same unit of measure.

Forest Condition Surveys for Management Purposes

In forest management, conventional mensuration of stands is still prevailing. In most cases, however, the 100 percent cruise of mature stands has been replaced by Bitterlich's angle-gauge selection, although frequently no division into diameter classes is made.

There are a number of new *volume tables* of various species (Douglas-fir, European white fir, poplar, etc.) available for *mensuration of stands*. Today, these tables are established by statistical methods. In Germany, tariffs and curves of average volume are widely used. In Central Germany, a new tariff system has been set up, which is employed for determination of volume, increment and yield classes.

New yield tables, based upon autochthonous material, have been constructed in England, Spain, Denmark, Sweden, Rumania, and Germany. The yield tables used in the Austrian National Inventory had been obtained by converting the relative site classes of customary yield tables into absolute site classes based upon the mean increment at the age of one hundred years. In Germany, efforts are made to subdivide the common yield tables according to regional and site conditions.

Today, design and procedure of *forest condition surveys* have to satisfy much *higher requirements* than a decade ago. Much more attention is paid to stem quality (wood classification), stem form, direct measurement of increment as related to crown quality, as well as to studies of the effect of thinnings. All these problems cannot be solved by conventional 100 percent cruises.

Only the application of *statistical sampling methods* permits the measurement of many more characteristics as well as the calculation of sampling accuracy as desired. Since a few years ago, statistical sampling designs have been applied successfully in forest valuation. These methods are gaining more and more importance, both in Austria and in Germany. Up to the present, only systematic layouts of sample plots have been put into practice. In Austria, circular sample plots of 0.02 to 0.04 hectares (0.05-0.1 acres) are preferred, the choice depending upon the diameter of stems being measured. In Southern Germany, 0.1 hectare circles (0.25 acres) are employed. In most cases, feasibility in the field, rather than theoretical considerations, will control the size of plots.

Recently, variable-radius plots have been found preferable to fixed-radius plots, especially on steep slopes, using Bitterlich's relascope and tallying any tree selected. The optical establishment of the variable boundaries in connection with compensation for slope provides such a great advantage that the tiresome establishment of fixed plots may be omitted. Any boundary tree in question can be checked with sufficient accuracy.

Advances have been made in estimating average growth of whole regions, either with the aid of yield tables or by taking increment cores.

The problem of direct determination of the current growth by taking increment cores evidently gains importance. In connection with this, the "Interpolation Method" (H. A. Meyer), and the "Tariff Difference Method" (Loetsch) are of interest.

The Swedish apparatus for measuring annual rings (by Ecklund) makes possible quick and accurate measurements and therefore is a valuable aid in analyzing increment cores. In order to facilitate work, a projecting screen has been additionally constructed in Austria and fixed to the instrument. An adding machine, connected with the apparatus, registers automatically the measured width of annual rings. In the future, punching the data into strips and then transferring them onto punchcards automatically is planned.

Sampling methods offer considerable advantage by temporal separation of field work and planning. Routine work in the field can be done by untrained personnel under the supervision of a forester. Forest regulation and planning, however, is the task of an officer after the data of growing stock, growth, and other characteristics of a unit are available. Thus, more accuracy is guaranteed than in the past.

Field data must be evaluated by means of punchcards in order to keep sampling methods economical. Only the multifarious divisions and groupings of data made possible by this system permit a thorough utilization of the collected material as well as far-reaching conclusions. In Austria, about 60,000 to 100,00 hectares (150,000-250,000 acres) are surveyed each year, the data being evaluated by the IBM-Hollerith machines of the Federal Forest Research Institute.

The punchcard method has been completed to such an extent that, in Austria, field data of classical age-class surveys, considering volume and increment readings from a table, may be evaluated completely by machines. Information on both description of stands and age-class tables are taken from punchcards and tabulated ready for use by the Tabulator 421 (IBM).

In the age of automation, forestry also must apply any technical means which allows the consideration of numerous data and releases personnel to do more valuable work.

Basic Research

For both the projected continuous forest inventory and other condition surveys, any basic material satisfying the increased requirements in accuracy has been lacking until now. In mixed stands and in uneven-aged stands, the use of yield tables is, in general, very problematical. Also, in Austria, volume tables and tariffs do not yield satisfying results, since, in most cases, they are not based upon autochthonous material and they never take into account individual site conditions.

In mountain forests, form factors of the various species are very variable because of great differences in thickening of the butt. These variations cause considerable error in volume estimates when common yield tables are used.

Therefore, form studies on single trees were started some years ago. The samples are taken from forests all over Austria, and not from only a few permanent plots.

Before felling, all characteristics of the tree being sampled which can be objectively measured on standing trees are booked. Besides the conventional ones, these characteristics include growing space, stem quality and crown classes. After felling, stump height and stump diameters as well as the length of crown and the five-year increment of height are determined. On the stem, diameters outside bark and thickness of bark are measured in sections of absolute and relative equal length.

The data collected will be evaluated by mathematical statistical methods. These investigations will yield basic material for volume and increment estimates as well as information about the limits of accuracy of a nation-wide stump inventory.

Objectives of the Research:

a. Cubing and form functions of all main species, according to Naslund, will be derived from the data. These functions will be adapted to reality with more accuracy. Moreover, simple tariffs may be computed.

b. In order to avoid disturbing variations of breast-height form factors as caused by butts, it is intended to determine Hohenadl's *true form factor* ($\lambda 0.9$); this factor shows less variation than the first one; it is a direct index of stem form and, therefore, permits flawless comparisons of stems with one another. According to Krenn-Prodan, Hohenadl's form quotient $\left(q_H = \frac{d1.3}{d0.9} \right)$ also will be determined in the future, since it is an index of dimensions of the butt. In order to consider these two topics, the diameter in one-tenth of the total height has to be measured, either directly or optically.

c. *Direct determination of growth* by means of increment core samples has to be intensified, with correction for climate, if needed.

d. Renouncing an extensive tabulating, field data shall be evaluated directly by punchcard system.

Bitterlich's *angle-count method* is a simple and economical way to measure nearly all of the characteristics mentioned above. Because of improvement of increment measures and of punchcard calculations, considerably better results of surveys may be claimed.

Hence, Austria is about to leave conventional principles and follow ways shown by Hohenadl, Krenn, and Prodan in Germany, and by Näslund and Hagberg in Sweden. In mountainous countries, Bitterlich's survey techniques are excellently suited to attain these objects.

Aerial Surveying and Photo-Interpretation

Today, the importance of aerial photographs in forest inventories and in forest organization is generally known. In regional inventories, aerial photographs serve, above all, as a tool for stratification. In the Austrian Forest Inventory, the boundaries of forest units have been drawn on photographs, thus doubling the performance of cruise. In mountains, stand boundaries can be established more accurately on photographs than on the ground; especially in terrain covered to a great extent with non-utilized forests, much unprofitable time is saved by use of aerial photographs.

Sample plots of the continuous inventory projected in Austria are transferred from maps to photographs with great accuracy by a gear added to Zeiss' stereotopograph (combined with Wild-autographs A 6 and A 8). No chaining is necessary to locate sampling points in the field, thus speeding up the procedure considerably.

Today, the costs of taking aerial photographs can be borne even by small forest agencies. In order to provide proper mapping, control points have to be marked on the ground. Frequently, survey points and lines can be readily picked up on the photographs. Elevation and triangulation data of these points must be known. The costs of sufficient ground control are but a small percentage of those of conventional ground surveys.

Aerial surveys reduce work to a minimum and increase the accuracy of parcelling. Finally, the possibility of preparing contour maps should be mentioned.

In order to map out mountainous terrain, stereographs of the second order and diapositives instead of prints are required.

Much information may be gleaned from stereoscopic images. The size, quality, and nature of forests, and other information can be obtained from the study of the three-dimensional image. Indirect measurements of trees and stands as well as volume estimates from aerial photographs, however, are too inaccurate for forest purposes in Central Europe. In Finland and in Yugoslavia, recent volume estimates from aerial photographs have shown a standard error up to 40 percent!

Therefore, only the combined application of both aerial survey of areas and ground sampling can be recommended.

Forest Survey Procedures

During the past ten years, the greatest advance in a long time has been made in forest survey procedure. Bitterlich's ingenious idea of angle-gauge selection and its application to a number of instruments have met with world-wide success and have revolutionized survey techniques.

Almost any of the measurements mentioned in the paragraphs above can be done by the "Spiegelrelaskop" and the other instruments devised by Bitterlich. Sufficient

accuracy is obtained by only little expenditure of money and time. Actually, only the invention of these instruments has permitted the new survey procedures.

Although Bitterlich's various techniques are obviously in world-wide use, and although foresters of all continents are anxious to improve these methods, their general application should be recommended to this Congress.

The author himself shall interpret this principle and its application.

Two years after its invention, angle-count sampling and the first relascope were subjects of a brief discourse at the Third World Forestry Congress held in 1949 in Helsinki. Since that time, this new method has gained many friends throughout the world and is more and more known as a valuable progress in forest inventory because:

1. The basal area density of a stand is simply found by a count of all stems greater in diameter than a given angle gauge. Yet, the basal area density is a basic value in forest mensuration, which formerly had to be determined by essentially more expenditure of work and time.
2. The angle gauge used in the enumeration sweep can be presented by simple instruments.

Grosenbaugh and other scientists in the U.S.A., Germany, and other countries soon recognized that the plotless cruising is not confined to determinate basal area only, but may be developed and completed. In numerous papers and experiments, theory and field application have been investigated and improved.

Bruce in America and Muller in Austria have encouraged the use of wedge prisms of glass. In the U.S.A., these simple, handy prisms have asserted themselves most, and indeed, they are the most convenient and easiest means to carry out an angle-count sampling in horizontal or slightly sloping terrain.

In Austria, Bitterlich attempted in 1949, with the first "Pendelrelaskop," to give his method an instrument self-adjusting for any slope and, at the same time, to obtain the trees' volume density by additional, direct form-height measurements. This aim was attained by the later improved "Spiegelrelaskop" and wins more and more importance in Austria. According to Pressler's method, the form heights of all trees (or every second, third, or tenth tree) selected by an angle gauge are measured with the relascope. Since the frequency of the stems of an angle-gauge selection is weighted by their single tree basal areas, the arithmetical mean of the form heights measured is weighted by basal area too and can be taken as representative of the average form height. The basal area density obtained by angle-gauge selection multiplied by the average form height gives the trees' volume density directly. No method as simple and theoretically correct existed before by which the average form height and the stand-volume density by direct measurements in the forest could be determined. The method may be recommended generally. Special literature is available from Dr. W. Bitterlich, Hallein 257, Salzburg, Austria.

To put the angle-count sampling and its combined procedures into practice, Bitterlich recommends the uniform use of basal area factor "4" (one counted stem represents 4 square meters per hectare). The often-advanced opinion that application of this sampling method is impractical because the optical establishment of the variable boundaries is inaccurate, or even impossible when sight is hindered, has been weakened. A chain, graduated into "units for proof" (using factor 4, the units are 25 centimeters) shows to every distance from a tree the diameter of boundary tree which must be exceeded by the diameter of the tree being measured in order to be counted. By this, the variable-radius plot method has the same possibilities as fixed-radius plots but still has the following advantages:

1. The frequency of the stems counted in an angle-gauge selection is weighted by their single tree basal areas. Hence, the arithmetical means of any other characteristics of these stems are also weighted by single tree basal areas, such as:
   a. The arithmetical mean of the form heights measured in an angle-gauge selection is correctly representative of the average form height.
   b. The arithmetical mean of the total heights measured in an angle-gauge selection is representative of Lorey's average total height of the stand.
   c. The arithmetical mean of the branch volume percents estimated on the trees of an angle-gauge selection may be taken as average branch volume percent of the stand, etc.
2. The variable-radius plot method guarantees the automatic adaption of the plot size to the density of the various diameter classes within a stand and, therefore, provides a better balanced sample of these diameter classes.
3. The percentage of sampled area (and with it the accuracy) agrees with the economic interest in diameter classes as it is proportional to the single tree basal areas.
4. The number of the stems counted is a direct measure of the basal area density.
5. In most cases, the optical establishment of variable boundaries is possible, in such a way saving time and work. Moreover, the relascope automatically takes care of correcting for slope to each tree sampled.

Bitterlich applies the angle-gauge selection not only at breast height, but also, by aid of the "Spiegelrelaskop," at various heights across the stand. This method gives valuable information of the average forms of trees. In connection with it, the "Vertical Angle-Gauge Sampling" devised by the Japanese Hirata, has been experimentally combined with Bitterlich's "Horizontal Angle-Gauge Sampling." Finally, Bitterlich has shown that by aid of a cardboard angle, the principle of the angle-gauge sampling may also be employed in order to find quickly the converting factor of pile volume to compact volume of piled round woods.

The optical caliper which Bitterlich has constructed allows sectional measurement of volume on standing trees from any point that must not be established. When the caliper is combined with a relascope, one person may carry out angle-gauge selections and estimate diameters. Compared to the "Spiegelrelaskop," the instrument is large and somewhat unwieldy; it also is sensitive to influences of weather and to damage because of its open mirrors. Therefore, its application will be restricted preliminarily to research work. Until now, but few models have been constructed.

Bitterlich's "Tarifmesswinkel" is now manufactured in West Germany. It is a simplified sector caliper with 45 volume diameter (d.b.h.) ratios which are called "tariffs." The determination of "tariffs" is done by aid of tables which are prepared either by comparing measurements on felled trees, or by form-height measurements or total height measurements on standing trees.

In 1959, the combined application of relascope and "Tarifmesswinkel" was suggested. When basal area factor 4 is used in an angle-gauge selection, each tree counted represents 4 square meters per hectare and, therefore, one particular tree represents as many trees per hectare as its basal area is contained in 4 square meters. A special scale attached to the "Tarifmesswinkel" reads the frequency per hectare for each stem counted. The "tariffs" for each plot ensue from form-height measurements of one or more stems with median basal area, which are determined by scaling of each tree sampled in the angle-gauge selection. This tariff is adjusted on the caliper, and a repeated scaling of the previously marked trees gives each tree's volume. With little time and work, the tariff sampling with relascope and "Tarifmesswinkel" yields the following characteristics of the various species and diameter classes: number per hectare, basal area, and volume per hectare, as well as determination of tariffs for small areas. Bitterlich recommends this method for wide use.

RESUMES

Progrès dans la préparation et la réalisation des enquêtes forestières

Le fait qu'on a excessivement puisé dans les forêts pendant les derniers décades, et les exigences augmentées del l'économie nationale demandent impérieusement un sondage individuel des conditions forestières. Ceci a forcément amené à l'emploi d'inventaires d'échantillonnage sur une base mathématico-statistique.

Les inventaires regionaux, en Europe centrale, étaient jusqu'à présent pour la plupart, exécutés selon des principes conservateurs. Aujourd'hui les inventaires périodiques ne suffisent plus. Une politique forestière et économique du bois consciente de ses responsabilités demande plutôt des bases que seule des inventaires continus pourront fournir. Ceux-ci doivent sonder couramment les changements des conditions forestières, relever les volumes sur pied et l'accroissement et permettre un contrôle objectiv du rendement (inventaires des souches) dans la même unité de mesure afin de pouvoir établir des bilans intermédiaires (3^{e} Inventaire général des forêts Suède).

Le sondage des conditions forestières pour les usages d'aménagement devra prendre en considération, en dehors des volumes sur pied et de l'accroissement par catègories de diamètre, des caractères de qualité et de conformation de tronc ainsi que la détermination de l'accroissement à la tarière. Tout cela n'est possible que par la méthode d'echantillonnage. La technique par placettes circulaires variables (relascope à miroirs d'après Bitterlich) et l'analyse à l'aide de cartes perforées ont donné les plus grands avantages. En Autriche, la technique aux cartes perforées s'emploie pour les inventaires d'échantillonnage aussi bien que pour e'inventaire conventionnel par classes d'âge (analyse complètement automatique; description du peuplement et table des classes d'âge directement d'après les cartes perforées). Par égard pour l'importance du problème des coefficients de forme en montagne, on est en train de créer de nouvelles bases pour la détermination des volumes et des accroissements à la base des connaissances de Hohenade-Krenn (coefficient de forme véritable, quotient de forme) et de Naslund (fonctions pour calculer les coefficients de forme).

La vue aérienne comme moyen de stratification pour les inventaires nationaux et pour l'évaluation et l'orientation est généralement reconnue; auprès de l-inventaire des forêts d'Autriche, elle a rendu possible une evaluation à double effect. Pour les inventaires à venir, les placettes d'essai fixées selon le programme sont transférées de la carte sur la vue aérienne en situation correcte, par où l'on peut se dispenser de mesures de distances. Des vols de prise de photographies pour des usages d'aménagement permettent l'aérophotogrammétrie à partir de points de contrôle en montagne et l'établissement de plans en courbes de niveau avec une grande précision, sous condition qu'avant le vol on procède à un abornement et que des stéréocartographes de deuxième ordre soient à disposition pour l'analyse.

Toutefois, l'estimation du volume sur pied ainsi que les mesurages indirectes des arbres et peuplements pris de la vue aérienne fournissent des résultats insuffisants pour la foresterie d'Europe centrale.

Le plus grand progrès fut apporté au développement des méthodes de mesurage par la géniale idée de la méthode de Bitterlich et son application pratique. Cette méthode a revolutionné toute la technique du mesurage pour le sondage des conditions forestières. Elle est recommandée pour l'emploi général au monde forestier.

C'est grâce à cette méthode que nous pouvons faire tous les relevés proposés ici avec une précision suffisante. Nous invitons M.Bitterlich à résumer, dans ce qui suit, les avantages des possibilités universelles d'emploi:

La méthode découverte par Bitterlich en 1947, de comptage angulaire, ainsi que le premier relascope à pendule, étaient déjà l'objet d'un bref rapport, en 1949, lors du III^{e} Congrès Forestier mondial, à Helsinki. Cette méthode, d'abord regardée seulement comme un mayen pratique pour l'évaluation de la densité de la surface terrière, a depuis été élaborée et développée. Bitterlich a donné à sa méthode, avec le relascope à miroirs un instrument permet de mesurer directement les hauteurs rectifiées par le coefficient de forme, (hauteur de Pressler), et de gagner, en combinaison avec le comptage angulaire, des valeurs mesurées et véritablement représentation pour la hauteur moyenne du peuplement, rectifiée par le coefficient moyen de forme et pour la densité des volumes. Le compas forestier optique (Optische Baummesskluppe) permet un cubage par sections des arbres sur pied d'un point terrestre non fixé auparavant. L'angle mesuré au tarif ("Tarifmesswinkel") fournit les volumes sur pied à partir du diamètre à hauteur de poitrine, à condition qu'on ait préparé auparavant un tarif de cubage d'après des comparaisons avec des mesures de hauteurs rectifiées par le coefficient de forme ou des mesures de hauteurs totales des arbres sur pied. L'emploi simultané du relascope et du "Tarifmesswinkel" amène à la méthode très rationnelle de l'échantillonnage au tarif.

Le coefficient de surface terriére 4 (chaque arbre compté = 4 m ^{2}/ ha.) est recommandé pour l'emploi de préférence. Des obstacles à la vue et des difficultés optiques dans l'évaluation des "arbres tangents" n'excluent plus l'emploi de la méthode de Bitterlich: Une mesure à ruban, courramment chiffrée en unités de contrôle, rend la technicité d'échantillonnage avec des placeaux circulaires variables parfaitement équivalente aux cercles fixes d'échantillon. Cependant, la première méthode a plusieurs avantages, avant tout celui que la fréquence des arbres comptés échéants est pesée selon les surfaces terrières individuelles.

Adelantos en los planes y procedimientos de reconocimientos forestales

Los excesos de la explotación forestal durante décadas recientes y las crecientes exigencias de la economía nacional hicieron necesaria una investigación específica de las condiciones en que se hallan los bosques. Esto llevó necesariamente a la aplicación de métodos para la recolección de muestras, basados en estadísticas matemáticas.

Hasta ahora, en los países de Europa Central los *inventarios regionales* se basaban en los principios de los reconocimientos forestales convencionales. En la actualidad, los inventarios periódicos ya no son suficientes. Toda política forestal y maderera responsable requiere datos concretos que sólo pueden obtenerse por medio de *inventarios continuos*. Tales inventarios deben establecer los *cambios actuales de las condiciones de los bosques*, el volumen y el crecimiento de las diversas especies de acuerdo con su diámetro, un inventario objetivo de las existencias, utilizando una unidad de medida uniforme a fin de permitir la preparación de hojas de balance provisorias. (Véase Tercer Inventario Forestal Nacional de Suecia).

Además dal volumen y crecimiento, con las diversas clases de diámetros, los *reconocimientos forestales* también deben tener en consideración la calidad y forma de los troncos, como asimismo la medición directa del crecimiento por incremento del núcleo, lo cual sólo es posible mediante la recolección de muestras. Los métodos para parcelas de radios variables, con utilización del "relascopio" y la evaluación por medio de tarjetas perforadas, ofrecen numerosas ventajas. En Austria se aplica el sistema de tarjetas perforadas para evaluar tanto la recolección de muestras con fines estadísticos, como los reconocimientos convencionales para la determinación de classes de edades (evaluación totalmente automática, descripción de las existencias y tablas de grupos de edades, tomadas directamente de las tarjetas perforadas). Debido al problema de los factores de formas variables en los bosques de la montaña, se hallan en preparación nuevos materiales básicos para los cálculos de volumen y de incremento, según los principios de Hohenadl y de Krenn (Factor de forma real, cociente de forma) y de Näslund (funciones de los factores de forma).

Las fotografías aéreas se utilizan generalmente para la estratificación en inventarios regionales, y también como medio auxiliar para avalúos de bosques y para la orientación. En el Inventario Forestal Nacional de Austria, el uso de fotografías aéreas permitió aumentar en un cien por ciento la eficacia de los métodos de avalúos. En el inventario continuo proyectado, las parcelas utilizadas como muestras se transfieren de los mapas a las fotografías con tal precisión que puede omitirse el proceso de medir distancias. Si se marcan en tierra los puntos de control y si se aplican los estereogramas de segundo orden, tanto el reconocimiento aéreo como la preparación de cartas de las curvas de nivel, serán sumamente exactos.

Los *cálculos de volumen*, como así también la medición indirecta de árboles y existencias, utilizando el método de la fotografía aérea, *no son suficientes* para fines forestales en la Europa Central.

La aplicación de la *ingeniosa idea de Bitterlich sobre la selección goniométrica* representa el progreso más notable logrado en los métodos para el reconocimiento forestal. Este método ha revolucionado las técnicas de reconocimiento y se *recomienda para su aplicación general* en todo el mundo.

Gracias a este método, todos los reconocimientos que se recomiendan en este trabajo pueden llevarse a cabo con suficiente precisión y a un costo reducido. Bitterlich resume los beneficios de su aplicación de la manera siguiente:

El recuento goniométrico de muestras, inventado por Bitterlich en 1947 y el primer "relascopio de péndulo" fue explicado brevemente al Tercer Congreso Mundial de Silvicultura, realizado en Helsinki en 1949. Desde aquella fecha, este método, que en primera instancia se consideró únicamente como un instrumento para calcular area basimétrica, ha sido perfeccionado y mejorado en diversos aspectos. El "relascopio de espejo" que fuera construído posteriormente por Bitterlich, también permite las mediciones directas de la altura de Pressler. Además de una selección goniométrica se obtienen valores básicos reales sobre la altura y forma de las existencias comunes y de la densidad del volumen de los árboles. Con la ayuda de un calibrador óptico es posible realizar desde cualquier punto, que no es necesario establecer de antemano, la medición transversal del volumen de los árboles en pie. El "Tarifmesswinkel" da el volumen de árboles en pie en dbh cuando las "tarifas" han sido establecidas ya sea por medio de la comparación de medidas de árboles talados o por la medición de la altura de los troncos o de la altura total de los árboles en pie. El estudio de muestras por medio de "tarifas" constituye la aplicación combinada del relascopio y del "Tarifmesswinkel."

Se recomienda muy especialmente la aplicación del factor 4 de área basimétrica (un tronco contado representa 4 metros cuadrados por héctarea). Las dificultades para establecer los límites variables ya no eliminan este método; una cadena ordenada en "unidades de prueba" hace que, en cuanto a precisión, las parcelas de radios variables sean equivalentes a las parcelas de radios fijos. Sin embargo, respecto a estas últimas, existen algunas ventajas, sobre todo la circunstancia de que la frecuencia de todos los troncos contados es analizada por las areas basimetricas de árboles individuales.

Forest Surveys and the Statistical Theory of Sampling —Some Recent Developments

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At present most forest inventories employ sampling methods. Actually, such methods were discussed already in the eighteenth century, see (1).[1] A large-scale forest survey based on sampling was made in 1911 (2, p. 9). Current survey methods are outlined, i.a., in (1)-(12).

The statistical theory of sampling is more recent and chiefly a product of the last 25 years. The basic theory was well established about 1950 as evidenced by the appearance of a number of textbooks on general sampling methods, such as (13) and (14).

The main purpose of the theory of sampling is to guide the choice of an appropriate sample design. It is convenient to use this term to denote the methods of selecting the sample as well as the methods used to estimate those quantities which are of interest. Although important, the determination of the size of the sample is only one phase of this choice.

A discussion of forest survey problems from the point of view of sampling theory is found in two excellent papers by D. J. Finney, (15) and (16). For further contributions, consult, e.g., (10), (17) and (18), which give extensive references. Evidently, articles on the method and theory of forest surveys occur in hundreds of periodicals. The present paper can therefore not claim to cover even the most important contributions.

Criteria for the Choice of a Sample Design

A sample survey is intended to give *estimates* of a number of quantities (in forest inventories: area, volume, growth, etc.), usually with totals also for subregions. Different sample designs provide estimates with different properties. These properties concern the magnitude of sampling and non-sampling errors.

The expected magnitude of a sampling error is expressed by the standard error.

Non-sampling errors (sometimes called "systematic errors") are inherent in the procedures and methods of

[1] Numbers in parentheses denote the references listed at the end of this paper.

mensuration and computation. Contrary to the sampling errors, they are as a rule independent of the size of the sample.

Statisticians have usually considered the case when one particular estimate (example: total volume) is of paramount importance. The problem of choosing a design has then been formulated in either of the following two ways:

1. To find a design that gives the smallest standard error of the estimate at a given cost; or
2. To find a design that gives the precision required at the lowest cost.

A formulation of this kind may often be rather inadequate. However, the problem of choosing an appropriate criterion in the case of several estimates has recently been treated by some authors; see (19); cf. also (20). It may be mentioned that the problem has also been considered with reference to non-sampling errors (21).

A more general criterion can be expressed in the terms of decision theory (22), (23): the choice of a design shall be made to secure a maximum total gain of the activity. Here the gain is defined as the difference between the value of the information procured and the cost of obtaining the information. (This is related to the general approach of operations research.) The dependence of the value of a survey on the possible errors of the estimates can often be expressed quantitatively when the survey is undertaken to provide a basis for economic transactions, such as timber sales or purchases. An example is (24).

It may be rather difficult in other cases to state explicitly and in detail the objectives of a forest survey. An application of the theories indicated above may therefore often be felt as making rather violent abstractions of a vaguely conceived situation. However, a choice between different sampling plans may mean a choice between one survey cost of 10,000 and another amounting to 1 million. The importance of finding a rational basis for such a choice cannot be overemphasized.

Patterns of Spatial Variation

The usefulness of a particular sample design depends to a large extent on the structure of the population surveyed. This applies especially to the precision of the estimates.

Generally speaking, it is the variability within the region surveyed which determines the precision of a forest survey. However, this relation is of a rather complicated nature, especially when certain types of sampling plans are used such as the "systematic" designs. To obtain a clear picture of the effect of different devices in a sampling plan it is desirable to develop concepts and terms in which to express the basic features of the variability. (Direct estimates of standard errors in different sampling schemes tend to give rather insecure and sometimes contradictory results unless based on an almost prohibitively large amount of data.)

Some general studies of the spatial (or in a wide sense "topographic") variation have been published in recent years. They have often been related to studies of systematic sampling; see the bibliography (25), and the papers (26)-(30).

Some of the earlier attempts to deal with the spatial variation were based on the assumption that a series of observations from different localities could be expressed as a sum of a smoothly varying trend and a superimposed "purely random" component. Such a decomposition may seem artificial. More realistic and more flexible models can be based on the theory of stochastic processes, which is one of the major fields of the theory of probability. An investigation (29) seems to show that it is possible sometimes to reach rather definite conclusions in questions regarding the efficiency of sampling plans by introducing only rather general assumptions about the nature of the spatial variation.

An Example

Some of the following discussion may conveniently be applied to a particular example. Terms used may also be clarified if introduced in connection with an example.

The example pertains to a large-scale survey. It is assumed that aerial photos are available and that the sole purpose is to estimate the total volume of the trees.

Only the methods of selecting the sample will be dealt with. This selection is composed of four different phases.

(a) A regular network of sample points is placed on the aerial photos. The points are classified by land categories (forests, agricultural lands, etc.). These categories constitute the strata of the next phase.

(b) In each stratum a certain fraction of the points are selected at random for photo-interpretation. The sampling fractions vary between the strata. In the photo-interpretation, circular sample plots are placed over the points selected. These plots are further subdivided into sub-strata. One such sub-stratum may contain, e.g., all those plots which represent sawlog stands.

(c) A fraction of the plots in each sub-stratum are selected as field plots. All trees on a field plot are tallied by diameter classes. These classes are the strata of the fourth phase.

(d) A certain fraction of the trees contained in a diameter class are selected as sample trees. The volume of each sample tree is then determined by means of observations of height, etc.

This plan shows some features of modern sampling methods. Still other procedures can be illustrated by introducing some modifications. It should be remarked that even a restriction to surveys of the combined type discussed will present an almost infinite variety of possible sample designs. Any attempt to find an optimal sample plan must be restricted to a rather limited class of designs. Several good examples of how to obtain an optimum plan are found in the literature; see, e.g., (5) and (32).

Multi-Stage Sampling

In the example, aerial photos are used as a frame for the sampling in phase (a). A sample of points uniformly distributed over the whole region can thus be selected. No such frame available, it might instead be feasible to select a sample of areas, e.g., large rectangular blocks, aerial photos of which are to be procured. A network of sample points is then selected from each block. Phase (a) would consequently be divided into two stages, the sample points of the second stage being a subsample from

the blocks selected in the first stage. The principle of two-stage sampling evidently offers opportunities of estimating the total forest resources even in regions that are imperfectly mapped.

Multi-Phase Sampling

The principle of multi-phase sampling has been the most important sampling device in forest surveys. In the four-phase sampling above, the information collected in each phase is used for stratification in the next phase. In (c) the trees are thus classed in strata (diameter classes). Fixed fractions of the trees in the different strata are then selected as the ultimate sampling units in phase (d).

The following points must be considered when applying stratified sampling:

1. The number of strata and the boundaries between the strata must be determined;
2. The size of the subsamples from the different strata must be fixed.

The allocation of a sample to different strata has received much attention in statistical theory. It may be mentioned that Tischendorf (31) in 1925 presented formulas for the allocation of a fixed number of sample trees to different diameter classes in order to obtain maximum precision of the total volume estimated. Other authors have subsequently presented corresponding general formulas for optimum allocation of a fixed total budget. Of course, the general principle is to use a comparatively high sampling fraction in those strata where the variation is large and/or the cost of sampling is low. Applications are found, i.a., in (5) and (32).

In the beginning, the first point above seems to have been somewhat neglected by sampling experts. However, the problem of "optimum stratification" was advanced by T. Dalenius in 1950 and it is now studied by several authors, see (19, Ch. 7, 8) and (33). Obviously, it would be of interest to explore, e.g., the best way of dividing the diameter scale into strata (for use in a stratified selection of sample trees).

Multi-phase sampling can also be applied in cases where information can be obtained from different sources, as illustrated by the following example, cf. (2, p. 4) and (34). The volume of each sample plot in phase (b) (see above) is ocularly estimated. In phases (c) and (d) a more accurate estimate of the volume is obtained for the subsample of field plots. The relationship between ocular estimates and accurate estimates is then established, e.g., by regression methods. Thus the ocular estimates in phase (b) can be calibrated. If the correlation between ocular estimates and field estimates is very close, the precision of this method is but slightly lower than that obtained, had all plots in phase (b) been examined in the field.

It is, however, important that unbiased formulas for error estimation are available when two estimates are combined by regression methods. If very inaccurate formulas are used, the final estimate may be even less precise than an estimate based on the field plot information only (29). This remark is of particular importance in connection with systematic sampling.

The method is applicable also when the ocular estimates are rather subjective. However, it is then imperative that the ocular estimates are made without prior knowledge of the subsequent sampling. This can be difficult to apply if the field plots are chosen by systematic sampling.

Sampling With Varying Probabilities

In stratified sampling the fraction usually varies between the strata. A system where each separate unit of the population has its own probability of selection is a further development. The method was discussed by M. H. Hansen and W. N. Hurwitz in 1942, cf. (35). The technique may lead to higher efficiency in the estimation and also to simplified computation of the estimates. In a certain sense the principle is automatically present in a forest survey where each part of a stratum is sampled proportionally to its area. An additional illustration is furnished by the angle-count method of Bitterlich.

Size and Shape of Sampling Units

A large amount of empirical evidence has been gathered concerning the influence of the shape and size of sample plots on the survey costs and the precision of estimates, (32), (36)-(39). The investigations show that the optimal size and shape of a sample plot is largely dependent on the forest type and on the kind of information wanted. It may be remarked in this connection that a close correlation between the ocular estimates and the field observations is important when field plots are used to calibrate volume estimates from aerial photos. A small field plot located at the center of a large photo-interpreted plot would presumably be rather inefficient.

Fairfield Smith (40) has developed a general formula for the dependence of the sampling error on the size of a plot. This formula can be derived at least approximately from certain general assumptions on the structure of the spatial variation (29). The present author suggests that a unified treatment of the problem of the appropriate sample plot size in forest areas that differ in density, volume, etc., may be possible by corroborating some theoretical model by empirical evidence. (From the point of view of the mathematical pattern of spatial variation, it may be scale-factors only that make the difference between the tropical rain-forests and the sparse vegetation of the arctic tundra.)

Cluster Sampling

If the location of the sampling units is considered only with a view of securing precise estimates of basal area, volume, etc., it would be advantageous to distribute the units rather uniformly over the area surveyed (or over each stratum in the case of stratified sampling). This applies, e.g., to the location of sample points on maps or aerial photos. If the spatial variation in a certain sense is homogeneous (or "isotropic"), it can be shown, e.g., that the triangular network has certain optimum properties (29).

When sampling units are located in the field, a uniform spacing would usually be rather inefficient owing to high travel costs. It is also customary, e.g., to group sample plots in clusters that contain several plots within a comparatively small area. Cluster sampling is applied in the line-plot survey, in the "tracts" of the present Swedish national survey (6), in the "camp-system" intro-

duced by Loetsch (41), and as "exploded" sample plots described in (42). At present, it is impossible to say anything definite about the optimal structure of such clusters. Mathematical models may be needed also in this matter to complement and systematize empirical evidence. This seems to be a rather urgent task in the field of forest mensuration research.

Systematic Sampling

The application of one single rigid configuration of sampling units is an extreme case of cluster sampling. This is the principle of systematic sampling. Although replaced by random sampling methods in many cases, it is still extensively practiced in forest surveys. Examples: the uniform distribution of sample points on aerial photos in phase (a) above, systems of equidistant strips, etc. Clusters of sample plots (lines, tracts, etc.), too, are often located in a regular geometric network.

The preference for systematic sampling in forestry may partly depend on long tradition. It is generally recognized, however, that systematic sampling offers certain special advantages. A very large number of investigations seem to indicate almost unanimously that the systematic sampling is more precise than the nearest equivalent random method. Even if a deep stratification is applied, the random methods usually involve the sacrifice of some efficiency to obtain randomness in the final selection of the sample units; see (43) and (44). If a stratification in condition classes or in stand types precedes the selection of sample units, the difference in efficiency between the two methods of selection may be rather small.

Another problem should be mentioned in this context. Stratification in land-use classes, forest-types etc., is often made for the total region surveyed. When estimates are extended to subregions (not considered in the stratification), it may be found that the efficiency of the stratified random sample is but slightly higher than that of the unrestricted random sampling (14), (45).

The presence of unpredictable periodicities in the pattern of spatial variation may seriously affect a systematic sample, see (46), where an example of periodicity in forest sampling is reported. Later discussions, (47), (29), however, seem to reduce the evidence of this example substantially.

The difficulty of estimating the standard errors constitutes another rather serious disadvantage in systematic sampling. The model which expresses spatial variation as a sum of a "smooth" component and a purely random term has been the basis of a number of formulas for estimating the sampling error. These formulas are based on the variance of the differences between neighbouring sample units or the variance of the residuals after a graphic or analytic graduation of the data. Formulas of this kind appeared in the 1920's, and they have subsequently been constantly rediscovered. When more flexible models are used, it can be shown that formulas of the type mentioned above may, in some cases, give high overestimates of the sampling errors—in other cases, serious underestimates. However, it seems possible to find (in most cases) formulas that provide a rather moderately biased error estimation by a closer consideration of the geometric pattern of each particular type of systematic sampling (28), (29). More empiric corroboration is needed also in this case.

Interpenetrating Samples

"Interpenetrating samples" can be classified as a type of cluster sampling. The principal idea is to select two or more equivalent samples from the population under study. Each sample is then treated as a separate survey. The principle has been advanced by P. C. Mahalanobis; see (48). The use of two orthogonal systems of lines in a line-plot survey (6, p. 9), where the two systems are allotted to separate field crews, is an example. In this connection, it may be mentioned that J. W. Tukey has recommended the use of a small number of independently selected systematic samples; see (49).

This form of sampling provides an opportunity to study the possible subjective errors (in the determination of land-use classes, site classes, etc.) by comparing the estimates of separate sub-surveys.

The standard error of the pooled estimate from all the samples can be calculated by a simple and unbiased procedure, if a number of systematic samples are independently selected. The size of the sampling error is rather obviously shown by the variation among the averages of the different interpenetrating samples. This may be valuable also in other cases when complicated methods of selection and estimation are employed. "Sampling error" must then be interpreted to include also the subjective errors. It should also be emphasized, cf. (49), that a pooled estimate from a number of independent systematic samples may often be much less precise than an estimate from a single systematic survey of the same extent as that of the interpenetrating samples combined.

Non-Sampling Errors

The non-sampling errors have been much debated in the literature of forestry. An early example is reviewed in (19, p. 48). However, empirical investigations of the non-sampling errors are seldom encountered. In some cases a routine system of observational methods may be used extensively without any examination of the possible bias ever being performed. The following statement by E. C. Crafts (3, p. 83) may serve as a comment: "Lack of knowledge breeds confidence." Independent replications of some of the most common routine procedures of, e.g., measuring diameter and height growth, assessing site classes and age classes, etc., may therefore be called for. (Cf. the method mentioned in the preceding section.)

Continuous Surveys

Under the heading "sampling on successive occasions," treatises in sampling outline a system of obtaining information on a changing population; see (13), (14). The methods dealt with may be described as two opposite extreme cases and a set of intermediate procedures. Both the extreme cases correspond to well-known methods in forestry.

At the one extreme, the same sample (or the same subsample of a large original sample) is resurveyed on each occasion. This method is useful when information

on the changes is requested. It corresponds to the remeasurement of permanent sample plots.

In the opposite case, different samples are selected on all occasions. Each sample may be chosen without regard to the previous selections, or the samples may constitute parts of a larger system as in the present Swedish national forest survey (6). This method is particularly suited to the case when precise estimates of the total volume, etc., are required for the whole period.

In the intermediate cases, part of an earlier sample is retained on the following occasions according to one or the other scheme of replacement.

It is a particular feature of forest inventories that sampling on one occasion can give information on past history by measurement of increment cores, stumps, etc. When full use is made of this possibility, the second extreme case (distinct samples on all occasions) may be preferable. The current theory of sampling on successive occasions should evidently be developed to cover the situation encountered in continuous forest surveys.

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RESUMES

Les inventaires forestiers et la théorie statistique de l'échantillonnage—Quelques travaux récents

Le but principal de la théorie statistique de l'échantillonnage est d'aider à choisir un plan d'échantillonage (méthodes de selection et d'estimation). Ce choix devrait être de nature à permettre de tirer le maximum de profit de l'inventaire, c'est-à-dire un aussi grand écart que possible entre la valeur des renseignements obtenus et le coût de ces renseignements.

L'auteur du rapport, sans entrer dans les détails techniques, passe en revue certaines des notions fondamentales de la théorie de l'échantillonnage, en soulignant particulièrement les méthodes récemment mises au point. Il donne de nombreux exemples ayant trait à l'àpplication de ces méthodes dans l'inventaire des forêts, mais sans chercher à traiter la totalité de ces applications.

En ce qui concerne l'efficacité des différents plans, l'auteur estime que les modèles mathématiques des formes de variations spatiales dans les forêts sont extrêmement précieux pour l'interprétation et la systématisation des renseignements obtenus par des voies empiriques.

Certaines idées et méthodes de base sont illustrées brièvement au moyen d'un exemple d'inventaire effectué par levé aérophotogrammétrique sur le terrain.

L'échantillonnage à "étapes multiples" est utile dans le cas d'inventaires pour lesquels il est impossible de se reporter à des cartes précises.

L'échantillonnage à "phases multiples" est largement utilisé pour les inventaires forestiers. Il sert de base à la stratification des unités d'échantillonnage. Il peut également être utilisé pour le calibrage des estimations visuelles (à partir de photographies aériennes, par exemple) grâce aux petites placettes mesurées sur le terrain.

Les placettes peuvent être groupées afin de réduire les frais de déplacement. Il sera toutefois nécessaire de poursuivre les travaux sur la structure optimum de ces groupements.

La sélection systématique des unités d'échantillonnage a rencontré beaucoup de succès dans le domaine de l'échantillonnage forestier. L'auteur estime que, dans la plupart des cas où l'on emploie l'échantillonage systématique, il est possible de découvrir des méthodes permettant d'estimer l'erreur d'échantillonnage avec un degré de partialité modéré.

Le système de "l'échantillonnage interpénétrant" ou les inventaires parallèles effectués séparément sont utiles pour recueillir des renseignements sur les erreurs subjectives des procédés d'observation. Elles se font toutefois généralement aux dépens de la précision de l'échantillonnage.

Enfin, l'auteur cite la théorie de "l'échantillonnage à reprises successives". Cette théorie ne résout toutefois pas certains problèmes propres aux inventaires forestiers permanents.

Inventarios de los bosques y teoría estadística del muestreo—Ultimos adelantos

El fin principal de la teoría estadística del muestreo es el de servir de guía al tomar las muestras (métodos de selección y de cálculo). La selección se ha de hacer con miras a lograr provecho máximo del estudio, es decir, la diferencia máxima entre el valor de los informes obtenidos y el costo de obtenerlos.

Evitando entrar en detalles técnicos, este trabajo examina varios conceptos fundamentales de la teoría del muestreo, poniendo de manifiesto métodos perfeccionados últimamente. Se hacen numerosas referencias al empleo de inventarios de los bosques, pero no se trata de abarcar todas las formas en que se puedan emplear.

En relación con la eficacia de distintos métodos se indica que los modelos matemáticos de las formas de las variantes especiales de los bosques son de gran valor al interpretar y sistematizar los datos que se obtienen de investigaciones empíricas.

Diversos conceptos y métodos fundamentales se demuestran con ejemplos brevemente expuestos de estudios combinados de fotografía aérea y en el terreno.

El muestreo de "etapa múltiple" es de importancia en inventarios cuando no se dispone de mapas exactos. Se usa extensamente en estudios de los bosques como base para la estratificación de las unidades del muestreo y también para valorar cálculos visuales, como en el caso de fotografías aéreas, por medio de submuestras tomadas en el terreno.

Para evitar grandes gastos de viaje las parcelas se pueden disponer en grupos, pero se requiere estudio detenido de la estructura óptima de los grupos.

La selección sistemática de muestras se ha extendido mucho en el muestreo forestal y el autor considera posible, en la mayoría de los casos de muestreo sistemático, el hallar medios de calcular errores que sean, no mas que moderadamente predispuestos.

El sistema de muestreos superpuestos o de estudios simultáneos efectuados independientemente es eficaz en proporcionar información sobre errores subjetivos en los procedimientos de observación, pero generalmente se logra a costa de la precisión del muestreo.

En conclusión, se hace referencia a la teoría de "muestreo en ocasiones sucesivas" aunque varias de las necesidades especiales del inventario continuo de los bosques no se satisfacen con esta teoría.

Machine Processing of Forest Survey Data

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One of the more striking advances in forest survey procedures in recent years has been the change from hand compilations to machine processing of data. Desk calculators and adding machines have replaced hand calculations in simple, small-scale surveys. Modern punched-card business machines are being employed to an ever-increasing extent in large-scale surveys. And a great deal of experimental and exploratory work is being done on the processing of data from forest surveys on high speed electronic computers.

The advantages that machines offer are: (1) Increased speed, (2) Reduced needs for manpower, and (3) Increased accuracy.

The word "offer" is used deliberately; none of the advantages are guaranteed. Mechanize and economize are not synonyms. In data processing, as in other fields of human endeavor, it is entirely possible to complicate an essentially simple operation with expensive machinery. However, if machines are chosen wisely and utilized efficiently, savings in time and manpower can be achieved, and fewer errors will be present in the final reports.

The combination of the first two advantages, increased speed and reduced manpower, can usually bring about a reduction in costs for any particular job of data processing. The savings are, however, often reinvested in the process, sometimes in order to obtain still greater speed, but more often with the object of securing more detailed information. It is probably safe to say that the dividends extracted from a data-processing system are more likely to be increased speed, accuracy and detail rather than a simple reduction in cost.

The realization of any of the benefits listed above requires the proper matching of the equipment to the job, and there is wide variety of equipment available at the

present time. Listing all of the machines in use would be a nearly impossible task. A limited survey of the field is feasible, but some system of organization is required. Three broad classifications may be recognized—first, key-operated desk calculators and accounting machines; next, punched-card business machines; and, finally, moderate to large size computers with internal storage. These classifications are not mutually exclusive nor even exhaustive but will serve as a framework for discussion.

Desk Calculators and Accounting Machines

The machines in the first classification have the great advantage of being relatively inexpensive; their cost ranges from less than a hundred to several thousand dollars. In general, these machines are designed primarily for computations; they replace the slide rule, the abacus or paper-and-pencil computation. All of these machines can perform positive additions rapidly and efficiently and, of course, any machine that can add can also do subtraction by adding complements. Multiplication and division can also be performed, even on the simplest machine, by repeated addition or subtraction, respectively, but these operations are time-consuming and inefficient.

The more complex—and more expensive—desk calculators have internal linkages or "hardware" and can perform "automatic" subtraction, division or multiplication. Furthermore, at least one company now offers a machine that can extract square roots at the touch of a key. Some machines also have features designed to facilitate the performance of a series of operations such as three-factor multiplication or two-factor multiplication followed by a division.

Data must be entered manually into all the desk machines in general use. By far the largest majority provide a keyboard for this purpose, but a few utilize dials or levers. Most adding machines print results on a paper tape; most calculators display the result in a series of dials, and the information must be copied if a permanent record is desired. In the last few years, printing calculators have been marketed by several firms. These machines are slower and have less capacity for accumulation and storage than their non-printing counterparts, but are useful when a record of input and intermediate results is needed.

The accounting machines employed so successfully and so widely in the business world have received little attention from processors of forest survey data, but these machines have a number of features that make them at least worthy of consideration. They surpass all the other desk machines in elaborateness of output. Results can be printed on wide forms that are more suitable for permanent records than pieces of paper tape. In addition, provision is commonly made for entry of alphabetic information on the printed form. Hence, output can be made quite readable, and little effort is required to place a full, permanent and intelligible identification on the results of a computation.

The accounting machines are not as flexible and, in general, cannot perform as many arithmetic operations as the desk calculators. However, they do have some unusual computational features. Chief among these is the provision of not one but several independent registers in which the results of the arithmetic operations can be stored. Several columns of figures may be added in one pass; a separate total obtained for each column; and the several sums printed side by side on the same form. This ability to accumulate several sums simultaneously, together with the provision for alphabetic identification, make the accounting machines quite useful in the preparation of the two-way tables usually employed in summarizing forest survey data.

The wide use of adding machines and desk calculators has certainly reduced the time and labor required to perform the computations involved in a forest survey. Increased use of accounting machines would undoubtedly result in still larger savings. However, even if the full potential of all these types of machines were realized, processing the data from a detailed large-scale forest survey would still be a lengthy and time-consuming operation. Data must be organized before it can be handled on desk machines. In the simpler types of surveys, much of this organizing is done as a part of the recording process. When only a few measurements or observations are taken on each sampling unit and when only a few breakdowns are required in the final report, field sorting is feasible and efficient. Volumes, basal areas or other transformations of the basic measurements can be obtained rapidly for the grouped data, and the data processing chore can be handled effectively on desk machines.

Punched-Card Machines

In recent years, the trend has been toward more and more detail in forest surveys. The multitude of classifications makes sorting in the field slow and difficult. Furthermore, errors are quite likely to occur, and it is extremely difficult, if not impossible, to check for accuracy. For these reasons, measurements and observations are now recorded for each sampling unit in many surveys. Hence, data are presented for processing in what is practically a random order. The major part of the job is then not computation or summarization, but organization. Individual records must be sorted, ordered and classified.

The labor involved in performing these operations by hand for a large-scale survey can become excessive by any standards. Mechanization or automation is required, and it is here that the punched-card, so-called business machines come into their own. Indeed, these machines, despite their name, were originally conceived and invented to handle survey data. In 1886, the United States census of 1880 was still being processed, and it required little foresight to realize that the reports of the 1890 census would not be completed until after it was time to begin work on the census of 1900. Dr. Herman Hollerith, a special agent of the Bureau of the Census, knew that cards with holes had been used to control the weaving of patterns in cloth. He conceived the idea of recording census data on similar cards and began experimenting with machines to process these cards.

After more than a half century of development, machines are now available that can perform a great many of the operations necessary in processing survey data. The chief types of punched-card machines are the key-punch, the verifier, the sorter, the interpreter, the reproducer, the collator, the tabulator and the calculator. These machines are best described by listing the operation for which they were designed.

The keypunch is used to punch original data into blank cards. The machine is activated by a keyboard similar to that of a typewriter. Both alphabetical and numerical information can be handled on the newer models. Information common to a number of cards can be entered automatically.

The verifier is employed to check the accuracy of the original keypunching. It is essentially a punch that doesn't punch, but instead lights a red light when the information being entered by the operator does not match that already punched in the card.

The sorter is a machine that separates cards into groups according to some specified criterion. The newer sorters will also count while they are sorting, and at least one will print the results of its counts.

The interpreter prints on a card the information recorded in the punched holes. The purpose is solely to improve legibility when individual cards must be handled and read. Some keypunches also print as they punch.

The reproducer can copy the punches in one group of cards into the same or different columns in another group of cards. It can also gang-punch the information from one master card onto a group of detail cards. The reproducer is also used for checking purposes—to compare two groups of cards that are supposed to be identical and to discover obvious punching errors such as blank columns and double-punched columns.

The collator is employed to merge or match two decks of cards. If, for example, deck A contains all the first cards of a number of two-card sets and if deck B is composed of the second cards, the collator can be used to unite the two decks so that the second card of each set follows the first card of each set in the single, combined deck that is the result of the merging operation.

The tabulator can list on a sheet of paper the information punched in a group of cards. It can also total information for groups of cards and print the totals and, if connected to a reproducer, it can punch the totals into summary cards.

The calculator is the newest member of the punched-card family and the one in which the most diversification occurs. The large-scale electronic computers of today can be card activated and, of course, are calculators; but the reference here is to the smaller, more readily available machines with limited storage and lacking internal programming. These machines take over the job of a desk calculator in a punched-card system; they can add, subtract, multiply and divide. Many have provision for performing sequences of arithmetic operations and some can make logical decisions.

Punched-card machines are now widely used in processing data from forest surveys. All the regional forest surveys in the United States depend upon punched-card equipment to a large extent, particularly for sorting, summarizing, and preparing reports. Still more intensive use is made of the machines in connection with the systems of permanent sample plots that have been installed by many forest landholders under the name of Continuous Forest Inventory or C.F.I.

The great mass of information collected on these plots and the requirement for individual tree records combine to form a data processing task of the first magnitude. The time required would be so long and the amount of labor involved so large that the job has never been attempted by hand. However, by using the punched-card machines, the information from such an inventory can be processed in a matter of days at a cost that is insignificant when compared to the expense involved in gathering the data.

The techniques developed for using business machines in conjunction with permanent sample plots will be described in some detail. The methods employed represent an advanced stage in processing data from a particular type of forest survey. Furthermore, the overall procedure and many of the specific techniques are applicable to forest surveys in general.

Data processing begins with the recording of the original information. At least two methods are employed in forest surveys when the data are to be handled on punched-card machines. The information may be handwritten on a tally sheet and later keypunched into the cards, or it may be entered directly into the cards in the field using a portable keypunch, a stylus, or an electrographic pencil.

The objective of both procedures is to obtain records that are inexpensive, accurate, easy to verify in the field and in a form suitable for further processing. Unfortunately, these desirable characteristics are to some extent incompatible. The use of handwritten tally sheets probably results in a minimum of recording errors, and field editing is not difficult. However, an extra expense and an opportunity for error arise in the keypunching that follows. On the other hand, the direct entry of information on cards in the field has the advantage of eliminating the keypunching operation, but recording errors occur more frequently. Furthermore, the records are not as legible and, hence, field editing and checking is hampered.

Regardless of the method employed to get information onto the cards, the next step is to check the correctness of the information. If a keypunch has been used, the cards will ordinarily be verified, checked for blank columns and double punches on the reproducer—or perhaps on a statistical sorter—and then listed on the tabulator for a hand check against the original records. If the information has been entered directly on the cards in the field, the double punch and blank column check is made and the cards are listed on the tabulator. The verifier cannot be used because the cards themselves are the original and only records. For the same reason, the examination of the listing is limited to a check for obvious errors.

In either case, the hand check of the listing may be supplemented or even replaced by machine checks for particular types of errors. Missing information, measurements that are impossibly large or small, and punches representing nonexistent classifications may be detected on the sorter. Furthermore, certain combinations of information such as a sawtimber length for a cull tree may be erroneous, and this type of error can also be discovered by sorting.

Once the errors have been found, correction is the next order of business. Sometimes this operation is done somewhat haphazardly and does not receive the attention its deserves. A systematic procedure is required so that new errors will not be committed in correcting old ones. In addition, safeguards are necessary to prevent cor-

recting one error in a card and leaving others undetected or uncorrected.

With a clean deck of cards in hand, the computations of volume begins. The requirement here is for an expression of volume that is at least partly mathematical. The tenth-inch diameter measurements and the one-foot height classes employed in C.F.I. work make a completely tabular approach extremely unwieldy.

The volume equations commonly employed are continuous over diameter and possibly height but are discrete in respect to species, cull and similar classifications. The usual arrangement is one basic equation with multipliers to adjust for species, cull, and intensity of sampling.

If the limitations of the available computer permit, the multipliers for each species and cull classification may be stored in the memory of the machine. The computer is then programmed to select the proper multipliers for each tree card, and the computations can be performed in a single pass through the machine.

If, on the other hand, a relatively simple computer such as a calculating punch is used, the multipliers must be punched on the tree cards. This operation is performed using the keypunch, the sorter, the collator and the reproducing punch. The multipliers for a particular criterion—species, for example—are keypunched into master cards, one species to a card. The tree-record cards are then sorted and arranged by species. Next, the two decks are merged on the sorter or the collator or by hand. The combined deck then goes to the reproducing punch, and the multipliers from the master cards are gang punched into the tree cards. The whole process is repeated as often as necessary to enter the other sets of multipliers. The tree-record cards then go to the calculating punch for volume computation.

Finally, the desired reports are prepared by sorting and tabulating. The data processing for the initial installation of a C.F.I. system is then complete—except for a thorough check of the reports for possible errors.

Electronic Computers

The methods of data processing described above are fast and cheap and produce reports that are relatively free from error. Punched-card machines represent a tremendous advance when compared to hand compilations and desk calculators. Yet still more advanced techniques are at hand. Electronic computers are coming to the fore, and forest survey data are beginning to be processed on such machines.

A large electronic computer is essentially a whole data-processing system assembled in one operating unit. The main components of the machine are:

1. An input device that permits information in the form of data and instructions to be read into the machine;
2. A memory in which information can be stored;
3. An arithmetic unit that can compute and make logical decisions;
4. An output unit that permits information to be read out of the machine; and
5. A control system that directs the operation of input-output devices and the arithmetic unit in accordance with the instructions stored in the memory.

It is this last system, the control system, that makes a large electronic computer essentially different from other data-processing machines. Desk calculators and business machines must be controlled by a human operator using keys, plug boards and the like. These machines do not perform the correct operation automatically. The electronic computer is also a general purpose machine that must be told what to do. However, the instructions may be assembled in a neat, compact and permanent package or program that can be read into the machine at any time. The program, once prepared, becomes a machine accessory that can be attached at will to convert the computer into a special purpose machine capable of doing a complex job of data processing automatically and without attention.

The application of electronic computers to forest survey data is still a new field; nothing approaching standard practices or techniques has been developed. However, enough experience with and knowledge of the machines has been accumulated to allow a prediction of probable developments.

First of all, the computers are not likely to be of assistance in taking or recording the original observations. Automatic instruments that gather and record data are in general use in other fields. These machines are sometimes physically attached to and form an integral part of a computer. Such a development is a long way in the future for forest surveys. Present work is not aimed at eliminating field crews but towards the more modest goal of developing devices that simplify their task of recording information in a form intelligible to a computer.

The second stage of processing data from a forest survey—checking and correcting the original observations—is, at present, best handled partly on a computer and partly by hand. The machines are ideally suited to the systematic detection of missing, contradictory or impossible values and will undoubtedly be used intensively for this purpose. However, the correction of errors still requires human editors and, in some cases, remeasurement in the field.

The scheduling of the data processing up to this point should then approximate the following scheme. First, the original measurements are recorded and checked in the field, then sent to a central office for further checking on a computer. As each set of data comes in, it is processed on the computer, and any errors discovered are either corrected by an editor or sent back to the field for correction. The corrected observations are checked again on the computer and finally filed to await the completion of the field work.

Checking should, of course, be kept as current as possible. Any remeasurements required will cost less if made before the field crews have left the neighborhood where the original observations were made.

Once the field work has been completed and the data corrected, the final steps of processing can begin. These steps are:

1. the computation of volumes or other transformations of the original observations; and
2. the compilation of statistics needed in the final reports.

The organization of the work will depend partly upon the computer employed and partly upon the design of the

survey, but one general principle may be stated. The program developed should do the remaining steps of data processing in one pass through the machine. If at all possible, data should go in, and finished reports should come out in a form ready for reproduction.

This goal is not difficult to achieve if the statistics in the final reports are linear combinations of the original observations or their transforms. Each observation may then be treated independently. For example, the volume of a given tree can be computed, weighted, accumulated in all the proper cells of the final reports and then forgotten. The computations proceed, tree by tree, in this manner and when the last tree has been processed, the reports of the survey are also complete.

The computations just described are lengthy but not complex and do not exceed the capabilities of a medium-sized computer. The controlling factor in the choice of a machine is more likely to be the storage space available for the program and results of the computations.

The requirements for storage space become still more acute for surveys employing elaborate sampling designs. If multi-stage sampling, regression estimates or the like are employed, the program will be longer and require more storage. Furthermore, the statistics in the reports are not linear functions of the original observations or their transforms and cannot be obtained by simple accumulation. The contribution of each observation to the estimates depends upon the magnitude of other observations and the outcome of other computations. Hence, a large amount of storage is required for intermediate results that will be needed in later computations.

A few years ago, only the largest and fastest computers had the storage capacity needed to process survey data efficiently. The early models were designed primarily for mathematical and engineering problems. Computing speed was emphasized but storage received less attention. Fortunately, the situation is now changing rapidly. The application of computers to survey and business work has led to the development of auxiliary disk and tape storage units that can be used in conjunction with the less expensive computers.

The combination of a moderate-sized computer and auxiliary storage units is well suited to forest survey work, and the number of such machines in use is increasing rapidly. There are now more than one hundred IBM 650 computers at work in colleges and universities in the United States. Thus, equipment suited for the job is available. Data collection and correction will probably remain a hand operation for some time to come, but the machines are ready to take over checking, sorting, computing and report preparation.

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RESUMES

Dépouillement méchanique des données relatives aux inventaires forestiers

L'auteur donne une courte description des types de machines utilisées pour le dépouillement des données recueillies au cours des inventaires forestiers. L'emploi de machines à cartes perforées pour recueillir les données de placettestémoin permanentes est présenté comme exemple de l'utilisation efficace de machines pour le dépouillement des données relevées au cours d'inventaires forestiers. L'auteur examine les perspectives des machines à calculer électroniques; il fait observer que le rassemblement et la correction des données restera pour quelque temps encore une opération manuelle mais que l'on peut utiliser les machines à calculer pour le contrôle, le tri, l'évaluation et pour la préparation du rapport.

Máquinas registradoras de datos para inventarios forestales

Este trabajo presenta una breve descripción de los tipos de máquinas registradoras empleadas en los trabajos de inventarios forestales. Para demostrar la eficacia de estas máquinas en la compilación de datos relacionados con los inventarios, se describe el empleo de ciertos tipos de perforadoras de tarjetas que recogen la información obtenida de las zonas de ensayo. También se trata de posibles perfeccionamientos de las calculadoras electrónicas en el futuro. Asimismo, se sugiere que probablemente la compilación y rectificación de datos continuará haciéndose a mano por bastante tiempo todavía, pero que estas calculadoras pueden emplearse para verificar, escoger, calcular y preparar los informes.

Aerial Photogrammetry In Forest Surveys

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Introduction

Nothing is more suitable for a study of the surface of the earth than the aerial photograph, and there has been no more revolutionary development during the history of topographical mapping than in aerial photogrammetry. This has been followed by new techniques in the investigation of natural resources such as those of the farm, the forest, minerals and water power. None of these resources is better adapted to detailed study in the aerial photographs than the forest, which appears so conspicuously in three dimensions under the stereoscope.

The measurement of trees and forest stands in the aerial photographs for volume estimation is largely based on photogrammetric principles similar to those applied in topographical mapping. Closely related to the quantitative information is the qualitative information supplied through the interpretation of aerial photographs, especially in the recognition of species, cover types and site types.

Basic Information

Information available from the aerial photograph on the nature and description of the forest has its main basis in the measurement and examination of the tree images, either individually or in the aggregate within the forest stand. The determination of topographical features and other environment factors from the aerial photographs is sometimes quite important.

Tree Height

Measurement by stereoscopic parallax is the oldest and most commonly used of all photogrammetric methods of determining the heights of trees or stands. According to Andrews (1934) the *parallax method* was used in Germany as early as 1925 by means of highly developed stereoscopic plotting machines which had been built for topographical mapping. A report was made by Andrews (1936) on his use of a parallax bar in an early test of the method in British Columbia. Present practice is largely based on the use of comparatively inexpensive stereoscopes, parallax bars and parallax wedges. The method is employed mainly on vertical photographs.

In the *displacement method,* the full length of the tree's image is measured, instead of merely the forward component of its length, as in the parallax method. A disadvantage of the displacement method, however, is that it does not provide for the stereoscopic observation of the image-measuring device. Both the displacement method and the parallax method are based on ordinary principles of photogrammetry. The displacement method applies only to vertical photographs.

The *oblique method* is so called because it is used in the measurement of the tree's image in oblique photographs. Its application is indicated by Seely (1934).

Obviously, the *shadow method* differs from the other methods because it is based on the tree's shadow instead of on the tree itself. This method was first described by Seely (1929). It is used mainly in vertical photographs, and its application has been facilitated by comprehensive tables of the altitude of the sun or by a shadow-height calculator designed to readily determine the sun's altitude by the graphical solution of the relevant astronomical problem.

Stereoscopic examination of the photographs is generally preferable in all methods to facilitate the locating of base and tip of tree or shadow and, so far as possible, to relate the easily measurable trees to those which are not fully visible. Various overlays suitable for the measurement of trees on aerial photographs are shown by Hardy (1956).

No comparison of the various methods of determining tree heights is complete unless the conditions which affect the precision of the results are taken into account. The measurement of evergreen trees, for instance, is facilitated by the better visibility which prevails in those seasons of the year when the foliage of nearby deciduous trees is absent or is not fully developed. In such instances, all methods will provide better results, and the shadow method will have a special advantage in the greater number of shadows which may be measured. The measurement of the deciduous trees may often be done to best advantage when two sets of photographs are available, one in which the deciduous trees are distinct because their foliage is present, and the other in which the height of the stand may be determined more definitely because of the absence of deciduous foliage. An exception occurs when the photographs are of sufficiently large scale to show the bare hardwoods clearly. Other factors affecting tree height measurements include the scale and definition of the photographs, the shape of the crown, the width of the angle of view of the camera, and the direction of the camera axis. Definition is, of course, related to qualities of lens and film and the conditions of exposure and processing of the photographs. Furthermore, camera vibration and the image motion caused by the travel of the aircraft during the instant of exposure are important. The measurement of the shadow is adversely affected by the difficulty of estimating the amount of slope in hilly ground. In dense portions of the stands, accurate tree height measurements are impossible. A series of tests, in which the results secured by the various methods would be compared objectively under conditions usually encountered, is desirable, particularly because of the limited scope of those few tests which have already been made.

Canopy Density, Crown Diameter, and Tree Count

Estimates of the percent of canopy density or crown closure shown by the aerial photographs are very important. Stereograms showing forest stands of known classification are valuable aids to the interpretation of canopy density, but a multiplicity would be required to represent fully all forest conditions at various seasons of the year, different scales and angles of view of photography with various air cameras, films, and conditions of photography. Crown density scales containing dots approximately as large as the tree crowns are described by Moessner (1949), and the development of an overlay incorporating a row of paired triangles is outlined by Losee (1956). A difficulty in the interpretation of canopy density is encountered because of the variations which occur in the displacement of the tree crowns in relation to the distance of the tree from the plumb point of the photograph. The establishment of correction factors to take account of these variations would be helpful.

Another useful measurement is that of crown diameter, which is especially important when estimates of timber quantities are being made in stands of low density or in other circumstances where the number of individual trees which can be measured and counted is sufficient for estimates of timber quantities. The height of the tree is often an important factor in the relation between volume and crown diameter. Crowns appear as relatively small objects in the aerial photographs, and good definition is essential for accurate measurement. Crown measuring devices have been dealt with by Losee (1956).

Conditions are seldom favourable for the counting of trees in aerial photographs, which is at best a slow and tedious process. Best opportunities occur in photographs of large scale, particularly when the stands are of low density or when evergreens are being counted at those seasons of the year when the foliage of nearby deciduous trees is absent. Also, it is an advantage if the crowns are distinct because of an approach to a conical shape and a tendency to be evenly spaced.

Species and Forest Types

With few exceptions, the recognition of tree species on aerial photographs of ordinary scale is quite difficult, especially before field checks are made. In a variety of ways, however, distinctions between species or forest types become possible. Bare deciduous trees are easily distinguished from evergreens in late autumn, winter and early spring. At other seasons, similar distinctions may be apparent from differences in the tones of the foliage, and broad forest types may be delineated. A process of elimination may be valuable, especially where few species exist. Crown characteristics and tone of foliage, including branching habit, shape and size of crown and arrangement, colour and degree of glossiness of the leaves, may be important. Greater possibilities for the recognition of species will be found in photographs of large scale. A knowledge of site or of ecological and phenological conditions may sometimes be useful. Infra red, colour, and camouflage detection films, as referred to subsequently, provide special distinctions.

In some regions, an expert may recognize land forms in the aerial photographs and, from the topographical position, slope and vegetation, may form an opinion of the soil parent material, soil texture, and drainage in their relation to forest site types.

Results obtained by the aerial photo interpreter in estimating the above variables have been reported by Andrews (1936), Nash (1949), Moessner, Brunson and Jensen (1950), Losee (1953), Worley and Meyer (1955) and Nyyssonen (1955). It is evident that information on the precision of tree height measurements is largely confined to the parallax method, with which valuable results are obtained at scales of about 1:20,000 or better. The standard error of estimate, with the probability of two times out of three, varies from 2.2 feet to 9 feet or more. For canopy density, the standard error generally varies from 9 per cent to 12 per cent. Tree counts seldom exceed 50 per cent of the true number. For crown diameters, the standard error varies from 0.5 feet to 4 feet.

Stratification and Sampling

The aerial photographs with their comprehensive and detailed view provide a unique opportunity for a classification or "stratification" of the forest stands. A single stratum may comprise all those stands which are of the same class in respect to such factors as height, cover type and canopy density.

In the triple sampling system used in the nation-wide Forest Survey of the United States Forest Service (Bickford, 1952), the aerial photograph stratification, instead of covering the stands fully, is often confined to systematically located circular photo plots of one acre in area. Circular field plots of one-fifth acre are located within some of the photo plots to provide tree measurements and a check of the photo interpretation of the acre plots. The photo interpretation of one-fifth acre plots would be difficult because the true position of trees near the perimeters of the plots cannot always be determined and because the amount of interpretive information on one-fifth acre is often very limited.

A summary of Canadian procedures in stratification and sampling is given by Seely (1957), who refers to the use of random, systematic, and more or less subjective methods of sampling, including a special method known as "selected line." In this last-named method, the plots are usually located singly or at regular intervals on lines drawn haphazardly on the map from points in the vicinity of the route of access to the stands. This method, together with various other methods, has been tested in comparison with random sampling in certain forest stands fully stratified by the photo interpreter. The results are subject to further study, but it appears that, within the aerial photo stratification, definite patterns or gradients in average tree size are comparatively limited, with the result that differences between the mean values of the various methods have been greatly minimized. Some of the Canadian procedures depend partly on the interpreter's ability to detect *differences* in his estimating of the average height of the stand, the per cent of canopy density, and other stratum factors. His estimates may be high or low but, if they are consistent, they do not prevent the satisfactory application of the sample plot data to the stratification.

The extent to which the information provided by aerial photo stratification makes possible a reduction in the number of field plots required for forestry inventory is

referred to by Bickford (1952). It seems possible that the economies to which he refers may also have some application in the use of permanent sample plots for studies of growth. A difficulty arises, however, in that the factors which govern growth, such as forest site, mortality, age of stand, and species percentages may not be easily determined from the air photographs, except possibly by the interpretation of the topography and by supplementary field work. It would be necessary, of course, to revise the stratification at each time of remeasurement. An investigation nevertheless appears to be warranted even if the only advantage to be gained is that of the improved estimate of the area of each forest stand or cover type as provided by the aerial photo stratification. Areas determined by the mere assumption that the area of the cover type is proportional to the number of sample plots may sometimes be subject to considerable error especially if the number of plots is limited.

Volume Tables for Photo Interpretation

Stand volume tables and tree volume tables, based on variables ascertainable from the aerial photographs, have been constructed or are being constructed either to make possible a stratification by volume instead of by its component variables, such as height and density, or for acceptance as standard tables in a direct approach to volume estimation.

Typical stand volume tables are those of Moessner (1957), and Avery and Myhre (1959). The variables employed by the former were those of average height, average crown closure per cent, and average crown diameter, all in reference to the dominant trees. The latter used the average height of the three tallest trees per acre and the crown closure per cent of trees 5 inches d.b.h. and larger. Crown diameter was omitted because, when tested in combination with crown closure or height, it did not contribute significantly to the prediction of volume.

The correlation between volume and several variables, including average height, canopy density or crown closure, crown diameter and tree count, has been tested by a number of investigators. Gingrich and Meyer (1955) found that the average height of the tallest three trees was better related to volume than the height of the single tallest tree or the average height of the dominants and codominants. Correlation was shown to be higher between volume and height than between volume and crown closure. Some degree of correlation was apparent between height and crown diameter, but after elimination of height there remained no significant correlation between volume and crown diameter. Nyyssonen (1955) showed that volume is predicted to a slightly better degree by mean height than by crown closure. He found that the correlation between volume and crown diameter was weak and questioned the reliability of crown diameter, having regard to the error in measuring it on the aerial photographs.

In the field measurement of sample plots for the construction of stand volume tables in Canada, the federal Forestry Branch has recorded all trees, has measured the canopy density and has secured information on cover type and site type. Also, crown diameter, height and age have been determined for a few trees in each plot, and a variety of information, particularly on stand history, has been noted. In place of the determination of canopy density in the aerial photographs or its ocular estimation on the ground, an instrument known as the "moosehorn" has been developed and used for the measurement of canopy density on the ground. In this instrument, evenly spaced marks resembling those of the "dot grid," which is employed in the planimetering of map areas, is incorporated in a small viewing box. Recent field tests of the instrument, which has a field of view of about 9 degrees, did not indicate that the degree of angularity is sufficient to cause systematic error. It has been found that average height weighted by volume is a dependable measure when used in compilation. The accuracy with which this measure, which generally falls between the heights of the dominants and the codominants, can be estimated in the aerial photographs is subject to further investigation. A test of the application of stand volume tables is being conducted in which the data of the standard tables are being compared with similar data collected locally. The test has included the measurement of a random sample to verify the aerial photo interpretation, the dependability of which is essential to the successful use of stand volume tables. Factors of stand history, age or site, disturbances, or variations in stand structure and species composition may cause a local stratum to differ in volume from that of its counterpart in the standard stand volume table. It is thought that this test will provide some indication of the advantages, if any, of the use of stand volume tables in reducing the amount of field sampling which would otherwise be required. An investigation is to be conducted to determine what economies may be found in relating the periodic measurements of permanent sample plots to estimates made simultaneously from stand volume tables and aerial photo stratification.

The interpreter might find it desirable, when trees can be readily counted and measured in the aerial photographs, to use volume tables based on the average crown diameter and height of individual trees. Tree volume tables for use in aerial photo interpretation are shown by Nash (1948). Further research in the relation of crown diameter to diameter of bole for various species, crown classes, height classes, density classes, and stand histories is warranted.

Special Aerial Photography

Forestry Tri-Camera Method

Seely (1948) describes a tri-camera system of aerial photography in which a central camera is pointed vertically downward while two others are directed obliquely, one to the port side and the other to the starboard. Lenses of 12-inch focal length are used. There are marginal overlaps between centre and side photographs, and a wide strip of territory is covered in each flight. The tilt of the oblique photographs is such that the scale of the horizontal plane of the land surface is compressed to provide economical photography, while the vertical planes of the tree images are photographed to best advantage for the measurement of tree height and identification of species. Because of the use of 12-inch lenses, the altitude of the aircraft in forestry tri-camera photography is much

higher for a given scale of photograph than the altitude of ordinary 6-inch lens photography, with the result that displacement of hills in the former method of photography is hardly greater than in the latter. A disadvantage is that unless a considerable volume of work is assured, the air survey company will not undertake the rather expensive installation of the required three cameras. An investigation to provide definitely comparative information between results obtained by the forestry tri-camera method and those obtained by more commonly used methods is desirable.

Large-Scale Photography

Large-scale photographs may provide greater reliability in the measurement of tree images and canopy density, in the determination of the average height of the stand, and in the counting of trees and recognition of species. Full coverage by photographs of such large scales as 1:1,200 or 1:2,400 would, however, be excessively expensive, and a sampling technique is preferable. The large-scale photographs would be used to improve the aerial photo stratification of the general coverage photographs, possibly by stereograms established from a comparison of the detail of the two sets of photographs. Estimates of volume might then be obtained from field sampling or the use of stand volume tables.

In past experiments with large-scale photography, difficulties have been encountered in relation to:

a. image motion which occurs because of the travel of the aircraft during the instant of exposure;
b. camera vibration;
c. the necessity to ensure film cycling adequate for stereoscopic overlap; and
d. difficulties of stereoscopic fusion of tree images of large scale.

Devices for image motion compensation have been used to move the film at the instant of exposure. Also, continuously moving film has been employed in special cameras. Adoption of these devices and cameras for forestry purposes has been retarded because of their expense and lack of consistent compensation. The use of continuously moving film is sometimes attended by scale distortions. A promising alternative lies in the use of cameras equipped with fast shutters to diminish the effects of image motion and camera vibration and with lenses of sufficiently long focal length to avoid difficulties of stereoscopic fusion. Also, the camera mechanism should provide for adequately rapid cycling of the film, or a slow-moving aircraft should be employed. Cameras of medium or large format and focal plane shutters equipped with lenses of focal length of 12 inches or longer or 70-millimetre cameras equipped with rotary disc-type shutter, such as the camera described by Aldrich, Bailey, and Heller (1959), may be suitable.

Infra Red

Shadows appear very dark in normal infra red photographs, while the effect of the chlorophyll of the foliage is to produce highlights, resulting in a variety of tones ranging from black to white. These tones are apparently governed by the amount of shadow within or between the crowns, together with the extent to which chlorophyll is present in the foliage. The comparatively small amount of detail in the shadows may be a disadvantage, especially in the stereoscopic examination of the forest stands in large-scale photographs. When, however, a minus-blue filter is substituted for the normally used red filter, a photograph is produced which, as pointed out by Spurr (1947), is intermediate in its characteristics between panchromatic and normal infra red.

The extent to which forest types and species may be recognized in infra red photographs, especially when taken during the summer months, is dealt with by Spurr and Brown (1946). Comparable results may sometimes be secured, especially in northern latitudes, by photographing with ordinary panchromatic film in autumn, winter, spring or early summer. Nevertheless, infra red photography may often be valuable in summer photography when distinct tonal differences, especially between broad-leaved and needle-bearing species, are required. Sometimes, however, panchromatic photographs taken during those seasons when deciduous foliage is absent are preferable to infra red photographs taken when the deciduous foliage is present. The height of the stand, the boundaries of forest types, and the extent of the understories of evergreen trees are often determined to better effect in the absence of deciduous foliage.

Colour

Colour photography offers advantages over black-and-white photography for the identification of tree species and insect-damaged trees. As indicated by Becking (1959) colour photography is adversely affected by haze in the atmosphere, especially at high altitudes, and is from 10 per cent to 30 per cent more expensive than black-and-white photography. Also colour film does not possess stable and uniform characteristics to the same extent as black-and-white film. Colour prints on paper, which are more convenient for use by the aerial photo interpreter than the usual colour transparencies, have been recently made available by Aero Ektacolor film. An advantage of this film is that extra prints may be secured readily from the negatives.

Camouflage Detection Film

This film combines some of the characteristics of infra red and colour films. It responds strongly to infra red rays, especially those received from the foliage of broad-leaved trees with their abundance of chlorophyll. Living trees vary in tone from purple to a vivid red, while dead foliage, such as that of trees damaged by the spruce budworm, appears blue-green or gray-green. At the Petawawa Forest Experiment Station near Ottawa, Canada, it was found that the tones of camouflage detection photographs taken in July were much brighter than those taken in September, and spruce plantations in early summer appeared in a brighter red than pine plantations, presumably because of the slower development of the foliage of the latter. Further studies are necessary to distinguish species, to identify partially defoliated trees, and to learn how well the vigour of coniferous trees is determined by the variation in tone as related to chlorophyll activity in the foliage.

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RESUMES

Recensement forestier au moyen de levés aérophotogrammétriques

Dans son introduction, l'auteur se réfère aux circonstances uniques dans lesquelles les levés aérophotogrammétriques sont appliqués aux recensements forestiers.

Les renseignements fondamentaux pouvant être obtenus de la photographie aérienne comprennent l'estimation de la hauteur des arbres par plusieurs méthodes de mensuration, l'estimation de la densité de la voûte de feuillage, du diamètre des couronnes et du nombre d'arbres, ainsi que l'identification des essences et des types forestiers. L'auteur examine la précision des ces estimations. Des recherches plus approfondies sont nécessaires pour comparer les résultats obtenus par diverses methodes de mensuration et pour constater la façon dont leur application est altérée par les conditions saisonnières, les circonstances dans lesquelles les photographies ont été prises, et autres facteurs.

En raison des détails qu'elle révèle, la photographie aérienne fournit une possibilité unique de classification ou "stratification" des peuplements forestiers. Cette stratification est parfois restreinte à des zones échantillons sur les photographies, alors qu'à d'autres moments, elle s'applique au peuplement tout entier. L'échantillonnage des forêts ainsi stratifiées a fait l'objet de comparaisons effectuées à l'aide de diverses méthodes.

L'établissement de tables de volumes basées sur des variables tirées des photographies aériennes est ensuite décrit avec mention particulière du degré de coorélation entre le volume et les variables de valeurs connues ou potentielles. La plupart des tables s'appliquent à l'ensemble du peuplement, mais certaines tables s'appliquent à tel ou tel arbre. Il peut être souhaitable parfois de préparer des tables locales de volumes en se fondant sur la corrélation entre les données locales et la table de volume standard.

L'auteur passe en revue les méthodes spéciales de photographie aérienne d'une importance particulière pour les recensements forestiers. Ces méthodes comprennent: photographie au moyen d'un système d'appareil de prise de vue triple, photographie à grande échelle de certaines zones échantillons, et utilisation de pellicules spéciales telles que infra-rouges, de couleur et spéciales pour la détection des camouflages. Des études plus approfondies sont nécessaires pour l'utilisation de ces méthodes.

La Fotogrametría Aérea en los Reconocimientos Forestales

Se presenta el tema con una referencia a las circunstancias especiales en que suele emplearse la fotogrametría aérea en los reconocimientos forestales.

La información básica que puede obtenerse con la fotografía aérea incluye cálculos sobre la altura de los árboles, mediante el empleo de diversos métodos determinantes y sobre la densidad del follaje; diámetro de las copas; número de árboles, así como acerca de las especies de árboles y de los tipos forestales. Después es necesario continuar las investigaciones para comparar los resultados obtenidos por los diversos métodos determinantes y para averiguar en qué forma podrían influir en la aplicación de estos datos las condiciones de las distintas estaciones, las circunstancias en que fueron tomadas las fotografías y otros factores.

La fotografía aérea con su amplio alcance de visión brinda una oportunidad única para la clasificación y "estratificación" de los rodales forestales. Algunas veces ésta suele limitarse a zonas de muestreo en las fotografías, mientras que otras incluye todo el cultivo. En este trabajo se comparan también los diversos métodos de muestreo de bosques estratificados.

Se describe, además, la preparación de tablas de volumen basadas en las variantes determinables en las fotografías aéreas, con particular referencia al grado de correlación entre el volumen y las variantes de valor conocido o potencial. La mayoría de estas tablas incluye por lo regular el cultivo forestal completo, pero hay algunas que se refieren al árbol de por sí. Algunas veces se ha optado por preparar tablas locales de volumen, estableciendo para ello la correlación entre los datos locales y la tabla de volumen normal.

Se examinan, al mismo tiempo, los métodos de fotografías especiales de mayor importancia. Entre ellos se incluyen el sistema de tres cámaras, la fotografía en gran escala a base de muestreo y el uso de películas especiales tales como la infrarroja, la de color y la empleada para la detección de camuflaje. Se insta para que se continúen las investigaciones relacionadas con el empleo de los métodos citados.

The following are SPECIAL PAPERS of Sessions A and B.

Forest Inventory In Taiwan, Republic of China

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Description In General

Over 1,969,000 hectares of land area in Taiwan are forested. Of these, about 80 percent, or 1,409,900 hectares, are nationally owned. The total national forested land is divided into 41 working circles for management purposes. Forest management plans are applied only to national forests. By 1949, plans had been developed for a total of 1,233,180 ha. No aerial survey method had been introduced before 1953. Area sampling and simple sample plot methods were used for forest management planning or cutting purposes. A timber cruise was made whenever a stand was sold. Forested land area was counted from the planimetric base map, by using the simple compass survey. No sampling error was determined, and the accuracy of surveys was hard to estimate.

In 1954, an overall survey of the land use and forest resources of Taiwan was developed by means of an aerial survey. Since then, the aerial survey technique has been applied in phases of forest management survey and forest resource inventory, and is being widely used in Taiwan.

Forest Resource Survey and Intensive Forest Management Plan Surveys

Land Use and Forest Resource Survey of Taiwan

The Land Use and Forest Resource Survey is a Chinese-American cooperative project sponsored by the Joint Commission on Rural Reconstruction (JCRR). Working technicians were selected from the following agencies:

a. Taiwan Provincial Department of Agriculture and Forestry,
b. Taiwan Forestry Bureau,
c. Taiwan Forestry Research Institute, and
d. College of Agriculture, National Taiwan University.

The objectives of the survey for forest resources are: (1) to yield reliable data on forested land area and timber volume, including current growth, mortality and other data needed to formulate forest policy so as to assure proper management of the forest resources of Taiwan toward a sustained yield of the forest; and (2) to furnish information and suggestions on forestry establishments to various forest agencies concerned.

In the survey, the aerial photogrammetric technique was applied. Twenty-four strips were flown in an east-west direction at right angles to the general topography to take aerial photos. These photographs were taken with lens of 24-inch focal length, minus-blue filter and infrared film on scales of 1:10,000 to 1:8,000.

A double stratified sampling method was applied to this survey. Photo sample plots were randomly selected on the sample strips, totalling 37,495. They were first classified by forested and nonforested land and stratified by volume class and conservation problem area class for these two major land-use types. A total of 545 ground plots was chosen at random from the photo plots in each stratum. The photo plot was the basic sample to obtain forested and nonforested areas and timber volume; ground plots were used to control the photo plots, as well as to obtain ground information.

Each forested photo plot was carefully studied in the third dimension by the photo interpreter. Forest types were identified. Tree height was measured with a parallax wedge; crown density with a density scale; crown diameter with a micrometer. Stand volume class was thus determined. Forest types are classified as:

Conifer Types	— Spruce and Fir Hemlock Cypress Pine spp. Other conifers
Conifer	— Hardwood Types
Hardwood types	— Tropical hardwoods Subtropical hardwoods Temperate hardwoods
Bamboo types	

Stand density classes are classified as:

Poorly stocked: Crown density in percent	10-39
Medium stocked: Crown density in percent	40-69
Well stocked: Crown density in percent	70-100

Volume classes are shown in the following table, by the average volume per hectare in cubic meters:

Code of volume class	Cubic meter per hectare
00	00 — 49
05	50 — 99
10	100 — 149
15	150 — 199
20	200 — 299
30	300 — 399
40	400 — 499
50	500 — 749
75	750 +

The sampling errors of the total forested land area and the total volume in Taiwan are given as percentages of their respective totals for forested land area and volume, namely, ± 1.5 and ± 1.6.

In general, the range in area sampling error shown below can be expected:

Class area in hectares	Approximate area sampling error in percentage
Less than 50,000	Variable, usually over 40
50,000 to 100,000	Ordinarily between 20 - 40
100,000 to 300,000	Usually between 10 - 20
More than 300,000	Commonly less than 10

Intensive Forest Management Plan Surveys

The intensive forest management plan surveys were made for national forest working circles or other specific

areas. Their objective is to provide necessary information for the compilation of forest management plans. Surveys were carried out by the use of aerial photographs, which were taken by the Chinese Air Force at scales of 1:10,000 to 1:20,000, with panchromatic or infra-red film and with or without minus-blue filter.

A stratified sampling method was applied to these surveys. The total forested land area of each working circle or specific area was classified by volume classes or stand size classes. Ground plots were chosen at random from each class, with an average area of 1 square kilometer for each plot.

Within each plot, the merchantable length, d.b.h., rough and rotten cull of each sample tree were measured. Reproduction was tallied on specified plot sheets; the stand size, stand density and forest type were also recorded for each plot.

The survey results of the National Forest Working Circles are shown as follows:

Name of Forest Working Circle	Area (ha.)	Growing stock (m^3)	Annual net growth (m^3)	Sampling error (%)
Yu-ching	22,778	850,699	56,541	7.07
Hen-chun	20,439	1,100,061	41,057	5.58
Lou-nung-chi	65,348	8,638,781	46,494	5.05
Ta-chia-chi	59,134	11,515,381	100,272	7.56
Tai-ping-shan	65,486	12,358,486	66,877	3.40

Supplementary Research Work

The main forest resource survey and forest management plan survey in Taiwan are carried out together with a number of special studies. These special studies or associated research work were done by the surveyor or other forest agencies. Some studies are described as follows:

1. *Form class volume table.* Only a tree volume table based on d.b.h., tree height and average form factor was used in Taiwan for timber cruise purposes. Now, to meet the needs for forestry inventory, a form-class volume table is being prepared, and a four-factor Mayer's formula has been adopted. The volume of sawlog portion and upper stem volume are computed separately. The formulas are:

$$\log V = a + bx_1 + cx_2 + dx_3$$

V = sawlog volume or upper stem volume
x_1 = logarithm of d.b.h.
x_2 = total sawlog length
x_3 = form class.

Form classes were classified from 60 to 95 percent; volume of sawlog and upper stem volume were given for each d.b.h. class and sawlog length class.

2. *Special volume table for hardwoods.* Data collected from hardwood cutting areas were grouped into three different species groups, i.e., *Machilus* spp., oak species and other commercial hardwood species. Regression between d.b.h. classes was given in this table.

3. *Preparation of aerial stand volume table.* This project has been in operation since 1959. A total of 150 sample plots, which cover the whole forest area, are planned to be taken. Data will be calculated, and a regression equation will be designed to meet the need of work. Aerial stand volume tables will be made for conifers and hardwoods separately, and stand volume tables also will be used for estimating stand volume or volume class in measuring photo plots and photo interpretation. The whole project is expected to be completed by 1961.

A point-plot method will be used in field sampling work. An angle gauge, using the metric system, was designed for this purpose by the writer.

Local Problems and Plans for the Future

Problems of forest mensuration and inventory in tropical regions still exist in Taiwan. The inadequate aerial photos for inventory purposes and unsatisfactory data in the field of forest mensuration are the main problems in Taiwan's forestry.

1. *Problems in taking air photos.* Due to rough topographic conditions and the adverse weather conditions in the high mountain regions, aerial photos of the flat plains and of the high mountains in large scale are quite different. Moreover, one can hardly find good weather for taking aerial photos. Aerial photos can not be used for survey or inventory purposes if taken on cloudy days. To take better aerial photographs is rather a difficult problem in Taiwan.

2. *Field work is sometimes delayed by the heavy rains.* There are few fine days, particularly in the northern and northeastern regions of Taiwan. Field work is sometimes delayed by heavy rain, particularly in the typhoon season. Crews are kept in tents during the days of bad weather.

3. *Only 1:50,000 topographic maps are available to serve as base maps.* Maps in larger scale have to be prepared by the forest agencies themselves. Equipment and experienced technicians are lacking.

4. *Associated data for inventory should be prepared.* Some special studies have been done to facilitate the forest resource survey, such as the form-class volume table, aerial volume table and branch volume table, but the data gathered were not enough. We have to collect more data for regression study to fulfill the need in many details. For instance, the volume of different forest types, volume classes, and crown density classes will reduce the office computation work. A key to the photo-identification of forest types and a handbook for sampling technique and method of survey design will be necessary tools in performing the various phases of forest inventory work.

However, the aerial survey technique has been widely used in Taiwan. The forest resource inventory and the forest management plan survey are the two main tasks in the field of forest inventory, even though we lack technicians, and a big budget could not be supported by the government. However, the pure technical work is being improved by qualified specialists. The following articles indicate the trend for forest inventory in the future.

Surveying

Surveying to be done at a rate of 4 working circles per year. Nearly 200,000 hectares of forest land will be surveyed. Before the aerial survey method was adopted, only 2 working circles, or 100,000 hectares of forest land, could be surveyed by using the area sampling method or simple sample plot method. Now, aerial photography is considered the best method in making a forest inventory. Most of the job is carried out by using photo-control ground inventory. Since we have 41 working circles in

Taiwan national forests, the whole area should be surveyed within a period of ten years. In other words, 4 working circles will be surveyed each year.

Forest Resource Inventory

Intensive forest resource inventory combined with topo-mapping survey for forest working circles or specific areas. In 1955, an intensive forest resource inventory and a forest management plan survey were completed for the Experimental Forest of the National Taiwan University. The photographs used were taken by the Chinese Air Force with infra-red film, on scales of 1:20,000 to 1:14,000, covering the Experimental Forest area of 32,000 hectares or 320 km^2. These aerial photographs were used not only for seeking area, volume growth and mortality, and to provide the data for management planning, but also for the purpose of mapping, which was carried out recently. Later, in 1959, a topo-map of the Ta-shui-shan logging area was accomplished on a scale of 1:10,000. The map was also drawn to reflect forest types. Hardwoods and conifer-covered areas were separated on the map very clearly. In this way, a very intensive forest management plan can be accomplished by providing a detailed forest-condition map which is drawn with a large-scale topo-map as its base map.

The job which is described above will be carried on in the future. Many projects are set; topo-mapping equipment has been bought for this purpose, and a comprehensive natural resource survey is being carried out in forested areas.

Photo Mosaics for Forest Management

Mosaics for specific areas may serve the purposes of forest management and inventory cheaper and better than topographic maps. The foresters can interpret the forest types, crown density, and volume class from the photo directly, even for forest road construction, watershed management planning, or other conservation purposes. The cost of control photo mosaics is cheaper than the cost of topo-mapping surveys, but the impression of natural conditions is much better when using photos instead of topo-maps. A plan to build a controlled mosaic for each National Forest Working Circle is being projected in Taiwan, planning to use an orthophotoscope for photo mosaic purposes.

Training Foresters In the Use of Aerial Photos

The technique of photo interpretation is much needed for forest management purposes. Foresters are encouraged to use aerial photos in Taiwan, and a training center is being established to provide necessary training to local foresters or foresters from neighboring countries.

RESUMES

Recensement forestier a Taiwan République de Chine

Sur la superficie terrestre totale de Taïwan, 1.969.500 hectares—soit 55,1 pour cent—sont baisés, et 80 pour cent de la superficie forestière totale, soit 1.409.900 hectares, font partie du domaine national. L'ensemble de ces forêts domaniales est divisé en 41 "cercles de travail" aux fins d'aménagement.

L'application de la méthode de recensement au moyen de levés aériens date de 1953. Un inventaire général de l'utilisation des terres et des ressources forestières de Taïwan a été effectué au moyen de levés aériens en 1954. Depuis lors, ces techniques ont été appliquées aux diverses phases des opérations de recensement en vue de l'aménagement forestier.

Les données relatives aux ressources forestières, dans le recensement général, sont classées par différents types sylvestres:

Conifères
- Epicéa-sapin,
- Tsuga
- Cyprès,
- Pin,
- Autres conifères.

Conifères-feuillus

Feuillus
- Feuillus tropicaux,
- Feuillus sub-tropicaux,
- Feuillus des régions tempérées.

Bambou

En ce qui concerne le recensement en vue du plan d'aménagement des forêts nationales, la superficie inventoriée s'élève à 233.185 hectares. Ce sont là les principales réalisations pour ce qui est de l'inventaire forestier de Taïwan. Les travaux de recherche et la formation pratique en matière de recensement forestier se poursuivent depuis six années. Les techniques de recensement par levés aériens appliquées à l'inventaire forestier ont été acceptées et sont utilisées de façon extrêmement efficace dans cette région. On est en train de mettre sur pied à l'heure actuelle un Centre de Formation en matière de Levés Aériens pour l'Inventaire Forestier au service des forestiers locaux et de ceux des pays voisins.

Inventario de Bosques de Taiwan, República de China

De la superficie total el 55.1 %, o 1.969.500 hectáreas, estan cubiertas de bosques, de los cuales como el 80 %, o sean 1.490.900 hectáreas pertenecen al gobierno. Todos los bosques están divididos, para fines administrativos, en 41 círculos de trabajo.

Los reconocimientos aereos no se emplearon hasta 1953 y, en 1954, se hizo un estudio general aéreo del uso de la tierra y de la riqueza forestal de Taiwan. Desde entonces se ha empleado el reconocimiento aéreo en los aspectos administrativos de los bosques.

Los datos del riqueza forestal, tomados en el estudio general, se clasificaron según las distintas clases de bosques:

Coníferas
- Picea-Abies
- Tsuga
- Ciprés
- Pino
- Otras coníferas

Coníferas y maderas duras

Maderas duras
- Maderas duras tropicales
- Maderas duras subtropicales
- Maderas duras de zonas templadas

Bambú

Para la preparación del plan administrativo de bosques se inventariaron como 233.185 hectáreas. Estos son los resultados principales del inventario de bosques de Taiwan. En los últimos seis años han proseguido las investigaciones y la enseñanza práctica en el trabajo. Los reconocimientos aereos para el inventario de bosques han sido aceptados y plenamente utilizados en ests ramo y está en vías de establecerse un Centro de Práctica de Reconocimientos Aéreos para Inventario de Bosques con el objeto de preparar silvicultores para la República y los países vecinos.

Progrès et réalisation dans le secteur des enquêtes forestières en Italie

ISTITUTO CENTRALE DI STATISTICA

Italie

1. Dès la proclamation de l'unité italienne, il fut procédé à des enquêtes statistiques nationales concernant entre autres les forêts.

Entre cette époque et la fondation de l'Institut Central de Statistique (1927), de nombreuses enquêtes furent exécutées en Italie; la plupart étaient de caractère général, et englobaient donc toutes les forêts; seulement dans des cas spéciaux, elles se rapportaient uniquement à certaines catégories de forêt.

Pendant cette période, la détermination de la superficie boisée subit de sensibles variations, non seulement en raison de l'inclusion ou non au compte des forêts des bois de châtaigniers à fruit, très importants en Italie, mais encore en raison des différents critères suivis pour distinguer les forêts des autres destinations permanentes du sol.

Dans la répartition de la superficie boisée entre les différentes formes d'utilisation, espèces ligneuses et catégories de propriété, également, on n'adopta pas constamment les mêmes critères.

Des différences analogues se présentèrent dans le secteur de la production ligneuse.

Ces imperfections, plus ou moins graves, se reflétèrent sur le premier "Cadastre agraire" (1909), que nous citons ici séparément des autres enquêtes antérieures à 1927, en raison de son importance particulière comme relevé général organique de superficie et de production, exécuté en considérant à la fois toutes les qualités de culture constituant la superficie productive et avec des instructions détaillées aux opérateurs. Toutefois, dans ladite enquête comme dans les autres, l'attribution de la qualification de "forêt" à de nombreux terrains plus ou moins revêtus de formations d'arbres ou d'arbustes, fut souvent décidée sur la base de critères économiques, ou laissée au jugement de l'operateur.

2. Dans cette situation, il était naturel de sentir vivement la gêne dérivant de l'absence d'une base suffisamment fondée, tant en ce qui concerne l'extension effective des forêts, que leur production, selon des critères techniques précis.

En 1928, l'Institut prit soin de définir les différentes qualités de culture, et par conséquent la forêt, entendant par forêt un terrain revêtu de plantes forestières, arbres ou arbustes, où l'envergure de leur cime, au moment de la maturité, était supérieure à 50% de la superficie totale du terrain.

Par la suite, plusieurs initiatives furent prises, qui avaient toutes pour but d'obtenir un tableau le plus complet possible des superficies et des productions forestières, comme la formation du Cadastre forestier, l'institution du Service annuel de la statistique forestière, la préparation de la Carte forestière.

Pour tous les relevés concernant le secteur forestier, l'Institut se sert de la collaboration du Corps Forestier de l'Etat.

3. Parmi les initiatives prises pendant la période d'avant-guerre, l'une des plus importantes fut la formation du Cadastre forestier, commencée en 1929, de même que la mise à jour du Cadastre agraire sus-mentionné, sur la base de caractères distinctifs définis des qualités de culture, communs aux deux cadastres, parmi lesquels la définition de forêt sus-indiquée se trouva, par la suite, en pleine harmonie avec le concept de forêt adopté par la FAO.

Par le Cadastre forestier, on détermina directement sur place les superficies des forêts et des autres cultures forestières en se servant des cartes topographiques à l'échelle 1/25.000.

Pendant les premières années de l'enquête, les superficies furent estimées oculairement par commune ou section de commune; par la suite, lesdites superficies furent déterminées par la planimetration des surfaces délimitées à vue sur les cartes susdites.

Outre les superficies boisées, on releva—suivant les formes d'utilisation, l'espèce ligneuse et la catégorie de propriété—les accroissements ligneux moyens de maturité et les quantités moyennes annuelles unitaires des produits non ligneux, et par conséquent les productions ligneuses de chaque commune.

Les terrains non boisés ayant une végétation ligneuse déterminant une envergure non inférieure à 5% de la superficie étaient également inclus dans l'enquête.

Au moment de la suspension des travaux, due aux hostilités, l'enquête avait touché 1/3 du territoire national.

4. Dans le but de combler une grave lacune sur la connaissance des phénomènes concernant le secteur forestier, et de pouvoir suivre les développements dans le temps de ce secteur, fut institué en 1933 un Service annuel de la Statistique forestière, service régulier qui continue son oeuvre, avec les agrandissements et perfectionnements suggérés par l'expérience.

Les variations annuelles se produisant dans la superficie boisée de chaque commune sont relevées; on y distingue les diminutions selon leur cause (déboisement, incendies, etc.), ainsi que les utilisations annuelles, ligneuses et non ligneuses.

Les utilisations ligneuses étaient subdivisées, tout d'abord, suivant la qualité et la destination économique du matériel enlevé de la forêt; par la suite, les utilisations ont été également réparties suivant le type de forêt, l'espèce ligneuse et l'assortiment.

5. En 1935, sur l'initiative de l'Administration forestière, fut préparée la Carte forestière d'Italie, qui

donnait une représentation graphique de la distribution territoriale des forêts sur les cartes topographiques au 1/25.000, séparément selon la forme d'utilisation et d'espèce ligneuse (unique ou groupe d'espèces), tenant séparés des autres les forêts extrêmement détériorées.

En raison des buts particuliers de ce relevé et d'autres circonstances concomitantes, les critères et les méthodes de la Carte forestière ne correspondaient pas entièrement à ceux du Cadastre forestier, mais en tout cas, la première vision planimétrique de tout le patrimoine forestier national était réalisée.

6. L'Institut Central de Statistique, dans le cadre du programme en cours de réalisation pour le perfectionnement graduel des statistiques forestières, a à l'étude une enquête générale sur la consistance des forêts. Cette enquête ne donnera pas seulement un tableau complet de la sylviculture italienne; elle permettra en même temps de mieux répondre aux nécessités toujours croissantes des organismes internationaux.

Cette enquête a pour but de déterminer la superficie boisée par type de forêt et par catégorie de propriété, ainsi que la production, ligneuse et non ligneuse, y relative.

Le relevé de la superficie se base sur l'usage des cartes topographiques à l'échelle 1/25.000, sur lesquelles seront reportées, non seulement les limites communales, mais les délimitations des fractions agraires-forestières, qui représentent l'unité territoriale de relèvement.

En outre, dans le but d'alléger les opérations de campagne, on utilisera les aéro-photo-grammétries exécutées en 1954, d'où l'on pourra tirer les périmètres des "comprensori" boisés à reporter sur la cartographie.

Sur la base de la cartographie ainsi préparée seront effectués, par des techniciens spécialement préparés, les déplacements nécessaires pour déterminer les superficies des différents types de forêts et leurs caractéristiques.

Pour le relevé de la production, on adoptera la méthode de l'échantillonnage.

7. Dans l'attente de la réalisation de l'Inventaire général des forêts italiennes, l'Institut a, ces dernières années, effectué certaines réalisations, à savoir: les enquêtes sur les terrains incultes productifs (1950), sur le chêne-liège (1952) et sur la culture du peuplier (cette dernière est encore en cours de réalisation), et a complété les statistiques annuelles des utilisations forestières, en remplaçant les données globales par communes par les données relatives à chaque superficie boisée utilisée, à partir de l'an 1955.

8. Ont été considérés "incultes productifs" les terrains quasi stériles qui ne donnent qu'une production spontanée très limitée, récoltée ou non, mais utilisable en soi, étant apte à la consommation.

L'enquête avait une double fin: déterminer la superficie et l'emplacement desdits terrains, et établir si, et dans quelle mesure, ils étaient transformables pour des cultures plus avantageuses.

La détermination des superficies a été exécutée en délimitant sur les cartes topographiques au 1/25.000 les morceaux de terre d'une superficie supérieure à 1 hectare, et en mesurant ensuite les surfaces ainsi délimitées. Pour les morceaux de terrains inférieurs à 1 ha., la superficie a été évaluée à vue.

Dans le même temps ont été déterminées les possibilités de transformation de ces morceaux de terrain en d'autres qualités de culture, et lesquelles.

9. L'importance économique du liège, en ce qui concerne également les échanges internationaux, et la disparité des données existantes relatives à l'extension de la culture du chêne-liège et à ses produits, poussa l'Institut à effectuer, en 1952, une enquête spéciale, pour déterminer la consistance numérique des arbres et la production de liège femelle et de liège mâle, tant dans les forêts, que dans les autres qualités de culture.

Pour les forêts de chênes-liège pures ou mixtes, et pour les formations avec arbres de chênes-liège dans des terrains non boisés, déterminant une envergure supérieure à 5%, la superficie en fut relevée au moyen de la délimitation, sur les cartes topographiques au 1/25.000, des périmètres des zones y relatives, et de leur planimétration.

Pour les arbres épars, seul le nombre en fut relevé.

La production de liège fut obtenue en considérant: la rotation habituelle de décortication, la circonférence de l'arbre (groupés en 7 classes), la hauteur moyenne à décortiquer, l'épaisseur moyenne de l'écorce à la maturité, et le nombre des arbres, démasclés ou non.

Ces éléments furent relevés directement pour les arbres épars et pour les forêts ayant une superficie inférieure à l'hectare; pour les autres forêts, au contraire, ils furent établi suivant les critères communs appliqués pour le calcul de la masse ligneuse.

La production moyenne annuelle fut déduite de la production à fin de rotation, divisée par le nombre d'années de la rotation même.

Il fut procédé également à l'évaluation de la production du futur immédiat, en tenant compte des utilisations à prévoir sur la base de la rotation habituelle, et de l'année du dernier levage.

10. Le plus grand perfectionnement apporté après la guerre à la technique des relevés relatifs aux utilisations ligneuses, est l'adoption de la "Coupe" comme unité territoriale de relèvement en remplacement du territoire communal tout entier.

On entend par "coupe" la superficie boisée sur laquelle a été effectuée, sans solution de continuité, une utilisation totale ou partielle de la végétation.

Dans le modèle établi, les utilisations, distinctes selon les assortiments et destinations économiques, ont été considérées en fonction des différents caractères: le type de forêt, précisant toujours l'espèce ligneuse s'il s'agit de bois pur; la propriété; la catégorie des coupes, divisées en coupes de maturité, culturales et mites; la révolution; la superficie de la coupe; et le volume de l'utilisation.

La "coupe" a toujours une importance particulière, car elle présente une notion plus directe et plus approfondie des quantités de matériels ligneux levées des forêts qui, dans des conditions de saine sylviculture, devraient correspondre à peu près à l'accroissement annuel.

11. L'importance toujours croissante que prend la culture des peupliers en Italie a conseillé d'effectuer une enquête spéciale pour en relever la consistance.

Cette enquête, qui n'est pas terminée, distingue les peupliers selon qu'ils se trouvent en culture forestière, en culture d'alignement, ou en d'autres formes de culture (en plein, champêtre, etc.).

Le but de l'enquête est de déterminer la consistance numérique des peupliers, et leur masse ligneuse.

La consistance numérique est déterminée sur la base du relevé de la superficie occupée, ou de la longueur des rangées, en se servant des cartes topographiques au 1/25.000, et suivant les critères adoptés dans les enquêtes déjà décrites.

Pour les arbres épars ou groupés, le nombre en est déterminé par comptage direct.

La masse ligneuse des peupliers est déterminée par la méthode de l'echantillonnage.

12. Dans le but de connaître la consistance de la sylviculture italienne après la guerre, et pour répondre à la demande de la FAO, une évaluation de la superficie et de la production des forêts, par forme d'utilisation et espèce ligneuse, fut décidée en 1947.

Les données obtenues relativement à la superficie ont été utilisées pour l'établissement d'un fichier des bois par commune; ces données sont mises à jour suivant les indications du Service annuel de la statistique forestière.

En 1948 fut instituée la statistique forestière trimestrielle concernant: l'état des cultures forestières, en rapport aux adversités climatiques, aux attaques de parasites, et aux incendies de forêts, la marche des coupes, la protection forestière et les activités de l'Etat en vue de l'accroissement de la sylviculture.

Il y a lieu, enfin, de signaler l'effectuation d'une statistique trimestrielle relative aux travaux exécutés en montagne et dans les zones du littoral; cette statistique, commencée en 1950, fournit des données intéressantes qui permettent de suivre la marche de travaux particuliers, l'importance de la main-d'oeuvre employée, ainsi que le montant des dépenses.

13. En conséquence du développement des enquêtes suivant la méthode de l'échantillon pour la détermination des productions des cultures agricoles, le territoire de chaque Commune a été subdivisé en circonscriptions plus petites, dénommées fractions agraires-forestières, d'une étendue comprise entre 100 et 200 hectares.

Ces fractions sont constituées généralement par des terrains ayant des caractéristiques agrologiques à peu près homogènes et, si possible, des limites naturelles (fossés, routes, fleuves, etc.) faciles à reconnaître sur le terrain à l'aide de la cartographie.

Lesdites fractions ont été choisies comme unités territoriales de relèvement pour les enquêtes suivant la méthode de l'échantillon faites pour l'agriculture, et serviront de base également pour les enquêtes du secteur forestier.

14. Dans le secteur forestier, comme dans d'autres, l'Institut a décidé l'exécution de certaines enquêtes à effectuer suivant la methode de l'échantillonnage.

Le système de relèvement de ces enquêtes prévoit le choix au hasard des unités-échantillons, selon le système Poisson. Dans le cadre dudit système, le nombre des unités-échantillons est calculé de telle façon que l'écart entre la donnée fournie par l'échantillon et la donnée effective, ne dépasse pas 6% (degré de précision), tandis que le nombre des unités dans chaque couche est déterminé suivant le critère du choix optimal, lequel tient compte, non seulement du nombre des couches, mais de la variabilité desdites couches, exprimée par l'éccart carre métrique.

Comme il a été dit plus haut, dans l'enquête en cours pour la détermination de la consistance en peupliers de l'Italie, la production dans chaque province sera déterminée suivant la méthode de l'échantillon.

A cet effet, les arbres de peuplier ont été groupés dans les deux formes suivantes de culture: culture forestière (forêts pures et forêts mixtes), et masses de formation (cultures d'alignement, en plein, champêtres), pour lesquels il y aura lieu de considérer deux "univers" distincts, comprenant chacun une forme de culture. Pour chaque univers, la stratification des fractions dans les 4 classes diamétriques prévues, a été obtenue en attribuant à chaque fraction la valeur moyenne du diamètre des abres compris dans chacune d'elles.

Une nouvelle enquête, destinée à faire mieux connaître la culture du chêne-liège en Italie, a été décidée suivant des critères analogues.

Pour l'enquête générale sur la consistance et la production des forêts en Italie, la détermination de la masse ligneuse sera effectuée pour chacun des 5 "univers" prévus, à savoir: fûtaies de conifères, futaies de feuillus, taillis sous-futaie, taillis simples, forêts mixtes de conifères et de feuillus.

La stratification des fractions pour chaque univers sera effectuée sur la base des accroissements moyens attribués à chaque fraction, distribués en 5 classes d'accroissement.

15. Le 1er octobre 1960, l'Institut effectuera le premier Recensement général de l'agriculture, en adoptant comme unité de relèvement l'entreprise agricole entendue comme une unité technico-économique constituée par des terrains, même en morceaux non contigus, où se réalise la production agraire et forestière, et habituellement l'élevage du bétail, au moyen d'un exploitant, c'est-à-dire d'une personne physique, d'une société, etc., qui en supporte le risque, seul ou bien (dans le cas de métayage ou de colonie partielle) avec un patron.

En Italie, les entreprises à caractère nettement forestier sont peu diffusées; généralement, les terrains boisés complètent les entreprises agricoles ou zootechniques.

Dans le questionnaire général d'entreprise établi devront être signalés: la superficie des forêts subdivisée selon la forme d'utilisation, les caractères concernant le système d'exploitation, la forme juridique de l'entreprise, la grandeur et le titre de possession des terrains, les cultures pratiquées, les installations et les édifices existants, les espèces et quantités de bétail, les forces de travail et les moyens mécaniques, tous éléments qui permettront de mieux connaître les conditions de la sylviculture italienne.

16. De la description des enquêtes effectuées dans le secteur de la sylviculture, dans le but de déterminer la superficie et la production des forêts, il ressort que, ce n'est que depuis le début de l'activité de l'Institut Central de Statistique que lesdites enquêtes sont effectuées sur des bases méthodologiques rigoureuses, qui ont permis d'obtenir des données plus exactes relativement à ce secteur.

En particulier, en ce qui concerne la détermination de la masse ligneuse, une contribution déterminante sera apportée par l'adoption de la méthode de l'échantillon, qui s'est déjà affirmée comme moyen scientifique de relèvement en d'autres secteurs.

RESUMES

Progress and Achievements In Forest Surveying In Italy

Before the Central Statistical Institute was established (in 1927), a number of surveys, most of them of a general nature, were conducted in Italy. These surveys covered all the forests and only in special cases did they deal with certain classes of forests.

The 1909 agriculture survey was an organic one, which took into account all types of crops, including forests.

Beginning in 1927, various attempts were made to determine the forest area and forest production. One of these efforts which was particularly important was the organization of the forest survey which, like the work to bring the agricultural survey up to date, was begun in 1929 and eventually suspended because of the hostilities.

A regular Forest-Statistics Service was set up in 1933. It is still functioning, and has been enlarged, and improved.

Later, on the initiative of the Forest Administration, a "forest map" was drawn, showing graphically the distribution of forests throughout the country as of 1935.

Within the framework of the gradual improvement of forest statistics, the Central Statistical Institute has under consideration a general survey the purpose of which is to determine the forest area and production. These findings will be based not only on the topographic maps, but also on photogrammetrical aerial surveys.

Pending performance of the said survey, the Institute has done certain research work concerning, for example, fallow land that is capable of producing, and concerning the cork oak. Research on the cultivation of poplars is being carried on.

At the same time, work has been completed on the annual statistics concerning forest utilization, the different wooded areas intended for felling being taken as a territorial unit for the survey instead of the entire territory of the Commune, which supplies interesting data and information concerning the volume and characteristics of such utilization.

In order to learn the status of Italian forest reserves after the war, it was decided to make an evaluation of the area and production of the forests as compared with 1947.

Then a quarterly statistical survey of forests was instituted relating to the status of forest cultivation, the rate of felling, etc., as well as a statistical survey, also quarterly, of the work carried out in the mountains and in the coastal regions.

In the special investigations, as in the general investigation, in connection with surveys of the amount of timber in the forests, the method specified is the sampling method, which has given excellent results in the research work carried on in other fields.

On October 1, 1960, the Central Statistical Institute will take the first general census of agriculture, adopting the agricultural enterprise as the census unit. The data and information gathered by means of the general enterprise questionnaire drawn up will make it possible, among other things, to learn the conditions underlying Italian silviculture.

El Progreso Logrado en los Estudios Forestales en Italia

Antes de la creación del Instituto Central de Estadística en 1927 se habían efectuado ya en Italia numerosos estudios, en su mayor parte de carácter general, abarcando todos los bosques y, sólo en casos especiales, ciertas clases de bosques.

El catastro agrario de 1909 constituyó un levantamiento orgánico efectuado tomando en consideración, a la vez, todas las clases de cultivos, inclusive los bosques.

A partir de 1927 se hicieron muchos estudios para determinar la superficie y la producción de los bosques. Uno de ellos, particularmente importante, fue la formación del Catastro Forestal, lo mismo que el poner al día el otro catastro agrario citado, que se comenzó en 1929 y se suspendió a causa de la ruptura de hostilidades.

En 1933 se instituyó un Servicio de Estadística Forestal regularizado, que sigue en funciones y que con el tiempo se ha ensanchado y perfeccionado.

Asimismo, a iniciativa de la Administración Forestal se levantó una "Carta Forestal" que da una representación gráfica de la distribución territorial de los bosques en relación con el año de 1935.

En el cuadro del perfeccionamiento gradual de las estadísticas forestales, el Instituto Central de Estadística tiene en estudio una encuesta general con el fin de determinar la superficie y la producción de los bosques, determinación que se basará no sólo en cartas topográficas sino también en levantamientos aerotopogramétricos.

Mientras se termina dicha encuesta el Instituto ha emprendido ciertas investigaciones, por ejemplo, de los terrenos incultos productivos; el alcornoque; el cultivo de álamos. Estas se llevan a cabo actualmente.

A la vez, se han terminado las estadísticas anuales de las explotaciones forestales tomando como unidad territorial para el levantamiento las superficies de bosque sometidas a desmonte, en lugar del territorio entero de la Comuna, lo que proporciona informes y datos interesantes del volumen y características de esas explotaciones.

Con el objeto de determinar la situación del patrimonio forestal de Italia después de la guerra, se decidió efectuar el avalúo de la superficie y de la producción de los bosques en relación al año de 1947.

Después se instituyó la estadística forestal trimestral del estado de los cultivos forestales, el progreso de los desmontes, etc., así como una estadística, también trimestral, de las obras ejecutadas en las montañas y en las zonas del litoral.

Tanto en las encuestas particulares como en la general relativa a los cálculos de la masa leñosa de los bosques, el método empleado es el del muestreo, que ha dado excelentes resultados en las investigaciones efectuadas en otros ramos.

El 1 de octubre de 1960 el Instituto Central de Estadística levantará el primer censo general de la agricultura, adoptando como unidad general para el levantamiento, la empresa agrícola. Los datos e indicaciones que se recojan con el cuestionario general de empresas establecidas, permitirán, entre otras cosas, conocer la estructura de la silvicultura de Italia.

El Diámetro Medio en el Inventario

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En el Inventario de los montes ordenados, suelen medirse con forcípula los diámetros normales de centímetro en centímetro agrupándose en clases diamétricas de 10 en 10 centímetros.

Los valores modulares que sirven para la cubicación de la masa se calculan para cada una de estas clases diamétricas en las distintas unidades inventariales, esto obliga a calcular dentro de cada clase diamétrica y unidad el diámetro medio de la clase como media cuadrática de los diámetros que la componen.

Tratamos de demostrar en el presente trabajo, que podemos ahorrarnos este cálculo admitiendo diámetros medios fijos, viendo que con esta simplificación el error que se comete es admisible.

Si partimos del supuesto de que los piés se distribuyen según el criterio areal y hacemos tender a cero el intervalo de la clase diamétrica, el diámetro medio (media cuadrática) de los piés cuyos diámetros están comprendidos entre dos valores *a* y *b* es la media geométrica de esos valores extremos.

Si usando forcípulas con intervalos de 1 centímetro se cuentan como de 23 centímetros, por ejemplo, los comprendidos entre 22,5 y 23,5 centímetros, los valores extremos de las clases diamétricas de 10 centímetros serán 19,5 centímetros, 29,5 centímetros, 39,5 centímetros, etc.

Tomando para cada clase la media geométrica de sus valores extremos, tendremos los siguientes diámetros medios:

Clase Diamétrica	Diámetro medio (cms.)
2ª	23,98
3ª	34,14
4ª	44,22
5ª	54,27
6ª	64,31
7ª	74,33
8ª	84,35
9ª	94,37
10ª	104,38

Si en vez de los diámetros medios obtenidos tomamos los terminados en 4 (24, 34, 44, etc.) cometeremos—admitiendo aquellos como exactos—un error por exceso en la 2ª clase diamétrica inferior al uno por mil y errores por defecto en las clases restantes, siendo el de la 4ª la clase el mayor error relativo y sensiblemente igual al 0,5%.

Para las áreas basimétricas el error relativo es sensible mente igual al doble del error relativo del diámetro. Por tanto podemos decir:

"Si dentro de cada clase diamétrica los piés se distribuyen según el criterio areal, los errores relativos en áreas basimétricas cometidos por tomar como diámetros medios de las clases los terminados en 4, son inferiores al 1% en todas las clases."

En la práctica de los conteos no nos encontraremos distribuciones de piés que se ajusten perfectamente a la ideal establecida según el criterio areal. Por consiguiente, los diámetros medios de cada clase diamétrica no serán los antes calculados para dicha distribución, ni los errores cometidos en áreas basimétricas al tomar como diámetros los terminados en 4, tendrán el tope máximo del 1%.

Si la adopción de estos diámetros fijos como medios no tuviese otra finalidad que la de usarlos en el cálculo de volúmenes y crecimientos de los árboles medios, podríamos aceptarlos sin preocupación alguna, ya que el error con ello cometido no superaría, muy probablemente, a los que la determinación de valores modulares de alturas, coeficientes mórficos y crecimientos relativos lleva consigo.

Ahora bien, dato muy interesante del Inventario es el valor n d^2 de cada unidad inventarial, valor en que se apoya el cálculo de áreas basimétricas y relaciones de espaciamiento.

Si obtenemos los valores de n d^2 haciendo entrar en la suma todos los piés contados con sus diámetros medidos de centímetro en centímetro, los resultados no tendrán otros errores que los puramente objetivos correspondientes a la operación del conteo. Pero operando así, tendríamos la parte más penosa de la obtención de diámetros medios y no tendría razón de ser la simplificación que proponemos.

Hemos de prescindir de este cálculo, y obtener los valores de n d^2 de cada unidad inventarial multiplicando los piés de cada clase diamétrica por los cuadrados de 24, 34, etc., centímetro y sumando estos productos.

Esta simplificación trae consigo un nuevo error en los valores de n d^2, además de los correspondientes a la operación de conteo, error que vamos a estudiar apoyándonos en distribuciones reales.

En los inventarios de tres montes, hemos hallado los diámetros medios siguientes, medidos de centímetro en centímetro.

Clase Diamétrica	**Número de piés**	**n d^2 metros cuadrados**	**Diámetro medio (cms.)**
	DEMARCACIONES DE LA SIERRA		
2ª	186.441	10.843,4081	24,12
3ª	114.206	13.183,4982	33,98
4ª	60.319	11.505,4066	43,67
5ª	19.786	5.609,1318	53,24
6ª	4.184	1.660,5266	63,00
7ª	826	440,8094	73,05
8ª	206	141,2686	82,81
9ª	37	32,1699	91,78
10ª	9	9,5800	103,17
11ª	5	6,5699	114,63
12ª	3	4,3200	120,00
Totales	386.022	43.435,6891	

Clase diamétrica	Número de piés	n d² metros cuadrados	Diámetro medio (cms.)
	RIO MADERA Y ANEJOS		
2ª	108.937	6.310,4238	24,07
3ª	71.019	8.302,4241	34,19
4ª	47.265	9.112,3782	43,91
5ª	20.864	5.982,2041	53,55
6ª	6.031	2.414,2369	63,27
7ª	1.340	713,8532	72,99
8ª	233	159,3980	82,71
9ª	57	48,9148	92,64
10ª	9	9,3318	101,83
11ª	2	2,5325	112,53
12ª	1	1,5625	125,00
14ª	1	1,9600	140,00
Totales	255.759	33.059,2199	
	GARGANTA DE HORNOS Y AGREGADOS		
2ª	68.655	3.963,9196	24,03
3ª	40.048	4.616,2027	33,95
4ª	19.515	3.692,1645	43,50
5ª	6.171	1.751,1836	53,27
6ª	1.597	632,4114	62,93
7ª	374	199,7568	73,08
8ª	26	17,4461	81,91
9ª	5	4,3705	93,49
10ª	5	5,2100	102,08
Totales	136.396	14.882,6652	

Supuesta constante la relación de espaciamiento en cada clase diamétrica, la distribución areal exige una constancia de los valores de n d² por clases diamétricas que no se presenta en las distribuciones copiadas.

Vemos en éllas que los valores de n d² crecen, alcanzan un máximo en la 3ª clase diamétrica y decrecen.

En efecto, para las clases diamétricas que están en la rama ascendente (2ª en Demarcaciones y Garganta y 2ª y 3ª en Rio Madera) los diámetros medios encontrados son superiores a los de la distribución areal, lo que indica que faltan piés de los diámetros inferiores; y las clases diamétricas situadas en la rama descendente, con falta de piés de los diámetros superiores, tienen un diámetro medio inferior al de la distribución areal.

Si multiplicamos en cada grupo el número de piés de cada clase por los cuadrados de 24, 34, etc., centímetros y sumamos estos productos, obtenemos los siguientes valores de n d²:

Demarcaciones ..... 43.753,5472 m².
Rio Madera ..... 33.153,8104 m².
Garganta ..... 15.048,7496 m².

Tomando como buenos los valores de n d² del Inventario, los errores relativos cometidos son:

Demarcaciones ..... + 0,73%
Rio Madera ..... + 0,29%
Garganta ..... + 1,12%

Los tres errores son por exceso, por dominar en las tres curvas n d² la rama descendente.

El cálculo de errores relativos en n d² por clases diamétricas, tomando para cada una de ellas por n d² el producto del número de piés por el cuadrado del diámetro terminado en 4, es el siguiente:

Clase diamétrica	Errores (%) D.S.	R.M.	G.H.
2ª	−1,0	−0,6	−0,2
3ª	+0,1	−1,1	+0,3
4ª	+1,5	+0,4	+2,3
5ª	+2,9	+1,7	+2,8
6ª	+3,2	+2,3	+3,4
7ª	+2,6	+2,8	+2,5
8ª	+2,9	+3,1	+5,2
9ª	+4,9	+3,0	+1,1
10ª	+1,6	+4,3	+3,8
11ª	−1,1	+2,6	—
12ª	+6,8	−1,6	—
14ª	—	+5,8	—

Corresponden los mayores porcentajes de error (4,9 y 6,8 % en Demarcaciones, 4,3 y 5,8 % en Rio Madera y 5,2 % en Garganta) a clases diamétricas cuyo valor n d² sólo supone el 1/000 menos del total del grupo.

En las experiencias de errores en los conteos realizados con toda meticulosidad hemos encontrado, para forcípulas con intervalos de 1 centímetro, un valor de la desviación típica de los errores cometidos en las medidas de diámetros normales x igual a 1,49 centímetros. Parece acertado por tanto, admitir en los conteos normales como valor de la desviación típica x el de 2,00 centímetros.

Veamos ahora el límite del error debido a la simplificación. Llamando x al error cometido en una de las sustituciones del diámetro medio por el terminado en 4, puede considerarse x como una variable, estocástica que puede tomar los diez valores +4, +3, +2, +1, +0, −1, −2, −3, −4, y −5 centímetros, según que las medidas de los diámetros medios terminen en 0, 1, 2, ... 9 centímetros.

Si admitimos que los piés tienden a distribuirse según el criterio areal, en una unidad inventarial que tuviese piés de las clases diamétricas 2ª a 6ª la probabilidad pi de encontrarnos con el valor xi será:

xi	pi
+4	0,1332
+3	0,1236
+2	0,1149
+1	0,1073
0	0,1003
−1	0,0943
−2	0,0887
−3	0,0837
−4	0,0791
−5	0,0749

La esperanza matemática de x valdrá:

$$E(x) = p_i x_i = +0{,}027 \text{ cms.}$$

La dispersión o varianza:

$$x = E(x - E(x))^2 = p_i x_i^2 - (E(x))^2 = 8{,}150 \text{ cms.}^2$$

Y la desviación típica será:

$$x = 8{,}150 = 2{,}85 \text{ cms.}$$

Para un determinado nivel de confianza los límites del error son proporcionales a las desviaciones típicas.

Si tenemos que aceptar forzosamente un error en el valor de n d² debido al conteo del que sólo podemos conocer sus probables límites, no vemos gran inconveniente en introducir voluntariamente, simplificando el

cálculo, un nuevo error cuyos límites probables no llegan a ser vez y media los del anterior.

Error que solo puede esperarse sea grande cuando el número de piés de la unidad inventarial sea pequeño—aunque en este caso también, es de temer sea grande el error debido al conteo—y que será tanto más pequeño cuanto mayor sea el número de piés de la unidad inventarial.

En el cuadro siguiente copiamos los resultados obtenidos para cada Cuartel de los tres montes considerados calculando los valores de n d^2 operando con diámetros fijos, terminados en 4, juntamente con el número de piés y el valor de n d^2 tomados de los Inventarios. También figuran los diámetros medios (media cuadrática) los errores relativos resultantes de la simplificación y los límites de estos errores.

Sección	Cuartel	Número de piés N	Valores de n d^2: Del Inventario m^2	Valores de n d^2: Calculados con diámetros terminados en 4. m^2	Error cometido con la simplificación. %
		DEMARCACIONES DE LA SIERRA			
1ª	A	26.495	3.409,5215	3.482,4840	+2,14
	B	13.011	1.746,5499	1.740,9356	−0,32
2ª	A	40.310	4.766,7923	4.840,7760	+1,55
	B	31.448	3.623,5077	3.647,6388	+0,67
	C	39.094	4.761,7991	4.799,5604	+0,79
3ª	A	33.745	3.687,3344	3.694,3420	+0,19
	B	46.700	4.304,5091	4.341,0120	+0,85
4ª	A	25.942	2.293,3327	2.313,7292	+0,89
	B	36.093	3.874,0927	3.903,3708	+0,76
	C	32.011	3.614,5563	3.628,3036	+0,38
5ª	A	19.827	2.481,3656	2.483,2952	+0,08
	B	20.803	2.394,6477	2.398,2648	+0,15
6ª	A	9.995	1.021,0348	1.025,9820	+0,48
	B	10.548	1.456,6453	1.453,8528	−0,19
Total		386.022	43.435,6891	43.753,5472	+0,73
		RIO MADERA Y ANEJOS			
1ª	A	26.769	3.699,5406	3.735,4364	+0,97
	B	28.719	3.516,1511	3.526,9844	+0,31
	C	32.922	4,693,0428	4.681,3572	−0,25
	D	29.235	4.171,1281	4.157,0640	−0,34
	E	23.751	3.200,3545	3.218,8716	+0,58
	F	24.882	3.550,0428	3.528,2852	−0,61
2ª	A	24.180	2.477,9107	2.477,9107	+1,30
	B	39.769	4.815,2310	4.837,9124	+0,47
	C	25.532	2.935,8183	2.957,9412	+0,75
Total		255.759	33.059,2199	33.153,8104	+0,29
		GARGANTA DE HORNOS Y AGREGADOS			
1ª	A	9.988	1.246,5927	1.259,5548	+1,04
	B	40.462	4.819,2796	4.841,5572	+0,46
2ª	A	28.971	3.242,5970	3.299,2836	+1,75
	B	56.975	5.574,1959	5.648,3540	+1,33
Total		136.396	14.882,6652	15.048,7496	+1,12

Vemos que en cuanto a su valor absoluto, de los 30 errores relativos obtenidos, solo 7 pasan del 1 % y uno del 2 %.

La posibilidad de la aplicación de esta simplificación a cualquier unidad inventarial, cualquiera que sea su número de piés, se deriva de las siguientes razones:

1ª En el cuadro anterior vemos que los errores relativos se agrupan alrededor del valor central, más o menos desplazado de cero.

2ª Si debido al escaso número de piés de la unidad inventarial, los errores debidos a la simplificación pueden ser grandes, también lo serán los debidos al conteo y con prescindir de la simplificación no aseguramos la bondad del valor de n d^2 obtenido.

3ª Los inconvenientes del error, quedan disminuídos por el hecho de poder conocer su valor central aproximado y los probables límites de ese error.

Si nos despreocupamos de los errores que con la determinación de valores modulares de alturas y coeficientes mórficos pueden cometerse y nos atenemos exclusivamente al error que en la cubicación de una unidad inventarial se produce como consecuencia de tomar como diámetros medios los terminados en 4, el error relativo cometido en cada clase será igual al cometido en n d^2.

En efecto, siendo n_2 el número de piés de la 2ª clase y D_2 el diámetro medio (media cuadrática) de la clase, el error relativo en n d^2 es:

$$\frac{n_2 \cdot 24^2 - n_2 \cdot D_2^2}{n_2 \cdot D_2^2} = \frac{24^2 - D_2^2}{D_2^2}$$

Y el error relativo en la cubicación de la clase será:

$$\frac{n^2 \cdot \frac{}{4} \cdot 24^2 \cdot h_m \cdot c_m - n^2 \cdot \frac{}{4} \cdot D_2^2 \cdot h_m \cdot c_m}{n_2 \cdot \frac{}{4} \cdot D_2^2 \cdot h_m \cdot cm} =$$

$$= \frac{24 - D_2}{D_2^2}$$

El hecho de que el valor modular de la altura reducida ($h_m \cdot c_m$) sea, en general, crecimiente con las clases diamétricas, hace que en tipos de distribución como los encontrados para los tres grupos estudiados, el error relativo en volumen debido a la simplificación sea mayor que el error relativo en n d^2, ya que en la distribución de volúmenes por clases diamétricas tomará mayor preponderancia la rama descendente, que es la de los errores relativos por exceso.

En los cuadros siguientes se comparan los errores relativos cometidos en volúmenes y en n d^2 para las mismas unidades.

Sección	Cuartel	Volúmenes: Del Inventario m_3	Volúmenes: Calculados con diámetros terminados en 4. m_3	Errores relativos: En volumen %	Errores relativos: En n d^2 %	Diferencia de errores %
		GARGANTA DE HORNOS Y AGREGADOS				
1ª	A	8.644,244	8.822,241	+2,06	+1,04	+1,02
	B	25.422,547	25.990,701	+2,23	+0,46	+1,77
2ª	A	16.832,320	17.221,082	+2,31	+1,75	+0,56
	B	27.542,641	28.123,586	+2,11	+1,33	+0,78
Total		78.441,752	80.157,610	+2,19	+1,12	+1,07

(La Tabla Continua.)

		DEMARCACIONES DE LA SIERRA				
1ª	A	21.741,073	22.427,625	+3,16	+2,14	+1,02
	B	11.149,564	11.230,986	+0,73	−0,32	+1,05
2ª	A	31.602,901	32.347,362	+2,36	+1,55	+0,81
	B	23.226,057	23.671,265	+1,92	+0,67	+1,25
	C	31.900,275	32.368,259	+1,47	+0,79	+0,68
3ª	A	17.729,408	17.972,831	+1,37	+0,19	+1,18
	B	19.450,187	19.905,032	+2,34	+0,85	+1,49
4ª	A	11.187,525	11.450,258	+2,35	+0,89	+1,46
	B	20.450,806	20.671,469	+1,08	+0,76	+0,32
	C	19.348,295	19.586,080	+1,23	+0,38	+0,85
5ª	A	14.268,950	14.450,620	+1,27	+0,08	+1,19
	B	13.537,314	13.708,437	+1,26	+0,15	+1,11
6ª	A	4.676,243	4.744,277	+1,45	+0,48	+0,97
	B	7.870,290	7.927,003	+0,72	−0,19	+0,91
Total		248.138,888	252.461,504	+1,74	+0,73	+1,01

Confirmando lo dicho, vemos que los errores relativos en volúmenes son mayores que lo de n d^2. Aproximadamente podemos decir que la diferencia entre ambos errores es + 1,00 % (diferencias extremas, + 1,77 en 1ª B de Garganta y + 0,32 en 4ª B de Demarcaciones).

Claro que estas diferencias no dependen exclusivamente del tipo de distribución, sino también de que los valores modulares de alturas reducidas sean más o menos crecientes con la clase diamétrica.

The Mean Diameter in the Inventory

No resume of this paper was made available.

Le diamètre moyen sur l'inventaire

Le présent exposé n'a pas fait l'objet d'un résumé.

Métodos Más Usuales en México en la Inventarización de Bosques de Clima Templado o Frío y Determinación del Volumen de Corta Anual

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En México los bosques de clima templado y frío ocupan una superficie aproximada de 10.5 millones de hectáreas y se han clasificado en la siguiente forma:

Agotados	4.0 millones de has.
Explotables no vírgenes	3.5 " " "
Vírgenes	3.0 " " "

Los géneros dominantes son *Pinus* y *Abies* vegetando en las partes elevadas de los sistemas montañosos y altas mesetas.

Para calcular las existencias, los incrementos y el volumen de corta anual, se procede en las siguientes formas:

Existencias

Mediante una inspección ocular del bosque se determinan los lugares adecuados para el levantamiento de los sitios de ensayo, los que generalmente afectan forma de fajas paralelas, de anchura uniforme (20 m. lo más común). La superficie ensayada, según las características de la masa, varía del 1 al 10 por ciento.

La medición de los diámetros de los árboles se hace a 1.30 m. del suelo (diámetro a la altura del pecho), haciéndose la inventarización a partir de .15 m. de diámetro.

Los resultados se tabulan en la siguiente forma:

TABLA 1

RESUMEN DE LOS SITIOS DE ENSAYO

PINO

D.A.P. Cms.	Sitio 1 7 Has. No. Arb.	Sitio 2 6 Has. No. Arb.				Sitio 6 10 Has.		Promedio Arb. por Ha.
15	165	150	...	...	...	135	...	11.51
20	131	138	...	...	...	112	...	9.18
25	102	134	...	...	...	103	...	8.39
..	...	...	...	...	...	...	...	...
..	...	...	...	...	...	...	...	...
70	2	10	...	...	...	11	...	1.15
75	5	17	...	...	...	10	...	1.36
..	...	...	...	...	...	...	...	...
..	...	...	...	...	...	...	...	...

La determinación del "Volumen por Hectárea" se hace cubicando cuando menos 3 árboles por cada categoría diamétrica usando la fórmula:

$$V = V_1 \frac{d^2}{d_1^2}$$

En otros casos los datos se armonizan por métodos gráficos y cuando todos los pares de valores han sido señalados en los ejes de coordenadas, se traza a pulso la curva $V=f(D)$ para deducir de ella nuestra tabla de volúmenes. Cuando los datos de volúmenes para diámetros iguales varían entre amplios márgenes y se desea obtener en la adaptación de curvas la mayor exactitud posible, se hace la armonización matemática por medio mínimos cuadrados empleando la ecuación tipo $V=cD^a$, en donde *"V" es el volumen, "D" el diámetro* con corteza a la altura del pecho y "c" y "a" las constantes que definen la dependencia funcional entre las variables "V" y "D". Reduciendo de la ecuación a forma lineal, tenemos:

$$\log V = \log c + a \log D$$

Para simplificar designamos: $\log V=X$; $\log c=K$; y $\log D=A$; entonces $X=K+aA$.

Los valores más probables de las constantes son aquellos para los que la suma de los cuadrados de las desviaciones es un mínimo, siendo estas desviaciones las diferencias entre los valores reales y los calculados a la variable dependiente.

Designando Suma por "S" y suponiendo que los errores de observación se distribuyen de acuerdo con la ley normal del error, los valores más probables de las constantes son aquellos que hacen de $S(K+aA-X)^2$ un mínimo. Las ecuaciones normales para la solución se obtienen igualando a cero las derivadas parciales de la expresión anterior respecto de las incógnitas "K" y "a." Efectuando esta operación respecto de "K" tenemos:

$$d\,S\,(K + aA - X)^2 = 0, \quad o\ 2S\,(K + aA - X) = 0$$

respecto de "a" tenemos:

$$d\,S\,(K + aA - X)^2 = 0, \quad o\ 2S\,(K + aA - X)\,A = 0$$

Desarrollando:

$$SK + a\,SA - SX = 0 \ldots\ldots\ldots(1)$$
$$KSA + a\,SA^2 - SXA = 0 \ldots\ldots\ldots(2)$$

Los valores más probables de "K" y "a" se obtienen resolviendo simultáneamente las dos ecuaciones normales (1) y (2).

Para un rodal de los bosques de la Unidad Industrial de Triplay y Maderas de Durango, en Durango, México, la tabla de volúmenes se obtuvo por este método de armonización matemática y como ejemplo una parte de la tabla con los datos necesarios para obtener los valores de las constantes "c" y "a" de la ecuación $V=cD^a$ se cita a continuación, la que por su tamaño únicamente se resume:

D Decim.	V en M3.	log D A	log V x + 2	A^2	(X + 2) A
1.2	.056	.0792	.7482	.0063	.0592
..	...	...	...	...	...
1.4	.080	.1461	.9031	.0213	.1319
..	...	...	...	...	...
..	...	...	...	...	...
3.8	1.675	.5798	2.2240	.3362	1.2895
..	...	...	...	...	...
..	...	...	...	...	...
..	...	...	...	...	...
9.6	14.319	.9823	3.1557	.9649	3.0998
SUMAS:		104.1548	379.6944	76.2016	269.3978

NOTA:—El número de árboles cubicados fué de: 162.

Poniendo las valores de estas sumas de la tabla a las ecuaciones normales (1) y (2), se obtienen las siguientes:

$$162\ K + 104.1548\ a - 379.6944 = 0$$
$$104{,}1548\ K + 76{,}2016\ a - 269.3978 = 0$$

De la resolución de estas ecuaciones se determinaron los valores $a = 2.7368$ y $K = 0.5842$.

Como en la tabla al logaritmo del volumen de cada árbol se le agregaron 2 unidades para trabajar con características negativas, se tiene finalmente:

$$\log V + 2 = .5842 + 2.7368 \log D$$
$$\log D = 2.7368 \log D - 1.4158$$
$$V = \frac{D^{2.7368}}{26.05}$$

Con esta ecuación se calcularon los volúmenes de los árboles en función de los valores de sus diámetros.

En los casos en los que se requiere mayor exactitud se usa la ecuación tipo: $V=D^a\ H^b\ c$ en donde "V" significa el volumen del árbol, "D" su diámetro a la altura del pecho y "H" la altura total del árbol; "a" y "c" son las constantes por calcular. Determinadas las constantes siguiendo el sistema anterior se obtiene una tarifa de volúmenes de las denominadas de doble entrada. Un sistema semejante utilizó el Ing. Rodolfo Rodríguez Caballero en el estudio de la Unidad de Atenquique, Jalisco, en donde consignó todas las características utilizables del árbol tales como volúmenes de fustes sin corteza, con corteza, de ramaje, alturas, coeficientes de apilamiento, etc.

Contando con los volúmenes correspondientes a los árboles de 15, 20, 25, etc., centímetros de diámetro y conociendo el número de sujetos que por categoría diamétrica existen en promedio en una hectárea, el volumen de la hectárea, o sean sus existencias, se obtiene multiplicando el número promedio de árboles por categoría por el volumen de árbol de esa categoría y summando los resultados. Las existencias totales delrodal será el producto de su superficie por el volumen de su hectárea tipo.

Incrementos

El incremento anual en volumen del rodal del bosque en estudio es el utilizado para calcular el volumen de corta anual. Este incremento lo obtenemos a partir del crecimiento anual en diámetro por árbol en las distintas categorías diamétricas.

Los datos necesarios los obtenemos de los mismos árboles que se cubicaron para formar la tabla de volúmenes $V=f(D)$, determinando en ellos sus edades mediante el conteo en la sección de corte, de los anillos de crecimiento anual para el efecto del trazo de la curva $D=f(E)$ por métodos gráficos.

Con la tabla de volúmenes y conociendo las edades que corresponden a los diferentes diámetros, se determinan los diámetros y volúmenes alcanzados por cada categoría después de cinco o diez años; con estos resultados se calculan los incrementos en volumen en dicho período y los anuales dividiendo dichos incrementos entre el número de años del período: $Ia=\frac{V-v}{n}$ en donde "V" = volumen del árbol al finalizar el período, "V" = volumen al iniciarse el período y "n" = número de años del periodo. El incremento anual del rodal, por unidad de superficie,

se obtiene sumando los incrementos anuales de cada categoría diamétrica.

D.A.P.	Volumen M3	Edad Años	Promedio Arb. Por Hect.	Volumen Por Categ.	Despues de 5 años D.A.P.	Despues de 5 años Volumen	Incremento Volumen 5 Años	Incremento En Un Año	Incremento Por Hect. Y Categoria
15	.136	28	11.51	1.565	18	.213	.077	.015	.172
20	.277	35	9.81	2.717	24	.433	.156	.031	.304
..	..	..	..	....	..	..	..	..	..
..	..	..	..	....	..	..	..	..	..
..	..	..	..	....	..	..	..	..	..
70	6.109	102	1.15	7.025	73	6.776	.667	.133	.153
75	7.244	112	1.36	9.852	78	7.980	.736	.147	.200
..	..	..	..	....	..	..	..	..	..
..	..	..	..	....	..	..	..	..	..

Sumas: Incremento corriente annual: 4.618 M3

En otros casos, en los árboles derribados, se hacen análisis troncales para determinar los volúmenes que el árbol tuvo en sus diferentes edades V=f (e), calculándose los incrementos por métodos gráficos.

Cuando se desea evitar el derribo de árboles se hace uso del taladro de Pressler para calcular los crecimientos en diámetro. Los datos necesarios de cada árbol son: diámetro a la altura del pecho; longitud de la viruta sacada con el taladro "L" y el número de anillos contados en dicha viruta "N". Con tales datos se obtiene el valor del diámetro que tenía el árbol N/2 años antes y al que denominaremos Dx. El crecimiento que el árbol de diámetro Dx tuvo en un período de N/2 años, será igual 2L/N.

Cuando para la adaptación de la curva D=f(E) se requiere la mayor exactitud posible, se hace la armonización matemática por mínimos cuadrados usando la ecuación siguiente:

$$D = a E^2 + b E$$
$$E = A D^2 + B D$$

En donde "a", "b", "A" y "B" son las constantes que definen la dependencia funcional entre las variables Diámetro y Edad.

En el caso de la ecuación $D = a E^2 + b E$, los valores más probables de las constantes "a" y "b" son los que hacen de $S (a E^2 + b E - D)^2$ un mínimo. Las ecuaciones normales se obtienen igualando a cero las derivadas parciales con respecto a "a" y "b".

$$a S E^3 + b S E^2 - S D E = 0$$
$$a S E^4 + b S E^3 - S D E^2 = 0$$

S = Suma
D = Diámetro
E = Edad

Para un rodal de los bosques de la Unidad de Explotación de Triplay y Maderas de Durango, se obtuvieron los siguientes coeficientes deducidos de los datos de la tabla que se cita a continuación y en donde las columnas "D" y "E" nos indican el diámetro medio de la categoría diamétrica y su edad media correspondiente, siendo "f" las frecuencias o número de árboles medidos:

D	E	f	fE^2	fE^3	fE^4	fD^2	fD^3	fD^4	fDE	fDE^2	fD^2E
12	20	12	4,800	96,000	1,920,000	1,728	20,736	248,832	2,880	57,600	34,560
18	32	11	11,264	360,448	11,534,336	3,564	64,152	1,154,736	6,336	202,752	114,048
..	..	..	....	....	....	....	....	....	....	....	....
..	..	..	....	....	....	....	....	....	....	....	....
..	..	..	....	....	....	....	....	....	....	....	....
74	175	4	122,500	21,437,500	3,751,562,500	21,904	1,620,896	119,946,304	51,800	9,065,000	3,833,200
77	185	7	239,575	44,321,375	8,199,454,375	41,503	3,195,731	246,071,287	99,715	18,447,275	7,678,055
..	..	..	....	....	....	....	....	....	....	....	....
..	..	..	....	....	....	....	....	....	....	....	....
SUMAS:			2,403,589	379,462,269	62,078,856,421	363,964	23,098,954	1,571,914,108	930,325	147,767,267	58,125,373

Ecuaciones normales:

$$62{,}078{,}856{,}421\ a + 379{,}462{,}269\ b = 147{,}767{,}267$$
$$379{,}462{,}269\ a + 2{,}403{,}589\ b = 930{,}325$$

y de donde:

$$a = 0.00041 \text{ y } b = 0.32208\ E$$
$$D = 0.00041\ E^2 + 0.32208\ E$$

Igual procedimiento se sigue para determinar los valores de las constantes: "A" y "B", siendo las ecuaciones normales:

$$ASD^4 + BSD^3 - SED = 0$$
$$ASD^3 + BSD^2 - SDE = 0$$

Conocidas las relaciones D=f(E), E=f(D) y V=f(D), se determinan los diámetros y volúmenes alcanzados por cada categoría después de un año y el incremento anual por unidad de superficie sumando los incrementos anuales de cada categoría.

Este procedimiento matemático fué introducido a México en 1937 por el Ing. Forestal H. Arthur Meyer para bosques de coníferas de gran extensión y de edades múltiples, determinando el crecimiento en diámetro mediante la derivada de la ecuación

$$D = a E^2 + bE$$

$$\text{Incremento igual } \frac{dD}{dE} = 2\ a\ E + b =$$

$$2\ a\ (AD^2 + BD) + b.$$

Otro procedimiento seguido en México con el mismo objeto consiste en usar polinomias de tercer grado de la forma:

$$D = a E^3 + bE^2 + cE.$$
$$E = A D^3 + BD^2 + CD$$

El Ing. Rodolfo Rodríguez Caballero, en el Estudio de la Unidad Industrial de Explotación Forestal de Atenquique, S. A. del Estado de Jalisco, cálculo del incremento en volumen a través de sus porcentajes empleando la siguiente expresión:

$$\%\ (Icv.\ Vf.\ sc./Vf.\ sc) = K.e.^{\ a.x + b.x^2}$$

en la cual: "K", "a" y "b" son las constantes; "e" es la base de los logaritmos Neperianos y "x" es el diámetro del árbol a la altura del pecho con corteza.

Los adelantos logrados en las técnicas de inventarización de bosques mediante la aplicación de la fotogrametría aérea de eje vertical y las teorías estadísticas racionales, por los EE.UU. y otros países Europeos desde a raíz de

la Segunda Conflagración Mundial, fueron introducidos en México hace apenas diez años. Sin embargo, contamos ya con procedimientos propios cuya bondad está sujeta a comprobación mediante experiencias controladas que nuestro Instituto Nacional de Investigaciones Forestales tiene en proceso para recomendar lo procedente.

El Ing. Rodríguez Caballero, Técnico de la Michoacana de Occidente, siguiendo los métodos fotogramétricos clásicos levantó triangulaciones topográficas de apoyo terrestre que se complementan con triangulaciones radiales mecánicas para construir el plano base; se clasifican los diversos estratos atendiendo a las características de espesura, mezcla de los principales géneros botánico-forestales y altura, estableciendo grados conforme a la irregularidad de los montes bajo estudio; se restituye la planimetría mediante múltiplex, multiscopio o sketchmaster; se muestrea al azar dividiendo los bosques en "Blocks" en los que se trazan fajas de poca anchura para localizar en ellas sitios generalmente chicos, por ejemplo de 20 x 60 m., variando la intensidad del muestreo del 2 al 4% de la superficie planificada; por estratos se aplican los promedios de número de árboles por hectárea determinando la precisión del muestreo; dividiendo los bosques en zonas, se construyen tablas de volúmenes en función del diámetro para cada una de las clases de alturas consideradas. Los incrementos en diámetro se determinan mediante observaciones de taladro, promediándolas por estratos, con los que se calculan crecimientos en volumen anuales o periódicos.

Las innovaciones introducidas por nuestros técnicos para la construcción del plano-base sustituyen las triangulaciones topográficas por una serie de bases terrestres que se incrementan a redes de triangulación fotogramétrica formadas por isolíneas que unen puntos principales contiguos y laterales calculadas analíticamente, con las que se construyen marcos de apoyo de "plantillas" de papel transparente hechas para cada foto y que reemplazan a su vez las "estrellas" de templets. La planimetría se restituye mediante el radialestereógrafo, aparato de invención mexicana, de alta eficiencia y bajo costo. La delimitación de estratos, que por ser estudiados individualmente en este caso se llaman "rodales", y su clasificación, se hace atendiendo a grados de espesura, de mezcla de géneros botánico-forestales y de existencias volumétricas por hectárea; en cada rodal se levanta un sitio de muestreo con extensión no menor del 2% de su superficie, haciendo extensivos sus resultados solamente al área del rodal a que corresponden. La cubicación de las existencias de cada rodal se basa en tablas de volúmenes construídas en función del diámetro y altura, deduciéndose ésta por zonas a través del promedio de numerosas observaciones. Finalmente, los crecimientos en diámetro se hacen por observaciones de taladro.

Las escalas de los vuelos fotogramétricos más usadas en nuestro país para fines forestales son las de 1:20,000, teniéndose voladas más de dos millones de hectáreas de terrenos forestales y estando por iniciarse en 1961 levantamientos extensos para la formulación del inventario nacional boscoso de México.

Posibilidad o Volumen de Corta Anual

Dentro del método de beneficio de monte alto, en México se aplica casi exclusivamente el sistema de selección individual o entresaca, ampliándolo en ocasiones a la selección de pequeños grupos de sujetos que han llegado a su edad de cortabilidad o turno elegido.

La adopción de este sistema se basa en lo quebrado del Territorio sobre todo en los lugares dondo existen los bosques de coníferas y el escaso valor de productos de pequeñas dimensiones aunado a la mayor protección que este sistema otorga al suelo y al repoblado.

Como nuestros bosques se encuentran formados por un conjunto de árboles de todas las edades, distribuídos irregularmente en toda la superficie, sin que los grados de edad esten debidamente proporcionados, hay necesidad de encauzar su explotación en tal forma que tienda a obtener, en el transcurso de determinado tiempo, un bosque normal.

Para obtener la distribución requerida de los diversos grados de edad, el problema que se presenta es la determinación del volumen que es necesario cortar anual o períodicamente. Este problema se resuelve tomando como base el volumen actual del bosque, el que correspondería en el estado normal, el incremento anual y la edad de cortabilidad o turno. El volumen de los árboles por aprovechar será mayor, menor o igual al incremento anual, según que las existencias actuales sean mayores, menores o iguales a las existencias normales.

Para reducir los gastos de explotación y aumentar el volumen de corta por hectárea, la posibilidad anual no se extrae de toda la extensión, sino que el bosque se divide en cierto número de partes con volumen semejante y cada año la corta se limita a una de estas divisiones. Las cortas se hacen sucesivamente en cada división hasta llegar a la primera. El intervalo de una corta a otra en la misma superficie es la duración del "ciclo de corta."

Conocido el volumen de corta anual, el valor del ciclo dependerá de la intensidad de corta que por hectárea se adopte ya que, entre mayor sea ésta, menor será el área de corta anual y, por lo tanto, mayor la duración del ciclo.

El Servicio Forestal Mexicano tiene establecido que el valor del ciclo de corta se calcule con base en el porciento de intensidad de corta que por hectárea se fije en relación con las existencias reales, generalmente un 35% como máximo. Considerando a las existencias reales como un capital cuyos intereses anuales, iguales al incremento corriente anual, se acumulan año por año a dicho capital para producir a su vez interés al año siguiente, las leyes que rigen el cálculo del interés compuesto fijan el procedimiento a seguir: elegido el porciento de intensidad de corta, se determina el volumen por cortar y el que quedará en pié por hectárea después de la corta; se calcula el porciento del incremento corriente anual de este último volumen y el período necesario para que al trabajar a interés compuesto iguale a las existencias reales encontradas por hectárea. El período así determinado nos da el valor del ciclo de corta.

El *área de corta anual* se obtiene dividiendo la superficie total arbolada entre el ciclo de corta.

El volumen de corta anual durante el primer ciclo, resultará al multiplicar el número de hectáreas que tiene el área de corta anual por el volumen que se cortará por hectárea.

Ejemplo:

	Superficie total arbolada	3520	has.
	Intensidad de corta por hectárea	35%	
V	= Volumen actual por hectárea	200	m.³
v	= Volumen que quedará en pié después de la corta	130	m.³
I	= Incremento anual por hectárea	4	m.³
p	= % de incremento	2	m.³
n	= Ciclo de corta		

$$V = v\ 1.0\ p^n;\ n = \frac{\log V - \log v}{\log 1.0p} = \frac{\log 200 - \log 130}{\log 1.02} =$$

22 años.

El área de corta anual será: $\frac{3520 \text{ Has.}}{22} = 160$ Has.

Volumen de corta anual: 160 x 35 = 5600 m.³

Observando en la explotación mediante los marqueos que se ejecutan en el arbolado por derribar el porciento de la intensidad de corta que se haya fijado, las áreas de corta anual van quedando automáticamente señaladas conforme se aprovechaen ellas la posibilidad anual. Una vez transcurrido el primer ciclo, el monte estará ya dividido en tantas partes como años tiene el ciclo de corta.

El error del procedimiento anterior al usar la fórmula $V = v\ 1.0\ p^n$ consiste en considerar también que cuando "v" se va acercando a "V" o sea a la saturación de la masa, los incrementos siguen aumentando conforme a interés compuesto cuando es lógico que éstos disminuyan entre mas cerca esté "v" del valor de "V." Este sistema únicamente se usa como preparatorio para la ordenación forestal.

Para conocer los métodos más adecuados de tratamiento silvícola, de cálculo de posibilidad y métodos de ordenación, el Instituto Nacional de Investigaciones Forestales y algunas empresas madereras de nuestro país ya iniciaron el establecimiento de estaciones de experimentación forestal.

RESUMES

Most Common Methods Used In Mexico for Making Inventories of Forests In the Temperate or Cold Zones and for Determining Yearly Cutting

The forests of the temperate or cold climate, made up mainly of *Pinus* and *Abies*, cover an area of approximately 10.5 million hectares, of which 4 million hectares are considered as being exhausted, 3.5 million are exploitable, and 3 million are virgin forests.

Growing Stocks. Stock is determined by means of test areas. The inventoried area ranges from 1 to 10 percent of the total. When photogrammetric methods are used, the areas are chosen randomly or systematically, and small sections representing no more than 4 percent of the total are inventoried with precision.

The measurement of sample trees is done by using the sectional method, and tables of volumes are drawn up by using graphs with mathematically harmonized curves.

Increments. The increment in volume is determined from the increment in the diameter in each diametrical category. The necessary data are obtained from the same trees that were measured to make the volume tables. The determination of increments with the Pressler borer is more common because it is not necessary to fell any trees. In order to calculate the allowable annual cut, the normal annual increment (NAI) is measured.

Allowable Annual Cut. For topographic, edaphic, and commercial reasons, the most common method used in Mexico is that of individual selection or group selection.

The most widely accepted procedure for determining the allowable annual cut is based on the theory that a forest represents capital accruing compound interest and thus the formula $V = v\ 1.Op^n$ is used. "V" is the actual volume per hectare; "v" is the volume remaining after cutting; "1" is the normal annual increment per hectare; "p" is the percentage of increment, and "n" is the cutting cycle.

The error in this method resides in the fact that when "V" gets close to "v," the increments decrease and do not continue to rise according to the rule of compound interest. This system is used preparatory to forest management.

Méthodes les plus usitées au Méxique pour inventorier les espaces boisés dans des climats tempérés ou froids, et détermination du volume de la coupe annuelle

Les forêts des climats tempérés et froids, composées surtout d'essences de la famille *Pinus* ou *Abies,* occupent une surface d'environ 10.5 millions d'hectares, dont 4 millions passent pour être épuisés; 3.5 sont exploitables, et 3 millions sont en forêts vierges.

Réserves. Pour déterminer le volume de celles-ci, on se sert d'échantillons. La surface inventoriée varie de 1 à 10% de la surface boisée tout entière. Quand on applique les méthodes photogrammétriques, les échantillons sont distribuées soit au hasard, soit systématiquement, et l'on fait, avec précision, l'inventaire de petites surfaces dont l'étendue totale ne dépasse pas 4%.

Le cubage des arbres-types se fait selon la méthode du sectionnement, et l'on se sert des méthodes graphiques pour établir les tableaux des volumes au moyen de courbes harmonisées par des calculs mathématiques.

Accroissement. L'accroissement du volume est déterminé en prenant pour base l'accroissement du diamètre constaté dans les différentes catégories de diamètres. Pour obtenir les données nécessaires, on se sert des mêmes arbres qui avaient servi au cubage sur lequel se fondent les tableaux des volumes. L'utilisation de la tarière de Pressler est le moyen le plus courant pour déterminer l'accroissement, parce qu'il n'exige pas l'abattage des arbres. L'accroissement courant annuel (ICA) est déterminé pour servir au calcul de la possibilité ou volume de la coupe annuelle.

Possibilité ou volume de la coupe annuelle. Pour des raisons d'ordre topographique, édaphique et commercial, la méthode la plus courante au Mexique est celle de la sélection individuelle, ou de la sélection par groupes.

Le procédé le plus en faveur pour déterminer le volume de la coupe annuelle se fonde sur la théorie que la forêt représente un capital travaillant à intérêt composé, selon la formule $V = v\ 1.Op^n$, dans laquelle "V" représente le volume actuel par hectare, "v" le volume qui reste après la coupe, "1"=ICA/Hectare, "p"=% d'accroissement et "n"=le cycle de la coupe.

C'est là un procédé erroné, du fait que, lorsque "V" se rapproche de "v," les accroissements diminuent et ne continuent pas à augmenter selon la loi de l'intérêt composé. Ce système peut s'appliquer en tant que préparation à l'aménagement des forêts.

La Pre-Carta Forestal En La República Argentina

La Dirección de Economía Forestal
de la Administración Nacional de Bosques,
Secretaría de Agricultura y Ganadería,

República Argentina

Las primeras inquietudes registradas en la República Argentina referentes a la elaboración de un Mapa Forestal datan del año 1906, cuando, a raíz de un decreto originado en el Ministerio de Agricultura, se establece "practicar la explotación y relevamientos indispensables para la clasificación de los terrenos de montes y su demarcación topográfica, para trazar el Mapa Forestal." Eran épocas en que la Nación, administradora de extensas superficies de tierras públicas, debía establecer las medidas conducentes a facilitar la solución de los problemas inmigratorios.

La necesidad de conocer el potencial forestal y de preservar tanta riqueza, dió origen además, a una reglamentación dentro del mismo decreto antes mencionado, por la cual "se prohibe" toda enajenación de bosques fiscales hasta tanto se confeccione el Mapa Forestal.

Queda así fundamentada en la República Argentina una verdadera preocupación forestal, traducida en una serie de relevamientos de bosques efectuados en forma muy expeditiva, como complemento de las mensuras de tierras ficales llevadas a cabo para librar neuvas extensiones a la agricultura y ganadería.

Con posterioridad, una serie de proyectos de leyes elevados al Poder Legislativo Nacional, prueban aquella preocupación por la riqueza forestal del país, mencionándose en casi todos ellos, la ejecución de un Mapa Forestal, al que se lo define, ya sea como un elemento cartográfico, como inventario o como estudios destinados a conocer el potencial leñoso industrializable.

Lo cierto es que, desde un principio y a través de los años, el término Mapa Forestal se interpretó de diferente manera, aunque, primando la concepción de que se trataba de un instrumento básico destinado a proporcionar al país, referencias indispensables sobre su riqueza en madera apta para la industria.

Delineada así, en breve síntesis, las primeras ideas y enfoques encaminados a la preparación de un Mapa Forestal Nacional, cabría sintetizar las principales etapas del proceso dirigido al logro de tal finalidad.

Anteriormente al año 1944, se llevaron a cabo relevamientos expeditivos e inventarios, principalmente en los territorios de Chaco y Misiones, sobre una superficie de algo más de 1.000.000 de hectáreas. Desde 1944 a 1949, ya creada una "Sección Mapa Forestal" en la ex-Dirección Forestal, efectuáronse estudios similares a los anteriores pero con una mayor cantidad de muestreo en los inventarios y con un criterio algo más ajustado en lo que concierne al método de trabajo. En este lapso se cubrieron aproximadamente unas 700.000 hectáreas boscosas en los territorios de Chaco, Formosa, Misiones, Neuquén, Chubut y Tierra del Fuego. Este fué, en realidad, un período de transición, caracterizado por la mayor atención que los técnicos prestaron a factores utilitarios, determinados por el interés industrial y la exigencia de material maderable.

A partir del año 1949, con la sanción de la Ley Nacional de la Riqueza Forestal n° 13273, cuando aún se hallan todos los bosques fiscales de los exterritorios nacionales bajo la jurisdicción de la Administración Nacional de Bosques, todo el esfuerzo técnico se vuelca en la realización de estudios dasocráticos o de ordenación, destinados a establecer planes de aprovechamiento, como lo requiere la ley forestal mencionada. Ese gran esfuerzo, en el que participó casi todo el personal capacitado de esta Repartición, fué necesario realizarlo a fin de evitar, en lo posible, inconvenientes en el aprovisionamiento de materia prima para las industrias. La superficie estudiada en esta tercera etapa superó las 250.000 hectáreas.

Así llegamos al mes de diciembre de 1956, en que se reorganizan los Servicios de la Dirección de Economía Forestal, creándose la División Mapa Forestal. En tal oportunidad se conjugan dos hechos de importancia:

1. Las jurisdicciones de la Administración Nacional de Bosques pasan paulatinamente a ser administradas por los nuevos gobiernos provinciales que se crean en lugar de las ex-Gobernaciones, y
2. Al tratarse el tema Mapa Forestal discutido en la 3° Reunión Nacional de Coordinación de Politica Forestal no se llega a un entendimiento general, propiciándose para nueva fecha, una reunión especial de técnicos en la materia.

Es así que en julio de 1957 se realiza en la Provincia de Córdoba, la primera Reunión Nacional de Mapa Forestal y se dan los lineamientos generales para concretar la confección del mismo. Las principales recomendaciones surgidas de esta reunión son las siguientes:

A. Entiéndese por Mapa Forestal, la suma de documentación que informa sobre la ubicación, extensión y características principales de las formaciones leñosas existentes atendiendo a la función que desempeñan, con el objeto de posibilitar su clasificación, de determinar las superficies que deben permanecer con cubrimiento forestal y de indicar las variaciones que se produzcan en las formaciones clasificadas. En regiones carentes de formaciones leñosas, el Mapa Forestal informará sobre cuáles deberán ser forestadas o reforestadas.

B. Cada Provincia elaborará su propia Pre-Carta, solicitando la colaboración de la Administración Nacional de Bosques cuando lo crea necesario. A fin de adoptar criterios uniformes entre los Servicios Provinciales y Nacionales se recomendó. Adoptar la clasificación múltiple y su expresión cartográfica, dentro del ámbito nacional,

viendo la posibilidad de incluir en ella los aspectos ecológicos.

C. En cuanto a la necesidad y posibilidad de unificar métodos de trabajo, de presentación de informes y material cartográfico, fué recomendado:

1. Que los Estados Provinciales y la Nación utilicen preferentemente el método aerofotogramétrico el que, además de su utilización a los fines del Mapa Forestal, podría utilizarse para el conocimiento general e integral de todos los demás recursos naturales.

2. Que a fin de obtener en el más breve término información forestal provisoria volcada cartográficamente, se confeccione una Pre-Carta Forestal que incluya las siguientes series: (a) Fitogeografía; (b) Clasificación preliminar de las formaciones boscosas; (c) Lugares conocidos forestalmente (ubicación de los estudios realizados); (d) Distribución de especies forestales; (e) Servicios forestales existentes (Jefaturas de Distrito, Inspección de Zona, Destacamento Forestal); (f) Viveros y plantaciones (nacionales, provinciales y privados); (g) Industrias forestales; (h) División política; (i) Vías de comunicación; (j) Morfografía (principalmente hidrografía y relieve); (k) Clima (temperaturas, lluvias y vientos); (l) Suelos (clasificación y erosión); (m) Uso actual de la tierra; y (n) Otros.

3. Para la Pre-Carta Forestal del país se adoptará la escala 1:1.000.000.

D. A fin de mantener intercambio regular de informaciones y conocer los progresos alcanzados, la Administración Nacional de Bosques actuará como agente coordinador de los trabajos del Mapa Forestal por intermedio de una comisión ad-hoc.

La Pre-Carta Forestal de cada Provincia está integrada por el conjunto de las series mencionadas ejecutadas sobre copias heliográficas del mapa base original preparado en tela por la Administración Nacional de Bosques.

A título informativo se señala que están prácticamente finalizadas las Pre-Cartas correspondientes a las provincias de Misiones, Chaco, La Rioja, y Córdoba, estando en preparación las de Formosa, Neuquén y Santiago del Estero.

Cabe agregar, como corolario a esta breve síntesis, que el concepto de Mapa Forestal y sus lineamientos ya están trazados, dándole al mismo un carácter económico-forestal. Es con este criterio que se va desarrollando la confección de la Pre-Carta en el país y, a pesar del número relativamente escaso de técnicos dedicados a esta tarea, ya sus frutos son palpables y lo que es fundamental, ya es conciencia, no sólo en las altas esferas oficiales sino también en las fuerzas vivas del país, su importancia en la actividad forestal argentina.

RESUMES

Preliminary Forest Survey In Argentina

Ever since the year 1906, when it first appeared in a decree of the Ministry of Agriculture, the term "Forest Survey" has been heard repeatedly, but its true scope has never been specifically defined.

This paper describes the work accomplished by the National Forestry Administration during the various stages of its life. This work, whether we call it forest surveying, inventorying, or regulation, has been carried on as intensively as circumstances have permitted, but not specifically with respect to a forest survey as such.

The true scope of this term and the general lines for preparing the country's Preliminary Survey were discussed at the First National Meeting on Forestry Surveying held in the Province of Córdoba in July 1957.

It was through the establishment of the Forest Survey Division in the Bureau of Forest Economics of the National Forestry Administration, and through the recommendations adopted at the aforementioned meeting, that the scope of the Forest Survey was more clearly defined and developed.

Hence, the paper mentions the principal recommendations adopted at that meeting and the fact that they are being gradually put into effect, with the first real results already apparent.

The topic of the paper is developed in a descriptive manner and gives an account of how the National Forestry Administration has approached the preparation of the country's Preliminary Survey in close cooperation with the provinces, without encroaching in the least on their autonomy.

Etablissement de la Carte Forestière Nationale de la République Argentine

A partir de 1906, date à laquelle le terme "Carte forestière" fait son apparition dans le texte d'un décret du Ministère de l'Agriculture, il est constamment repris sans qu'on arrive à en préciser la signification.

La présente communication rapporte l'action poursuivie par l'Administration Nationale des Forêts et fait état des différentes étapes parcourues dans ce domaine. Ce travail, qu'on le nomme enquête, inventaire ou organisation du fonds forestier a été mené activement dans la limite des disponibilités, mais non pas en fonction de la Carte forestière nationale.

La véritable portée de ce terme et les principes à suivre dans l'établissement de la Carte forestière nationale firent l'objet des débats de la Première Réunion nationale de la Carte forestière qui eut lieu dans la Province de Cordoba en juillet 1957.

C'est grâce à la création d'une Division de la Carte forestière au sein de la Direction de l'Economie forestière de l'Administration Nationale des Forêts et grâce, plus tard, aux recommandations de la Réunion mentionnée cidessus, que des éclaircissements ont pu être apportés sur la Carte forestière.

C'est pourquoi la présente communication fait mention des principales recommandations approuvées par ladite réunion qui, menées à bien dans l'intervalle, nous donnent la première indication de la véritable portée de l'entreprise.

Le sujet est traité sous une forme descriptive et synthétique qui permet d'exposer comment l'Administration Nationale des Forêts a procédé à l'établissement de la Carte forestière nationale, en étroite collaboration avec les provinces, sans porter la moindre atteinte à l'autonomie de ces dernières.

Determination de l'ensemble des ressources forestières de la République Populaire Roumaine

M. STĂNESCU, I. MILESCU, R. DISSESCU ET G. PREDESCU

Roumanie

En commençant de l'année 1948, c.à.d. à partir du moment où nous passames à la réorganisation de la production forestière sur de nouvelles bases, la déterminations des ressources forestières de notre pays se présente sous un aspect tout nouveau.

Un rôle important dans l'obtention de ces données a joué la déterminations de l'ampleur du fond forestier, réalisé en même temps que les travaux d'aménagement exécutés au cours des année 1948-1956.

La détermination du fond forestier a été exécutée d'une maniere différentielle et toujours en fonction de l'urgence de la valorification c.à.d. dans le sens que pour les peuplements qui devaient être exploités au cours des 20 premières années, on utilisa des procédés de détermination précis, comme, par exemple, un inventaire total ou partiel, tandis que pour le reste des peuplements on utilisa les tables de production.

Les inventaires totals ont été appliqués à un très petit nombre de peuplements qui se trouvaient dans des conditions spéciales. Dans la majorité des cas on utilisa l'inventaire partiel et l'utilisation des tables de production.

L'inventaire partiel fut exécuté pour des peuplements homogènes, la surface desquels variait entre 0,5-50 hectares, utilisant pour ce travail le procédé des bandes

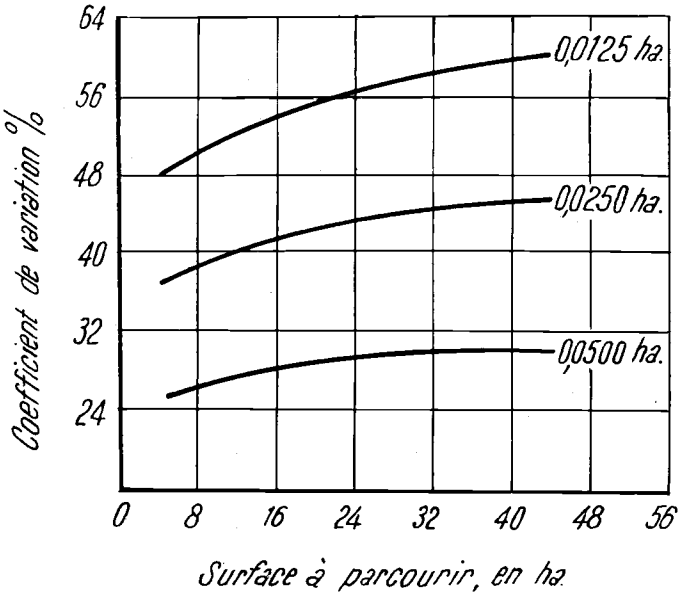


Figure 1. Le coefficient de variation en rapport avec la surface à parcourir et l'étendue des sondages.

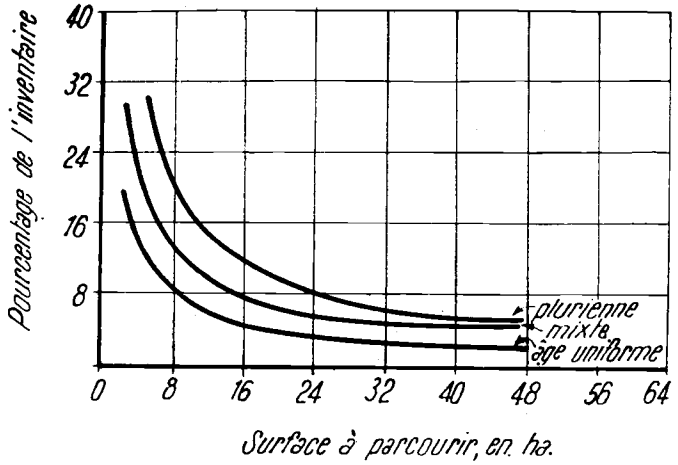


Figure 2. Pourcentage de l'inventaire en rapport avec la surface à inventarier, d'après les types de structure, pour une tolérance de ±10 pour cent.

d'essai d'une largeur de 10 m et d'une surface de 0,10 hectares et de 0,05 hectares.

La distribution des bandes sur l'étendue des peuplements fut exécutée d'une manière mécanique, la distance entre les rangées des bandes étant déterminée d'une manière pouvant assurer l'inventaire de 10% de la surface du peuplement. La tolérance pour la détermination de la masse ligneuse de chaque peuplement a été de ± 10%, indifféremment de l'étendue et de la structure de ce dernier.

Pour l'amélioration de la détermination de la masse ligneuse dans les peuplements où pendant cette période on ne procéda pas à l'inventaire, le laboratoire de spécialité de l'Institut des recherches forestières rédigea des tables de production pour les principales espèces forestières, utilisant la méthode des surfaces volantes.

Pour établir les procédés adéquats d'inventaire partiel, dans les conditions des Carpathes, on effectua dans ce domaine dans le courant des dernières dix années des investigations systématiques.

Au commencement les investigations furent orientées vers la stratification des peuplements, en ce qui concerne leur structure, distinguant les peuplements pluriennes, mixtes et équiennes, purs ou mélangés.

Les progrès enregistrés sur le plan général dans le domaine de l'inventaire partiel ont amélioré les méthodes de travail, surtout par suite de l'introduction du calcul statistique et du perfectionnement des appareils pour la délimitation des placettes d'échantillonnage.

Les investigation ont démontré la possibilité d'appliquer le calcul statistique et l'inventaire partielle dans les forêts pluriennes, si on prend comme élément statistique la surface de base ou le volume réalisé pendant un seul sondage. De même, on a reconnu la possibilité d'apprécier les précisions réalisées pendant des inventaires partiels par l'intermède de l'erreur à craindre.

L'expérimentation dans les trois types de structure susmentionnés des différents procédés d'inventaire a permis d'en tirer les conclusions suivantes:

A. Pour les peuplements pluriennes à caractère vierge:

1. Les grands coefficients de variation d'ordre 48-60% pour les sondages de 0,0125 hectares, ainsi que la facilité de la délimitation des placettes d'echantillonage à surfaces réduites, ont permis d'établir la surface minimale du sondage à l'étendue de 0,0250 ha, la meilleure surface étant de 0,05 hectares (graphique 1);

2. La proportion de l'inventaire pour une précision voulue ne dépend pas de la forme et de la grandeur du sondage, mais de la surface du peuplement. Cette proportion dans les peuplements irréguliers doit être substantiellement augmentée pour atteindre la même précision (graphique 2);

3. Les sondages de forme circulaire présentent, en gardant la même précision, un rendement plus grand et un prix réduit que les sondages de forme rectangulaire;

4. La délimitation optique des sondages circulaires est possible seulment jusqu'à une surface de 0,05 ha pour un seul sondage. Le procédé Bitterlich ne donna pas de résultats satisfaisants à cause de l'irrégularité des peuplements et spécialement à cause des distances de pointage imposées par de grands diamètres (au-dessus de 100 cm à 1,30 m) par exemple dans les peuplements purs ou mélangés de hêtre dans la région de montagne;

5. Quand pour une précision accrue on a besoin d'une inventaire partiel qui dépasse 30 % de la surface du peuplement, il est préférable d'éxécuter un inventaire total.

B. Pour les peuplements à structure mixte, les investigations trouvèrent des coefficients de variation très différents, qui les placent, soit vers les peuplements équiennes.

C. Pour les peuplements équiennes:

1. La proportion de l'inventaire est sensiblement réduite à la même précision à cause des petits coefficients de variation;

2. Le procédé Bitterlich donna de bons résultats, même avec la moitié du nombre des sondages recommandé par l'auteur;

3. Dans les peuplements équiennes et purs on peut utiliser avec succès les tables de production roumaines;

4. Les autres conclusion établies pour les peuplements pluriennes sont valables aussi pour ces peuplements.

Les résultats des investigations et l'expérience acquise pendant ces 10 années d'inventaires partiels et totals, ayant pour but la déterminations du fond forestier, sont synthétisés par les nouvelles instructions d'aménagement qui etablissent:

1. L'applications de procédés différents pour la déterminations du fond forestier, en fonction de l'urgence de la valorification et du type de structure;

2. Tolérances et taux d'inventaire différentiel par rapport à la valeur, la structure et le traitement appliqué aux peuplements;

3. L'application des sondages circulaires au lieu des sondages rectangulaires;

4. La matérialisation et la surveillance des sondages circulaires dans les peuplements soumis au jardinage.

RESUMES

Determination of the Total Forest Resources of the People's Republic of Rumania

The determination of the extent of the forest resources of the People's Republic of Rumania was begun in 1948 and was carried out at the same time as the first stage of the forest management reorganization, which was completed in 1957.

Subsequent research has shown:

1. The possibility of making a partial inventory in the case of the uneven-aged stands of the Carpathians;
2. The desirability of making a distinction in the accuracy and working methods required, according to the structure of the stands. The proportion of the inventories depends on the area of the stand;
3. The necessity of using circular plots up to 0.05 hectares in area instead of rectangular survey strips (test strips 0.1 or 0.05 hectares in area) in the case of uneven-aged stands delimited, insofar as possible, by optical methods;
4. Financial considerations justify the use of surveys over larger areas delimited by an optical method.

The diversity of the conditions existing in mixed stands has made it necessary to treat them, in that respect, as uneven-aged stands.

The same accuracy may be obtained in the case of even-aged stands with a much less extensive survey. The use of optical methods of delimitation in such stands presents no difficulties; that is why the Bitterlich Method has produced good results.

Cálculo del Total de Recursos Forestales de la República Popular Rumana

Los cálculos de la extensió de la requeza forestal de la República Popular Rumana empezaron en 1948 y se han llevado a cabo como primera parte de la reorganización de la ordenación de bosques cuya primera etapa acabó en 1957.

Investigaciones porteriores demostraron:

1. La posibilidad de utilizar el método de inventarios parciales en rodales incoetaneos de los Carpates.
2. La utilidad de fijar una diferencia entre la precisión como tal y los métodos de trabajo en relación con la estructura de los rodales. La proporción de los inventariós dependerá de la superficie de los rodales.
3. La necesidad de sustituir tanteos de superficies circulares hasta de 0,05 hectáreas rectangulares (con fajas de prueba de 0,1 o 0,05 hectáreas) para masas diversificadas cuyos hayansido fijados por medios ópticos, siempre que esto sea posible.
4. En el caso de tanteos en extensiones mayores con límites fijados por medios ópticos, se expondrán razones de orden económico.

La diversidad de condiciones que presentan las masas de índole mixta han determinado su asimilación, desde ese punto de vista como rodales incoetáneos.

Se puede consequir la misma precisión en el caso de rodales coetáneos con un costo más reducido de inventario. El uso de procedimientos ópticos para fijar los límites de tales masas forestales no ha presentado dificultad alguna y es por ello que el método de Bitterlich haya producido buenos resultados.

l'Unification de la methodologie d'evaluation de la masse ligneuse sur pied de la Republique Populaire Roumaine

I. Decei, I. Milescu, S. Armasescu et F. Carcea

Roumanie

Les nécessités de l'économie forestière socialiste imposent l'adoption d'une méthode et de procédés de travail unitaire, caractérisés par une technique et une efficacité supérieure correspondantes aux sollicitations de plus en plus exigeantes de l'exploitation forestière.

La meilleure valorification et l'utilisation rationnelle de la masse ligneuse entraînée dans le circuit économique consitituent une des préoccupations majeures des techniciens, des économistes et des hommes de science. Dans le courant des dernières années, on sentit le besoin de mettre cette question à point et d'unifier la méthodologie de l'évaluation de la masse ligneuse sur pied, en vue d'une détermination aussi correcte que possible du volume et des sortiments devant être exploités annuellement et ayant comme base les chiffres indicatifs des aménagements, en corrélation avec les chiffres imposés par le plan d'état.

Dans la République Populaire Roumaine l'économie forestière adopte comme base pour ces travaux de planification et de valorification de la masse ligneuse une documentation offerte par les aménagements et par les éléments de calcul obtenus par un "acte de mise en valeur," acte qu'on rédige annuellement pour chaque peuplement qui est destiné à entrer dans le circuit économique.

L'évaluation de la masse ligneuse sur pied pour les travaux de mise en valeur dans les forêts traitées en futaies, a été effectuée chez nous des années durant par le procédé de cubage et d'assortiment appliqué aux arbres d'essai (Urich II).

L'application de ce procédé couteux et embarrassant ne donna pas toujours de résultats exacts sous le rapport de la précision du cubage et de l'assortiment. Cette situation a imposé une série d'investigations en vue de trouver et d'adopter une nouvelle méthode plus efficace et en même temps plus précise qui permettrait la détermination du volume et de l'assortiment, sans avoir recours à des arbres d'essai.

Apres quatre ans de recherches et d'expériences, dans des conditions de production, on élabora un nouveau procédé de cubage et de triage pour l'évaluation de la masse ligneuse qui a comme base la classification par catégories des arbres sur pied.

Ce procédé qui fut mis à point dans sa forme actuelle a comme point de départ la conclusion qu'à des cotes égales de la hauteur d'un arbre, correspondent des cotes égales du volume du fût. Les investigations ont établi que cette loi est valable pour toutes les espèces, indifféremment des dimensions de base (diamètre et hauteur).

Les cotes du volume du fût pour les différentes cotes de la hauteur sont les suivantes:

Pourcentage de la hauteur
10 20 30 40 50 60 70 80 90 100
Proportion du bois rond (bois de grume), %
23 42 57 71 81 89 95 98 100 100

Ces caractéristiques et ces conclusions complètement nouvelles, ont donné la possibilité de mettre à point le criterium de la classification des arbres, et d'établir sur une base scientifique la relation entre la portion de bois de la longueur totale d'un arbre apte à être employé comme bois de travail et les taux d'utilisation du volume comme bois de travail et respectivement comme bois de feu.

Des considérations pratiques et celles qui sont en liaison avec les nécessités de précision, ont imposé l'adoption, en fonction de la longueur de la partie du tronc apte à être employé comme bois industriel, de quatre classes d'arbres. Les classes établies de cette manière avec leurs correspondants en ce qui concerne le volume en pourcentage, sont présentées dans le tableau suivant:

Spécification	Classe de qualité	Portion de bois de travail de la longueur de l'arbre entier (du fût)	Proportion de l'utilisation du volume de l'arbre (du fût) comme bois d'industrie %	et de feu %
Feuillius	I	> 0,5	80	20
	II	0,25 — 0,5	55	45
	III	< 0,25	30	70
	IV		—	100
Résineux	I	> 0,6	98	2
	II	0,4 — 0,6	80	20
	III	< 0,4	55	45
	IV		—	100

Pour établir ces classes et les proportions aptes à être employées comme bois d'industrie, on a tenu compte entre autres, aussi de la longueur pratiquement élaguée, hauteur à laquelle commence la ramification de l'arbre formant la couronne, ainsi que des défauts plus importants qui peuvent être facilement dépistés pendant l'inventoriation.

Le criterium scientifique de la classification des arbres une fois établi, ainsi que les classes de qualité avec leurs correspondants dimensionnels et volumétriques, on pût metre à point d'une manière détaillée, le procédé de classification et d'assortiment des arbres sur pied.

Le procédé consiste en:

1. l'inventoriation des arbrea d'après leurs espèces, les catégories de diamètres et leur classe de qualité;

2. la division des arbres de chaque classe de qualité en deux catégories distinctes qui contiennent exclusivement des arbres destinés à l'industrie et des arbres pour combustible, par la multiplication de leur nombre avec le pourcentage du bois pour industrie correspondant à la classe de qualité respective. La possibilité du regroupement sur des bases objectives de ces quatre classes de qualité d'arbres en deux classes seulement, constitue en fait une autre caractéristique essentielle et originale dans la technique du triage des arbres, ainsi que dans la rédaction d'actes d'évaluation sur pied. Cette caractéristique a rendu possible le cubage et le triage de tous les arbres occupant la même étendue avec l'aide d'une seule table de cubage, ainsi que le triage des arbres de première qualité. Selon les vérifications effectuées, cette possibilité a été d'une réelle utilité dans l'application de ce procédé sur une grande échelle avec un minimum d'effort et de temps et une grande sûreté de précision en ce qui concerne la détermination.

Ce procédé adopté comme résultat d'une collaboration fructueuse entre les représentants des secteurs de spécialité, utilise comme instrument de détermination de la masse ligneuse une série de tableaux suivants:

1. Table générale de cubage, d'après l'assortiment dimensionnel;

2. Table de triage industriel à base d'indices maximaux de triage.

Récemment l'Institut de recherches forestières a élaboré pour 12 espèces forestières des tables générales de cubage par assortiments dimensionnels. La clé d'entrée dans ces chiffres est axée sur le modèle des tables générales de cubage par classes (séries) de hauteur, tables introduites récemment avec succès pour les travaux d'aménagement des forêts dans notre pays. Les tables par assortiments, dont nous donnons un exemple dans le tableau Nr. 1, contiennent en dehors du volume total du fût, des branches, de l'écorce et du bois de combustible, le volume du bois destiné aux industries par groupes d'assortiments dimensionnels: gros bois (plus de 24 cm, avec 2 sous-divisions); bois moyen (12 à 24 cm) et bois mince (sous 12 cm).

Tableau 1. Série d'hauteur Nr. 1

Espèce hêtre

Diamètre en cm	Volume de l'arbre avec écorce, m³	Volume du fût avec écorce, m³	VOLUME DES ASSORTIMENTS							
			Bois de travaux sans écorce					Ecorce du bois industriel	Bois combustible	Bois de branches
			Gros >40 cm	24-40 cm	Moyens 12-24 cm	Minces <12 cm	Total			
20	0,455	0,435	—	—	0,344	0,022	0,366	0,027	0,045	0,017
40	2,284	2,147	—	1,762	0,085	—	1,847	0,102	0,298	0,037
60	5,491	4,868	3,698	0,514	—	—	4,212	0,224	1,007	0,048

Ces groupes ont été établis sur la base de la décroissance du fût des arbres, tenant compte des standards d'Etat en vigueur, de l'usage et de la demande d'une grande quantité de bois rond (brois en grume).

Pour satisfaire la demande des organes de planification et d'exploitation, le tirage dimensionnel est insuffisant. Prenant comme point de départ l'idée des indices maximaux de triage, l'assortiment qualitatif est obtenu à l'aide des tables de triage industriel ayant comme base les indices maximaux. Ces tables ont été élaborées ayant à la base un materiel de recherches représentatif et très vasto (à peu près 2500 arbres) récolté dans tout le pays par l'Institut des études et des projections forestières et de l'Institut des recherches forestières. Les tableaux rédigés par ces institutions contiennent des indices maximaux établis initialement pour ces quatre classes de qualité, indices qui expriment par un taux les volumes qui peuvent être obtenus à un moment donné d'un lot d'arbres par chacun des assortiments industriels importants. Dans l'exemple que nous donnons pour le robinier (tableau 2) on voit qu'a un diamètre de 26 cm on peut obtenir au maximum: 80% bois pour mines, 63% poteaux ou bien 76% pilots.

En conséquence, on peut par ces indices obtenus procéder à un triage maximum séparément pour chaque assortiment, en donnant la possibilité au organes forestiers d'exploitation d'obtenir soit le maximum d'assortiments considérés comme étant les plus valeureux, soit un maximum d'un autre assortiment au cas d'une commande reçue.

Tableau 2. Variation du taux du bois de travail pour assortiment industriel pour le robinier (indices maximaux pour les arbres de l-ère qualité).

Assortiment	Diamètre en cm:													
	8	10	12	14	16	18	20	22	24	26	28	30	32	34
	indices en pourcentages													
Poteaux	—	—	—	—	15	30	41	50	57	63	69	74	79	83
Bois pour mines	—	—	27	45	58	67	73	78	80	81	79	73	65	55
Billes, perches	100	100	100	100	100	99	98	94	86	76	63	50	35	20

Le triage dimensionnel et industriel ayant à la base les indices maximaux, donne en même temps la possibilité d'une analyses objective du plan; de la corrélation et de la répartition des charges par rapport aux possibilités effectives en assortiments des peuplements mis en valeur. Cette action tend à contribuer, en fin de compte, à une meilleure valorification et une bonne utilisation de la masse ligneuse.

RESUMES

Standardization of the Methods for Estimating the Total Timber Stand In the Rumanian People's Republic

To be able to estimate as accurately as possible the total timber stand under exploitation, we conducted research to find and adopt a new method for measuring timber volume and grading trees that would not necessitate the felling of sample trees. The procedure worked out is based on the conclusion, which is of great scientific value, that volume readings taken at the same proportional height from various trees give the same percentages of the total volume of such trees, regardless of species, diameter, or total height.

This correlation forms the basis for classifying trees, with respect to the amount of the total log volume suitable for industry and the amount to be used as lumber and firewood, into four grades.

Tree inventories by grade are divided into trees for industry and trees for firewood by multiplying the total number of trees by the percentage of lumber for each grade. In establishing the total volume according to dimensions and industrial use, the "general scaling and grading tables" are used, which give lumber volume, according to dimension and the "Maximum Index Tables," which make possible industrial grading, based on a top grade for each group.

Unificación de la Metodología de la Evaluación de la Masa Lenosa en Pie de la República Popular Rumana

Para calcular de la manera más exacta posible la masa leñosa sometida a explotación, hemos hecho investigaciones para hallar y adoptar un nuevo procedimiento de cubicaje y la clasificación por grados de árboles que evite el corte de árboles de prueba. El procedimiento adoptado lleva a la conclusión (ques ofrece gran interés científico) de que calculos de volumen obtenidos a la misma altura proporcional de árboles differentes da la misma proporción de volumen total para ellos cualquiera sea la especie, el diámetro o la altura total del árbol.

Esta correlación se establece a base de la clasificación de los árboles en función de madera adecuada para las industrias y del largo total del árbol y de la tasa de aprovechamiento del volumen como madera de trabajo y como leña, en las cuatro classes de calidad.

Los árboles inventariados según clases de calidad se dividen en árboles para la industria y para leña con la multiplicación de su número con las proporciones de madera de trabajo correspondientes a la clase de calidad respectiva. Para determinar el volumen total del conjunto dimensional e industrial se emplean las "Tablas generales de cubicación y clasificación por grados de árboles," que dan el volumen de madera por grupos dimensionales y las "Tablas de índices máximos," que ofrecen la posibilidad de una clasificación por grados industrial según la norma de clasificación máxima de cada conjunto.

Comments

Gerd Hildebrandt (Germany):

In his excellent report, Bertil Matérn has shown some aspects of recent developments in statistical surveying methods. He started from the assumption that it is desirable or necessary to get an estimation of volume, growth, etc., for a large-size forest area. Undoubtedly, this is the task of forest inventories in many countries. In most countries of Central Europe, however, we have for management purposes additional tasks and so some additional problems. Our forest resources are limited and, as a result of intensive forest management for more than 150 years, our forests are distinguished by many small stands with different conditions. So, besides the volume and growth of large forest areas, also the volume and growth of each individual stand has a bearing on forest management.

Some recent inventory methods in our region are unsatisfactory either from the statistical point of view or because the results are inadequate or the methods are too expensive. This unsatisfactory situation is the reason for the gradual change, which we can now observe. There is also a trend toward improved statistical methods in the intensively managed forests of Central Europe for our management purposes. I think this is remarkable.

In connection with the report given by Mr. Matérn, I want to call your attention to this practical question and to the additional statistical—practical and theoretical—problems.

Of course, it is impossible to give an idea of a solution of our inventory problems in the short discussion time, but I will try to mention in one sentence the requirements for an inventory method under intensive forest management so that you can see the recent practical and statistical problems.

In my opinion, the inventory method for management purposes should be efficient, flexible, simple—I think this is also necessary—and economical, giving us: First, the volume and current increment of a greater forest district with high and definable precision and distributed by species and diameter-and-age classes; second, for certain important stands, the volume and current increment, also with high precision; and third, the volume of the old (mature) and middle-aged individual stands with lower precision, probably with a discrepancy of 10-15%. Another important requirement is the suitability for reinventory in the sense mentioned by R. C. Wilson yesterday afternoon.

The problems are resolvable in a satisfactory way, I am sure. In my opinion, a solution and progress is possible with statistical methods—perhaps in connection with some additional conventional measurements or estimations. I think the use of aerial photographs for stratification or typing and the use of the Bitterlich method and others can be helpful, too. Some successful investigations have recently been carried out in Germany, Austria, France and other countries. There are also good experiences in the practical use of new statistical methods.

J. R. Dilworth (U.S.A.):

Mr. Chairman, distinguished members of the Congress. It is a pleasure for me to have this opportunity to comment on the fine paper presented by my Canadian friend and colleague, Mr. H. E. Seely. He has long been recognized as a leader in the field of forest photo-interpretation.

The theme of this Congress is "multiple use." Mr. Seely, and other speakers as well, have emphasized the "multiple use" of aerial photos in forestry. The aerial photograph along with variable plot cruising, statistics and electronic data processing make the ideal combination for conducting forest surveys.

Intensive use of aerial photos in forest surveys has come about during the past ten years. However, we must

recognize the pioneer work of men like Mr. Ellwood Wilson of Canada and Professor Hugershoff of Tharandt, Germany.

Forest photogrammetrists will agree with Mr. Seely in the basic concepts, correlations, and techniques that he has presented. These relationships hold for most of the forest stands of North America.

Inventory by conventional or photo-cruising methods does not lend itself to any one system because of the extreme variability of forest species and stands. Although basic principles prevail, application requires sampling design and techniques that are molded to the local conditions that prevail. In view of this fact, I would like to speak to Mr. Seely's paper in light of experiences in the Pacific Northwest. These points may be summarized as follows:

1. The parallax bar method of tree height measurement is preferred because it enables the interpreter to take advantage of small stand openings.
2. Late fall, winter and early spring photography are not suitable for intensive interpretation because of the severe shadow problem resulting from the rough terrain, relatively tall trees and the coniferous character of our commercial forests.
3. Suitable correction factors to compensate for loss of crown resolution and individual interpreter skills are essential.
4. A fine dot-grid of 100-200 dots per square inch aids in estimating crown closure.
5. Color film is helpful in species identification. Continuous coverage in color is usually too expensive, but spot samples of color photo coverage have proven very useful.
6. Large-scale photography is very valuable in photo interpretation. The normal maximum scale for forest inventory purposes is 1:9,600 because of the excessive displacement of our tall trees on photos of larger scale. The usual scale is 1:12,000, if intensive interpretation is a factor.
7. We have used aerial photo-cruising with considerable success. Cruise accuracies of three percent have been realized.
8. Photo-cruising using tree aerial volume tables is highly dependent upon tree count. Although 20 to 30 percent of the total stems are not visible and hence not counted, the volume of uncounted trees in a 100-year old stand of Douglas-fir is only 3 to 5 percent, and can easily be corrected by double sampling.
9. High-quality prints of good resolution are needed for adequate interpretation. We use log-etronic prints that provide the uniformity and shadow detail conducive to good interpretation.
10. We prefer the better detail of the 12-inch focal length photography.

It is quite apparent that photo-mensurational research is going on throughout the world. We hope that there will be a good interchange between all investigators to permit forest photogrammetrists to meet the challenge that is theirs.

Itizo Mine (Japan):

On behalf of the specialists in forest mensuration of Japan, I should like to express many thanks to Dr. R. Braun and Dr. W. Bitterlich of Austria, Dr. B. Matérn of Sweden, and Professor G. Furnival of the U.S.A., for their instructive speeches about advances in forest survey design and procedure. I have no questions, but I should appreciate it if you could permit me to have a little time to explain conditions in our country.

Since Dr. K. Kinashi, associate professor of the University of Kyushu, first introduced articles of Bitterlich and Grosenbaugh to Japanese foresters, many foresters in Japan have expressed great interest in the new method. There have been several field tests, and some new instruments have been devised, simpler in form than the relascope. However, we also use the relascope and prism.

Mr. T. Hirata, my colleague at the University of Tokyo, published his procedure for determining average stand height, using Bitterlich's method, but converting the horizontal angle to the vertical. At about the same time, Dr. Esseed of the Netherlands published the same procedure independently, as you know. We are continuing studies in this field.

We have a great deal of interest in forest inventory on a large scale. The Forestry Agency in Japan tested the procedure of a national forest inventory for the entire nation in 1953. Since then, a national forest inventory has been carried out on both national and private forests. We use a random sample-plot method combined with aerial photographs.

With respect to the details of design and procedure, it is difficult to explain in a limited time, but if any of you wish further information on this, I should be glad to answer by letter after the Congress. I should appreciate it if you would give me your name and address. I thank you all very much.

G. Angus Hills (Canada):

I wish to support the statement just made by the member from Mexico that, if an inventory is to be used as a basis for the multiple use of an area, it must include more than an estimate of present wood production. It is the land and not the forest which has a multiple use, and consequently there is required an inventory of the capacity of the land to produce crops of forest trees and other vegetation which provide not only raw materials for industry but for wildlife habitat, recreational activity, watershed protection, etc.

In Ontario, we indicate the capacity of an area for multiple use by mapping patterns of what we call physiographic site-types and by describing the specific forest and other vegetation types which may be associated with the physiographic types. Although the physiographic site-types are defined in terms of landform and soil features, the range of these features coincides with significant variations in the type of development and growth of vegetation. The simultaneous establishment of physiographic and forest types through site research provides a stable physiographic framework within which multiple land-use planning can be conducted.

With each physiographic site-type are associated a number of vegetation types which vary according to natural succession and cultural treatments. Thus a physiographic site-type represents a series of ecological units which vary in their productivity within the limits imposed by the physiographic controls. Ecological units are mapped by

indicating the distribution pattern of either present or proposed vegetation types in relation to the mapped distribution of physiographic types.

The application of this method to specific areas in Ontario is discussed in a number of reports, three of which are now in press.

Itizo Mine (Japan):

Many thanks to Mr. Seely, Canada, and other experts for their outstanding speeches on aerial photogrammetry in Forest Surveys. In 1934, aerial photographs were first used on a large scale in forest surveys in Japan.

In 1948, we used aerial photos prepared by the U. S. Army and started preparation of a topographic map required for compilation of management plans for private forests.

Since 1952, photogrammetry in Japan has made great progress through the excellent cameras and instruments imported from Zeiss, Germany, and Wild, Switzerland. The practical application of aerial photos has been studied, and they have proved to be effective for such uses as the preparation of topographic maps, modification of operation maps, forest resource inventories, erosion-control planning, design of proposed forest roads, and disaster surveys.

With respect to the details of aerial photogrammetry in Japan, I should like to report on them at some future time. I thank you very much.

Edwin Zaidlicz (U.S.A.):

Mr. Chairman, fellow foresters; I comment on Dr. Braun's and Dr. Bitterlich's report on advances in forest survey.

Here, in the Northwest, my colleagues are faced with much the same problems as outlined by Braun and Bitterlich. We face a multiplicity of needs and forest conditions. We deal with large tracts of old-growth forests and with those of second-growth. We apply intensive inventories in some ownerships, while extensive cursory inventories must suffice in others. Our survey procedures range from continuous forest inventory, permanent plots, with supplementing highly accurate type and topography maps, to procedures which can best be termed "one-shot horseback" guesses.

One need, however, transcends all others, regardless of the intensity of survey, and this is the need for improvement of techniques to assure higher accuracy at lower costs. I heartily agree with the comments made yesterday that the Bitterlich angle count or variable plot radius concept was a highly significant breakthrough in the improvement of surveying techniques.

The other big breakthrough we recognize, which also was developed by Dr. Bitterlich, was the advent of electronic data-processing computers. We strongly subscribe to Dr. Braun's and Dr. Bitterlich's contention that our skilled survey personnel must be freed of routine and time-consuming work to pursue more productive tasks. After Bitterlich's release of his angle-point technique, foresters here and abroad quickly modified and projected variations of the basic concept. With electronic computers, we can today, on our higher order of forest surveys, derive and analyze data, variables, influences and correlations through a myriad of ingenious electronic programs that were deemed impossible ten years ago.

In addition to this ability for analysis of complex relationships, we find the costs of extracting basic data to be much lower.

I cannot quarrel with Dr. Braun's and Dr. Bitterlich's material as presented. However, here in the Northwest coastal forests during inclement winter months, the wedge prism, as mentioned, is used very successfully. Variability of stands and stem size and number dictates the use of different diopter prisms. We use the prism on very steep slopes as well as on gentle ones. I might add that the Bitterlich concept and the prism have been used extensively by our foresters for volumetric as well as qualitative appraisals of timber stands for sale and exchange. We, also, use the prism to derive single tree and stand-form classes or form quotients for improved volume determination.

There are many variations of the procedures outlined by Braun and Bitterlich being used by our foresters. The forester must possess the flexibility to alter or vary the survey technique to fit the local need as limited by innumerable variables. The point of paramount importance, however, is the conception of the basic principle of technique and the free, sincere exchange of this information with all foresters. Breakthroughs of basic technique comparable to Dr. Bitterlich's explode a chain of implementing research and improvisation that markedly advance our common cause.

Thank you.

Following is Session C—

Semi-Arid and Arid Land Forestry
Sylviculture en terres semi-arides et arides
Terrenos Forestales Aridos y Semiáridos

Forestry and Forest Grazing in the Mediterranean Region

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Introduction

1. Forest-grazing problems have always been raised at international and regional conferences. Within the FAO, such problems have been an almost permanent concern of the Mediterranean Forestry Sub-Commission. Also, the FAO Working Party on Mediterranean Pasture and Fodder Development is concerned, to a considerable extent, with subjects related to that problem. Recently, during the seventh session of the FAO Mediterranean Forestry Sub-Commission, held in Lisbon in May 1960, "the interrelations between forest and range mangement from a technical and administrative point of view" have been the subject of a separate presentation and analysis on a national scale. More recently, during the seminar on "Soil conservation in arid and semi-arid zones," organized by the French Institute of Technical Cooperation and Teheran University, grazing problems have been one of the main subjects presented and discussed. It is true that, during the last ten years, considerable progress has been made towards approaching this problem, but still the fact remains that much deeper thinking is needed towards formulating and implementing policy and procedures in further approaching and solving such a very complicated problem. It is urgently necessary to proceed in establishing the fundamental principles in formulating forest-grazing policy and the basic criteria in implementing that policy.

This paper deals mainly with principles and criteria to be adopted in harmonizing forest economy with forest grazing. No detailed reference is being made to the technical aspects of the subject. Much more emphasis is put on the main lines of political and social-economic action in planning and carrying out a new land-utilization pattern, as regards the integration of forestry and grazing.

Land resource devastation all over the Mediterranean region is considered to be the key problem of the interrelations between forestry and grazing. The centuries-old influence of traditional pastoral economy and dry farming has caused enormous decline, so that no restoration can be attained unless serious infrastructure work is carried out.

Soil erosion has spread out its tentacles all over the region. Erosion, being the cause and, at the same time, the effect of indiscriminate land use, was for centuries the "substratum" on which pastoral life and dry mountain farming survived and still "are being conserved." On the other hand, these two land-utilization categories "conserve" erosion, thus completing the vicious circle of causes and effects on land resources.

To the extent that soil resource devastation is considered to be the *key problem* in the actually existing interrelations between forestry and grazing, to the same extent resource "restoration" might prove to be the *key solution*. Such a restoration, effected in the frame of an overall agrarian, livestock and forestry transformation and development, could reverse the retrogressive down-trend and begin a progressive uptrend in soil resource conditions, thus building up a new biological balance of soil and man, and, consequently, of forest and grazer.

Main Types of Mediterranean Forest and Rangeland

2. *Mediterranean climate,* typically dry and hot, is characterized by the low rainfall, which occurs mostly during the winter, and by the almost constant lack of rain during the summer. In this region there is a variety of climatic zones, from the arid zone (annual rainfall: 100-300 mm.) to the humid Mediterranean zone (annual rainfall: 800-1000 mm.). According to the classification of various climatic zones adopted by the FAO Mediterranean Forestry Sub-Commission, the region is divided into three more or less clearly distinct zones.

a. *Zone with Eumediterranean climate.* Under this name, land areas with semi-arid up to sub-humid climates are grouped. Average annual rainfall is 300 to 500 mm., and 500 to 800 mm., respectively. It is very unevenly distributed throughout the year. Coastal, plain and semi-mountainous areas bordering on the Mediterranean sea are grouped in this zone.

b. *Transition to the arid zone of North Africa and the Near East.* Average annual rainfall does not exceed 100 to 300 mm. Nomadic grazing is the main characteristic of this zone.

c. *Transition zone to the humid-temperate (Southern Europe) mountainous regions.* Average annual rainfall is 800 to 1000 mm. It covers large areas of the Iberian (Spain), Italian (Apennines) and Balkan (Dalmatia, Greece) peninsulas.

3. *Forest Vegetation* presents a similar overall aspect in accordance with the basic characteristic of the Mediterranean climate in its different segments. There is a great diversity in forest types dependent on geographical situations and ecological conditions. In a region like that, which has been subjected to human influence for thousands of years, it is always difficult to establish the ecological laws determining distribution of different types of forest and range vegetation.

In the Eumediterranean zone, evergreen schlerophyl vegetation prevails together with the so-called Mediterranean conifers: *Pinus halepensis, Pinus brutia, Cupressus, Pinus pinaster,* etc. Further, in the transition to temperate-humid zone (Southern Europe), forest types are more varied: Oak, chestnut and beech from the deciduous

broad-leaves and *Abies cephalonica* (Greece), *Pinus nigra* (Greece, Calabria, Corsica, Dalmatia, Spain, Turkey), *Pinus maritima* (Spain, Southern France), *Pinus leucodermis* (Greece), *Abies nordmanniana* (Turkey), *Abies numidica, Cedrus,* etc. Very limited areas of the so-called Central European conifers (*Pinus sylvestris, Abies alba*) cover the upper extremes of the mountains on the northern borders of the zone.

In the transition to the arid zone, semi-destroyed forests of *Quercus lanuginosa, Quercus infectoria, Pistacea atlantica,* and *Amygdalus* predominate.

4. In most of the Eumediterranean zone, the stages of forest degradation do not include a stage dominated by perennial grasses, as is the case in the humid-temperate climates. Excluding the natural alpine or pseudoalpine perennial pastures, as well as those perennial natural grazing grounds derived from high mountainous forest clearings, the rest of the natural grazing grounds located on the Eumediterranean zone constitute a stage of a retrogression process: *forest—maquis—stony grazing grounds composed of annual grasses and legumes—mostly rocky ground.*

Maquis land is the typical goat-range in the region. Though annual grass ranges are poor and up to 50% rocky (calcareous), a mixture of annual legumes renders them quite valuable as seasonal (late fall, winter, early spring) sheep-grazing grounds.[1]

Frequency and abundance of perennials increase as one proceeds from the upper limits of the Eumediterranean zone to the mountainous zone. Forest ranges within and above the *Pinus nigra, Abies* and *Fagus* forests, as well as alpine or pseudoalpine pastures, are made up mostly of perennials. Overgrazing prevents any uptrend in range conditions.

Actually, ranges in "excellent" or "good" condition, in terms of U.S.A. judging standards, exist on a very limited scale. However, protection of the cut-over areas from grazing reveals excellent grass growth. These little "islands" within the forests mark their potentiality in forage production, and this explains the reason for their being so much more attractive to the grazers. In most of the mountainous rangeland, "fair" conditions prevail.

Another factor which affects range conditions lies in the fact that mountainous ranges have been overused for centuries for sheep grazing only. Long overgrazing by sheep resulted in the gradual elimination of plants desirable to sheep and, consequently, to the predominance of grasses less desirable to them, but palatable to cattle. Cattle grazing, however, is very limited over these ranges.[2]

[1] In Greece, according to Dr. Ch. Diapoulis, Professor of Botany, 16 species of genus *Medicago* and 70 species of genus *Trifolium,* all native, enter into the floral composition of the rangeland.

[2] It has been observed, for instance, that in the alpine or pseudoalpine pastures of Greece and Italy (Southern Apennines) there is a clearly remarkable downtrend from the *Festuca ovina* to the *Festuca halleri.* This stage of degradation is the result of long overgrazing by sheep, which, giving preference to the tender *Festuca ovina,* rendered the coarseleaf *Festuca halleri* predominant over the range. There is no evidence of such a trend in the cattle pastures of the calcareous Northern Apennines and Alps. This difference marks the need for range-livestock readjustment on the basis of a more progressive and intensive sylvo-pastoral system on the mountainous forest rangeland.

Almost all over the Mediterranean natural grazing grounds a considerable difference is ascertained when comparing actual to potential carrying capacity. On the other hand, protection of the grazing lands often results in the increase of unpalatable or undesirable plants.

Forest Grazing—A Mediterranean Reality

5. Natural grazing grounds in the Mediterranean region are overgrazed. Centuries-old overstocking resulted in enormous devastation of the rangeland resource and, consequently, in an ever-increasing pressure of grazing within the forest stands. The overstocking factor constitutes indeed the key factor, which affects interrelations between forestry and grazing.

According to data collected by the FAO Mediterranean Forestry Sub-Commission, the actual stocking rate of the natural grazing lands (including forests and fallows) ranges from 3 to 4 hectares per animal unit (cattle), and the grazing period from 4 to 7 months. Potential grazing capacity, however, does not exceed 8 hectares per head/period.

On the other hand, the stocking rate within the forests (including the timber-producing forests) almost all over the region is found to be very high, ranging from two to four head of small animals (sheep) per hectare, and the grazing period from 4 to 7 months. That means two to four hectares per animal unit (cattle) and period of grazing. More particularly, the stocking rate within the forests for some countries of the region was forecast to be as follows:

Italy:	2,7 small heads (sheep or goats) per hectare
Spain:	4,0 small heads (sheep or goats) per hectare
Morocco:	2,3 small heads (sheep or goats) per hectare
Algeria:	1,0 small heads (sheep or goats) per hectare
Tunisia:	1,7 small heads (sheep or goats) per hectare
Greece:	3,3 small heads (sheep or goats) per hectare

Note: Conversion factor applied for this estimate is: 1 head of cattle = 8 head of sheep or goats.

From the above figures, it is clearly shown that the actual in-forest stocking rate is approximately equal to that of the natural grazing land. Consequently, even if forests might be considered as being typical rangeland, the actual in-forest stocking rate would exceed grazing capacity. It is, therefore, evident that such an in-forest stocking rate, upsetting any concept of harmonizing forest conservation and timber production with grazing through adopting solely the principle of "management," renders this problem quite obscure, unless a radical change in the general land utilization pattern of the region would be achieved.

6. The existing structure of the pastoral economy profoundly affects range utilization and, consequently, in-forest grazing pressure.

Nomadic life, being exclusively dependent on the natural grazing lands, was the cause of the serious desertification of large areas of the Near East and North Africa.

The system of villager-herdsman, which prevails in the Southern European countries, was also proved to be one of the main causes of the range abuse. Under the existing situation, a substantial percentage of the villagers in each community or village are herdsmen.

This leads to both a range utilization anarchy and an uneven distribution of range utilization shares between families.

To make this statement clear, let us take Greece as an example. Taking into account the typical mountainous zone of the country, ranging from 800 meters up to the tops of the mountains (2900 meters), it has been estimated, from a recent census of forestry, range and livestock made in 1954 by the Forest Service, that the mountainous zone covers 3.300.000 hectares, i.e., 25% of the country's total area, and contains 15% of the rural population. It has been further found that out of 160,000 families living in 1520 villages, 43% raise range-livestock in different sized herds (from 6 head of sheep or goats up to 200 and over). The internal structure of the livestock economy in this particular zone is shown in the following table:

Class of herd size	Number of owners	Percent of total population (160.000 families)	Animal population (head)	Percent of total
6 — 15 head	20.850	13,1	220.000	7,6
16 — 30	17.900	11,4	410.000	14,0
31 — 50	13.450	8,5	550.000	19,0
51 — 100	9.890	6,3	750.000	25,5
101 — 200	4.200	2,8	640.000	25,1
201 and over	1.280	0,9	350.000	12,1
Total	67.550	43	2.920.000	100

It must be noted that, excluding the landless categories of range-livestock raisers (3,7% only), the balance (39,3%) at the same time raise crops by dry farming.

This example, which is representative of other countries (Turkey, Southern Italy), shows how complicated is the social structure of the livestock economy and, consequently, how much effort is needed for an effective integration of forestry and grazing.

Another evidence of the underdeveloped livestock economy in the region under consideration is the predominance of sheep and goats in the total livestock population of the region. The following table indicates that almost 4/5 of the total livestock population are sheep and goats.

	Livestock Population (In 1000 heads)			
	Cattle	Sheep	Goats	Total
Southern European Countries	25.280	86.360	30.190	141.830
%	17	61	23	100
Near East & North Africa	9.980	43.780	22.540	76.300
%	13	58	29	100

7. Forest grazing revenue value, though not easy to compute, reveals a non-negligible contribution to the total annual income from livestock. Recent estimates made in some countries of the region give a quite clear account of this contribution.

Italy: From the total forested area (5.800.000 hectares), some 414.000 tons of forest forage are obtained annually through grazing; that means an annual production per hectare of grazed forests: 70 kg. In addition, 62.000 tons of forest trees (deciduous broadleaves) are lopped annually, i.e., 18 kg. per hectare of coppice forest. The revenue value of this forest forage is estimated to be approximately $39.000.000, an amount which represents 3% of the national livestock income and 21,7% of the national forestry income. Revenue of forest forage per hectare: $9,6.

Tunisia: From 780.000 hectares of grazed forests, there is obtained annually forest forage of $10.000.000 revenue value, i.e., $13,0 per hectare.

Greece: The revenue value of forest forage obtained through forest grazing is estimated at $20.000.000, or $11,2 per hectare/year. The total revenue value represents 9% of the annual national livestock income and 50% of the annual national forestry income.

These three examples might be considered as representing average conditions of the whole region, as regards this particular matter.

8. Contrary to the economic significance of forest grazing comes the almost catastrophic influence of in-forest grazing, reflected not only in forest composition, growth and allowable annual cut, but even in the existence of the forests. In-forest grazing, as it has been practiced for centuries and acting in combination with other negative factors, resulted in forest degradation. Degraded forests and maquis land of rather substantial size exist in many countries of the region. According to the FAO Mediterranean Development Project, out of 23.000.000 hectares, which is the official figure for forested area in Yugoslavia, Greece, Turkey, Syria and Tunisia, the extent of true forest area is only 12.000.000 hectares. The catastrophic influence of in-forest grazing leads in constantly changing the forest-stand composition in timber capital, age-classes, etc. The fir forests, which are considered to be the most rendable forests of the region, are being so harmfully affected by sheep and goat grazing that, through lack of natural regeneration, forest stands tend to become degraded and "even-aged" instead of "all-aged."

The average annual increment for the whole forested area of the region does not exceed 1,0 cubic meter. Even the richest of the high-elevation coniferous timber areas of the region are poor in timber capital and annual increment, as compared with those of Middle Europe.

Forest Economy and Forest Grazing—Competition or Coexistence

9. Looking into the matter of the interrelation of forestry and grazing from the viewpoint of ensuring timber production all over the forested areas, it can be fairly stated that no rational solution could be attained unless the principle of *competition,* i.e., the principle of segregation, were to be adopted and implemented on a national scale. On the other hand, large areas of semi-destroyed forests, coppice forests and maquis land, actually used for both marginal timber production and grazing, cannot be converted to timber-producing forests unless disproportionally large investment is undertaken. Moreover, even if a long-term reforestation program were undertaken, it would take generations to carry it out. It would be, therefore, a logical approach to adopt and implement the principle of *coexistence,* i.e., the principle of integration, instead of that of segregation, of timber production together with protective forests and grazing land.

10. The principle of competition has been adopted and implemented in the temperate-humid regions of the "green" Alps, due to a substantial reduction in in-forest grazing developed there over the last half-century. A favorable climate together with a prosperous agriculture have naturally led to an increasingly marked separation of crop-raising, pasturing and forestry. Following the principle of segregation of forest economy and grazing, a forest-pasture balance was obtained in place of the previously existing situations based on the principle of "mixed crops", i.e., both timber production and in-forest grazing. The problem was laid down on a competitive basis, and it was proved that timber-producing forests and in-forest grazing could not coexist.

The forest policy in Cyprus was based on the same principle when, before World War II, it removed goat grazing from its forests altogether. Yugoslavia, too, applied the same policy after the war. Further, other countries of the region have taken similar measures aimed at eliminating, either totally or partly, grazing from forests. Greece, for instance, has, by law, eliminated goat grazing from fir forests. However, all these countries are still facing the acute problem of sheep and cattle grazing in the forests on a basis of coexistence. But it is a forced coexistence, imposed long since by social, economic, and traditional reasons. Hence, the question arises: Can we convert the already existing forced and uncontrolled coexistence into a rational one, i.e., one based on a biological and economic balance of forestry and in-forest grazing? This fundamental question raises many other more specific questions, one of which, strictly technical, is the following: To what extent may protective and timber-producing forests be subjected to grazing, without any biological disturbance or reverse in forest conservation and timber production? More specifically, can we establish ecological rules determining potential in-forest grazing capacity, absolutely harmonized with both forest stand regeneration demands and forest forage utilization? Taking into account the actually existing stocking rate on the Mediterranean forest as compared with the potential grazing capacity, as defined above, it can be fairly indicated that, despite the inadequacy of the up-to-date knowledge, the difference between these two factors is great. Consequently, the needed drastic readjustment in stocking rate might be considered almost revolutionary. On the other hand, even though such a biological balance of forestry (timber production, protective functions) and in-forest grazing could be definitely attained, it would be so delicate and fragile, due to the unfavorable climatic and ecological environment, that it would require for its implementation very expensive fencing and expensive guarding.

11. To these reserves and questions one would be inclined to state the example of the U.S.A. where, in the Western States, the principle of integration of forestry and grazing was adopted and successfully implemented on the basis of "coexistence." Indeed, in the U.S.A., integration was founded and developed on a technical basis 40 years ago. A new branch of forestry was developed there, that of Forest Range Management. However, historical, social and economic conditions, on which such a development was based, were and still are different from those prevailing in the Mediterranean region. There exist a number of striking contrasts, the most important of which are the following:

a. Whereas in the mountainous forest regions of the West, summer grazing has to be, in most cases, harmonized with forest and forest-range conservation, in the Mediterranean forest regions, mountain farming, in-forest grazing, forest-range utilization and timber production are being practiced with great complexity. The difference becomes more distinct, if we take into account that mountainous national forest and rangeland in the West has not as yet been colonized, whereas Mediterranean forest regions are densely populated.

b. Whereas, in the West (with the exception of the Northwest), in-forest grazing, in many national forests, constitutes the main use of the forest resources, Mediterranean forests are being subjected to intensive management and utilization for timber and other by-products. Lacking any general and intensive timber management and utilization on the Western forests, there is no general problem in segregating timber-producing forest stands from the areas subjected to grazing, such as is the case in the Mediterranean forests.

c. Whereas in the Western forests there is, actually, no problem of reforestation, Mediterranean forestry is confronting a very large and urgently needed reforestation program. This renders more difficult any approach in integrating forestry and grazing.

Looking into forest-range management from the viewpoint of harmonizing forest and range conservation with grazing, it can be undisputably said that in the U. S. forest policy, the main principles and objectives have been efficiently implemented and fully covered. However, for reasons explained above, no emphasis has been given to the objective of harmonizing timber production with in-forest grazing. In fact, there was no general need for such an objective, such as is the overall case in the Mediterranean region.

Forest Economy and Grazing—Segregation and Integration

12. In view of the Mediterranean forest-range complex, which comprises in-forest colonization, in-forest grazing, timber production, protective functions of the forest, etc.,

it can be fairly said that two more or less clearly distinguished forestry zones might be separated into:

a. The higher elevation forestry space, where the best fir, black pine and beech forests, with rangeland adjacent to them, predominate. It is this space in which forestry, grazing and, to a lesser extent, dry farming are being practiced, whereas potential development should be directed towards a modern and intensive forestry and livestock economy, supplemented with forage-crop production.

b. The lower elevation forestry space, where dry farming, grazing and extensive forestry are being intermingled in a rather traditional system of land utilization. In terms of the Mediterranean climatic zones, high elevation forestry space corresponds to the extreme northern limits of the "transition zones" and, vertically, to the upper "mountainous climatic zone." On the other hand, lower elevation forestry space corresponds to the southern limits of the transition zone (coppice oak forests) and the whole Eumediterranean zone.

High elevation forestry space should be treated on the basis of "segregation." Proper distribution of the space in forests, pasture and crop-raising land should be the first step. Grazing should be entirely prohibited on the forests. Uncontrolled grazing in wide rangeland should be replaced with intensive "pasturing" over smaller areas. Forage crop production on artificially reseeded dry and irrigated fields as well as pasture improvement should be called for in order to supplement livestock feeding and render livestock independent of in-forest grazing.

Low elevation forestry space should be managed on the basis of "integration." This space covers a substantial portion of the Mediterranean forest area. The principle lies in harmonizing extensive forestry with controlled grazing. This dual use of coppice and semi-destroyed forests is both a physical and economic necessity. Therefore, there must be constantly kept in mind the need for a type of management which will permit the production of wood products as well as forage on a sustained yield.

13. Harmonizing forest economy and grazing, as outlined in the preceding paragraph, is being governed by the following three fundamental principles:

a. Within the surroundings of an "extensive," traditional agriculture and pastoral life, it is not possible to "isolate" any forested portion of the land to be subjected to "intensive" management and utilization. In other words, proper management of the forestry space must be matched by proper management of the adjacent arable and natural grazing land. This principle derives from the social and colonization structure of the Mediterranean region.

b. In a climatic environment like that of the Mediterranean region, it is never possible to ensure, even if advanced techniques and practices in range management would be applicable, that some prolonged periods of drought would not upset the management. Consequently, a regulated balance between pasturage and supplementary fodder obtained by purely agricultural means should be necessary.

c. In a region where an overall problem of land resources devastation exists, it is certain that no technical management of declined and degraded grazing resources is feasible and effective, unless serious land restoration and improvement are carried out in both the adjoining farming land for fodder production and the grazing land itself for increasing forage production.

14. The integration of forestry and grazing comprises two main lines of action:

a. "Protection" of timber stands against grazing—more particularly:

(1) Elimination of goat grazing from all forests except evergreen schlerophyl forests;
(2) Elimination of sheep grazing from fir forests, except in the open and woodland pastures included in the major forest area; and
(3) Elimination of any grazing from critical watersheds.

b. "Management" of in-forest grazing elsewhere is to be permitted in combination with forest-rangeland management and improvement.

These two objectives cannot be attained unless they are "supplemented" with fodder production in the adjoining agricultural and range lands.

Subject to balanced use, this appears to offer a rational solution. Taking into account that land resources have badly deteriorated, there is an urgent need for soil restoration through investment of outside energy, by means of contour terracing ("banquettes") of the declined arable and grazing land. Contour terracing, wherever it can be applied, introduces modern farming in between the terraces and ensures fodder-tree planting on the terraces. It also offers the possibility of cultivating sown perennial pastures on the terraces (alfalfa, sainfoin, for instance). The role of fodder trees in both the production of fodder and improvement of the terraced grazing land has been emphasized during the last years.

Where pasture is predominant, fodder trees planted on the terraces protect the soil and supplement the forage resources, thus allowing proper grazing management. Furthermore, once trees have been established on the terraces, the natural forage rapidly reappears, provided grazing is controlled.

Experience already gained as to the dry pastures established through artificial reseeding has shown that, particularly in the xerothermic Eumediterranean region, it is difficult to establish these pastures under normal dry-farming conditions. In many cases, artificial dry pastures proved to be extremely sensitive, even to moderate grazing. On the other hand, the absorptive capacity of the terraces considerably alters the water regime and may well help to support and conserve perennial seedings on them.

Contour terracing, together with tree plantation and perennial grass and legume seedings on the terraces, has been remarkably developed in North Africa. This so-called French-Algerian method in soil defense and restoration has been expanded from the pioneer country, Algeria, to Morocco, Tunisia, Libya and recently, overseas, to Yugoslavia and Greece. In Algeria some 250.000 hectares of devastated agricultural and grazing land on slopes have been fully terraced in "banquettes." The cost of terracing, tree planting and grass seeding on them was found to be $110 per hectare.[3]

[3] Different in scope (upland flood control only) and also in shaping is the "contour trenching" system that is being successfully applied in Wasatch Mountains of Utah (U.S.A.).

Carob tree plantations, for fodder and other uses, have been considerably developed in Israel and Sicily since the war.

In addition to the fodder trees, numerous shrublike forage legume species existing in the Mediterranean forest may well serve as another possibility towards creating new sources of fodder. Research recently conducted in Yugoslavia on the nutritive value of some of the shrublike legumes endemic to Mediterranean Southern Europe, such as *Colutea arborescens, Coronilla emeroides, Petteria ramontacea,* etc., produced valuable data. Thus, it was found that in a feeding period of six weeks during winter, the weight of sheep fed with one kg. of dry foliage of *Colutea* was increased by 8 kgs. per head, while the weight of sheep fed with one kg. of dry alfalfa was increased only by 0,87 kg.

Deciduous forests and shrubs have also played and still play an important role in fodder production for supplementing livestock feeding. Such rather traditional use of these forests for fodder has drawn, during the last years, the attention of forest and animal husbandry services towards a systematic, and on a management basis, use of this source of fodder.

Experiments in this field, aimed at determining the nutritive value and the most suitable method of lopping green leaves and branches, are being conducted in Yugoslavia. Some first orientation data, already drawn, are very encouraging.

Such experiments may well help in reorienting the actual use of the coppice oak forests for fuelwood production and for uncontrolled sheep and goat grazing, to a progressive and more profitable dual use, i.e., for timber and cattle grazing. In this connection, harmonization of the felling operations with the utilization of the leaves and branches for fodder might prove to be a very successful integration.

15. Converting of the actually existing situation into the scheme outlined in the preceding paragraphs must be based on three basic criteria—the economic, the natural and the social—pertaining in particular to forest economy. These criteria are necessary in designing and implementing land utilization readjustment and also in determining on a national basis the extent in area and time of changes in the actually existing land-use pattern, as regards the subject under consideration.

The economic criterion makes necessary an increase of timber production through intensive and systematic utilization of the existing commercial forests, as well as through new reforestation. It should be noted that the annual average timber consumption in wood-deficient Southern European countries does not exceed 0,08 c.m. as against 0,33 c.m. for the rest of Europe. The difference is greater in the case of the Near East and North Africa. On the other hand, the same criterion dictates an increase of production in livestock products. The actual level of livestock output per capita in the Southern European countries is only one-fourth or one-third of that of the rest of Europe, and the situation is even worse in the Near East and Africa. The consumption level in Mediterranean Europe is lower by 2/3 than in the rest of Europe.

The natural criterion renders necessary the conservation of land and water resources and imposes protection of the critical watersheds from any grazing. The natural criterion plays a decisive role in designing Mediterranean forestry and emphasizes the need for forest protection from grazing over large areas.

The social criterion imposes additional employment of the underemployed mountain population, in order to increase the annual family income.

Forestry has already been called upon in several Mediterranean countries to play a decisive role in helping to create new sources of employment through intensification of timber-cut in commercial forests, and primarily through carrying out long-term reforestation programs. However, as has been pointed out in the preceding paragraph, intensification of forestry is incompatible with in-forest grazing.

17. Rational segregation of the producing and protective forests from the pastures must also be based on three criteria corresponding to the factors involved, i.e., the natural, economic and social factors.

The natural-technical criterion imposes the selection of the most suitable ecological environment for each category of land use, since this environment is determined by factors such as location, pedological structure, microclimate, site conformation and phytosociological structure.

The economic criterion, applied on every site except those where absolutely protective reasons impose permanent forest cover, must be adopted on a comparative basis per each one of the two utilization categories.[4]

The social criterion imposes segregation to be adopted so as to ensure a constant mountainous rural economy based upon permanent employment and stable annual income.[5]

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[4] According to E. Rieben, in the forests of Jura (Switzerland), which are located in the vicinity of the northern limit of the transition zone, annual forestry revenue per hectare is twice as much as that of pastures.

[5] From estimates made in Italy, forestry employment in terms of annual cost per hectare is 25% higher than that of intensive pastures.

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RESUMES

Economie forestière at pâturage en forêt dans la région méditerranéenne

Le rapport en question se réfère aux principes et critères qui doivent régir l'harmonisation de l'économie forestière et de la pâture effectuée dans les forêts. Il n'examine pas, en details, les points de vue techniques du problème. L'accent est mis surtout sur les directives générales, sur une base politique, administrative et sociale de planification et de réalisation d'un aménagement de l'espace forestier méditerranéen, pour un équilibre sylvo-pastoral.

La dégradation des ressources des sols sur toute la région euméditerranéenne est considérée comme constituant le *problème-clef* des rapports entre l'économie forestière et le pâturage. L'influence de la vie pastorale traditionnelle et de l'agriculture marginale, exercée depuis des siècles, a abouti à une si grande dégradation, que pour arriver à une restauration, de sérieux travaux d'infrastructure sont nécessaires.

Dans la plus grande partie de la région méditerranéenne dans les stades de régression (dégradation) de la végétation naturelle ligneuse n'est pas compris le stade d'apparition et de prédominance des plantes vivaces herbagées, comme il est de règle dans les climats tempérés humides. Si l'on ne prend pas en considération les pâturages naturels des régions de montagne, le reste des terrains de parcours herbagés dans la zone euméditerranéenne constituent le stade d'un processus de dégradation: forêts—maquis—terrains de parcours rocheux composés de graminées et légumes annuels.

La surcharge des pâturages constitue le *facteur-clef* dans toute la région. D'après les données de la FAO, Sous-Commission des questions forestières méditerranéennes, la charge actuelle en bétail de tous les terrains à vocation pacagère y compris les forêts et les jachéres est évaluée à 2-3 hectares par unité de bête (bovin) et période de pacage (4-7 mois). Celle-ci représente le double de la capacité de charge qui, d'après des estimations, s'élève à 8 hectares, facteur qui augmente la pression de la pâture dans les forêts.

La pâture effectuée dans les forêts, malgré son influence catastrophique sur l'existence de la forêt et le rendement en bois, constitue une réalité forestière méditerranéenne.

La valeur financière des pâturages dans les forêts est considérable. D'après l'estimation de sa valeur pour les pays, Italie, Tunisie, et Grèce, il en résulte une valeur de fourrage par hectare de 10 à 13 dollars. Pour l'Italie et la Grèce plus particulièrement, d'après une évaluation récente, le rapport (%) de la valeur annuelle totale de fourrages dans les forêts envers: (a) la valeur de la production d'élevage nationale totale, (b) la production totale nationale forestière, s'élève respectivement à 3% et 21,7% pour l'Italie et 9% et 50% pour la Grèce.

Ayant en vue l'esquisse de la réalité forestière méditerranéenne ci-haut, du point de vue des rapports: forêt-pâturage en découle la question: qu'est-ce qui est préférable, *coexistence* ou *concurrence*? autrement dit *ségrégation* ou *intégration*?

Le principe de ségrégation, tel qu'il est appliqué dans les pays de l'Europe au voisinage des Alpes, ayant un climat tempéré-humide, n'est pas applicable sur toute l'étendue du territoire forestier méditerranéen, pour des raisons naturelles, sociales et économiques.

D'ailleurs le principe d'intégration, tel qu'il est appliqué avec succés en Amérique ne l'est pas pour les forêts productives en bois, se trouvant dans la zone de transition. Mais elle est applicable dans les forêts dégradées ainsi qu'aux maquis de la région.

D'autre part il n'est pas applicable dans les forêts de sapins, de pins noirs, de hêtres et en partie de chênes, exploitées tout le long de leur étendue, car production de bois et pâture des forêts de rendement sont généralement incompatibles.

Conformément à tout ce qui a été ci-dessus mentionné, la situation de l'économie forestière et de l'élevage méditerranéens suggère la seule réponse possible à la question ci-dessus: *ségrégation et intégration.*

Ce dyptique, présuppose, dans son application, la séparation, sur une échelle nationale par pays, de grandes régions forestières de montagne, qui, d'une part disposent de forêts riches en bois et forment d'autre part une unité agro-sylvo-pastorale.

Dans ces grands blocks forestiers l'application du principe de la ségrégation de la forêt et du pâturage doit suivre les directives d'action suivantes:
(a) éloignement de toute sorte de pâture des forêts en voie d'exploitation,
(b) amélioration et utilisation rationnelle des pâtures sur l'étendue boisée.
(c) transformation des cultures montagneuses en plantes fourragères.
(d) transformation graduelle d'une partie de l'élevage pastoral de moutons en élevage semidomestique de bovins.

Dans les autres forêts l'application du principe de l'intégration de la forêt et du pâturage doit suivre les directives d'action suivantes:
(a) Eloignement de la pâture de chèvres de toutes les forêts exploitées.
(b) Eloignement de toute sorte de pâture des forêts protectrices.
(c) Eloignement de la pâture de moutons des forêts de sapins.
(d) Aménagement de la pâture en forêt là ou celle-ci est permise et amélioration des terrains de parcours.

Pour mettre en application les lignes directrices d'action ci-dessus mentionnées, c'est à dire, la protection des forêts contre la pâture, l'aménagement de la pâture dans les forêts non-protégées, et l'aménagement des terrains forestiers à vocation pacagère, il faut augmenter la production des fourrages, effectuée d'après les méthodes modernes de l'agriculture et aussi d'après quelques techniques typiques euméditerranéennes, basées sur l'utilisation des arbres et arbustes fourragers.

Considérant la dégradation grave des terres cultivées et pacagées, il sera nécessaire, en beaucoup de cas, de combiner la production fourragère avec la restauration du sol par l'application de la technique du terrassement en banquettes qui rend possible:
(a) l'amélioration des cultures agraires entre les banquettes.
(b) en ce qui concerne le terrassement de terres à vocation pacagère, la plantation des abres fourragers et l'enherbement des terrasses avec plantes légumineuses vivaces.

Cette méthode, appelée franco-algérienne, s'applique déjà avec succès en Algérie et par les autres pays de l'Afrique du Nord.

L'arbre fourrager ainsi que plusieurs sortes d'arbustes légumes peuvent servir de substituts parfaits des pâturages artificiels arides. Ces derniers ont prouvé être perissables dans le milieu aride et chaud de la zone euméditerranéenne.

Tandis que dans la zone euméditerranéenne et dans celle de transition vers les zones désertes, la solution du problème des rapports entre forêt et pâturage consiste en une balance entre l'agriculture et l'élevage, dans la zone de transition vers celle tempérée-humide et les régions montagneuses la solution consiste en une balance sylvopastorale moderne, renforcée par la production fourragère.

Les rapports de la forêt et du pâturage suivant les trois critères reliées à l'économie forestière, soit économique, social et naturel, peuvent être régles tant sur une échelle nationale que locale, conformément au schéma ci-dessus.

La Silvicultura y las Dehesas Forestales en la Región del Mediterráneo

Este trabajo trata sobre los principios y criterios que deberían regir la integración de la economía forestal y de las dehesas forestales. No hace referencia detallada a los aspectos técnicos de este problema. Se concede mayor importancia a los lineamientos generales de las medidas que deben adoptarse para lograr una solución racional de este problema.

Se considera que la disminución de las tierras disponibles en toda la región del Mediterráneo constituye el *problema básico* de la relación entre la economía forestal y las dehesas. La centenaria influencia de una primitiva economía pastoril y de una agricultura marginal, ha dado por resultado una devastación tan terrible de la tierra que, para restaurarla, se hace imprescindible llevar a la práctica serios proyectos infraestructurales.

En la mayor parte de la zona del Mediterráneo los grados de retrogresión de la vegetación forestal natural no incluyen una etapa dominada por pastos perennes, como es el caso en las zonas húmedas templadas. Con exclusión de las dehesas naturales en las zonas montañosas, las demas tierras de pastoreo de la región del Mediterráneo Septentrional se encuentran en una etapa de proceso retrogresivo: campos de pastoreo en brozas forestales rocosas, con gramíneas anuales y con leguminosas.

El pastoreo excesivo es el *factor principal* en toda la región. De acuerdo con la información suministrada por el Subcomité de la OAA (FA) para Problemas Forestales del Mediterráneo, la actual proporción de pastoreo en todas las dehesas naturales, inclusive bosques y barbechos, se calcula que es de 3 a 4 hectáreas por unidad de ganado y el período de pastoreo es de 4 a 7 meses. Esto constituye el doble de la capacidad real que de acuerdo con algunos cálculos asciende a 8 hectáreas y es otro de los factores agravantes de la presión que ejerce el pastoreo sobre los bosques.

El pastoreo en los bosques, a pesar de la influencia destructiva que ejerce sobre la existencia de los mismos y sobre la producción de madera, es pues una realidad económica en la zona del Mediterráneo.

El valor de las rentas producidas por este pastoreo en los bosques es importante. De acuerdo con cálculos hechos para Italia, Túnez y Grecia, las rentas obtenidas del pastoreo en los bosques montan de $10 a $13 por hectárea. Con respecto a Italia y a Grecia, de acuerdo con cálculos recientes, el índice del valor total anual del pastoreo en los bosques en proporción con a) el total de las rentas nacionales producidas por el ganado, y b) la producción forestal nacional total, fue respectivamente del 3% y del 21,7% para Italia y del 9% y del 50% para Grecia.

En virtud de esta realidad forestal en la región del Mediterráneo, desde el punto de vista de la relación entre la silvicultura y el pastoreo, surge la siguiente interrogante: ¿*Competencia* o *Coexistencia*?, o, en otras palabras: ¿*Segregación* o *Integración*?

El principio de la segregación tal como se aplica con éxito en los países europeos de la región de los Alpes con clima húmedo y templado, no es aplicable en la totalidad de la superficie forestal del Mediterráneo, por razones de carácter natural, social y económico. Por otra parte, el principio de integración aplicado con tanto éxito en la zona occidental de los Estados Unidos, no es aplicable en los bosques madereros de la zona de transición, pero sí es aplicable en talleres y bosques de madera de baja calidad, como así también en brozas. En general se estima que los bosques productores de maderas y el pastoreo en bosques son dos cosas incompatibles.

De conformidad con ello, la situación forestal y la economía ganadera del Mediterráneo imponen como única solución posible a este problema, la *"Segregación y la Integración."*

Esta díptica, para su aplicación, requiere la reserva, en una escala nacional, de grandes superficies forestales montañesas que ofrecen, por una parte, bosques con abundantes maderas y, por la otra, una unidad agro-silvícola-pastoril.

En estos grandes grupos forestales la aplicación del principio de la segregación de la silvicultura y del pastoreo, debería seguir las siguientes pautas:

(a) Protección de los bosques productores de madera contra toda forma de pastoreo y
(b) Administración y mejoramiento de las dehesas situadas dentro de las principales superficies forestales.

El principio de la integración de la silvicultura y del pastoreo, debería ajustarse a las siguientes normas:

(a) Eliminación total del pastoreo de cabras en los bosques;
(b) Eliminación de todo pastoreo de los bosques protectores;
(c) Eliminación del pastoreo de ovejas en los bosques de abetos;
(d) Regulación del pastoreo en los bosques, ya que tal pastoreo es permisible, como así también administración y mejoramiento de las dehesas naturales adyacentes.

No podrá lograrse la aplicación eficaz de la díptica más arriba indicada, a menos que la protección de bosques contra el pastoreo, la regulación del pastoreo en bosques y la administración de las dehesas naturales puedan coordinarse totalmente con la producción de forrajes de acuerdo con los métodos agrícolas clásicos y con algunas técnicas típicas aplicadas en la zona septentrional del Mediterráneo respecto a los árboles utilizados para forrajes.

Teniendo en cuenta la severa devastación agraria y de pastos causada por la erosión de la tierra, con sus numerosas colinas, la producción de forrajes debe combinarse, en la mayoría de los casos, con trabajos de infraestructura para la restauración de la tierra, que ha de consistir principalmente en la formación de terrazas siguiendo la curva de nivel ("banquettes").

Las terrazas que siguen la curva de nivel permiten:

(a) Mejores cultivos agrícolas entre terrazas, y
(b) En cuanto a las terrazas para pastoreo, el plantío de árboles para forraje debajo de los cuales pueden plantarse estacas de plantas perennes.

Los árboles de forraje, y también muchos otros arbustos leguminosos pueden reemplazar ventajosamente a las dehesas secas artificiales que han demostrado ser poco resistentes al medio ambiente cálido y seco de la zona septentrional del Mediterráneo.

En la región septentrional del Mediterráneo y en las zonas de transición hacia los desiertos la solución del problema de la interrelación de los bosques y de las dehesas radica principalmente en un moderno equilibrio agro-pastoril, pero en la transición hacia las zonas húmedas y templadas y en la zona de las montañas, la solución se halla en un moderno equilibrio silvícola-pastoril complementado con la producción de forrajes.

En el nivel nacional, como así también en el nivel local, la regulación de las interrelaciones de la silvicultura y del pastoreo, de acuerdo con lo que se indica más arriba, sigue tres criterios importantes para la economía forestal: el económico, el social y el natural. La combinación acertada de los tres debe considerarse como la mejor solución para el problema.

Progress in the Integration of Forestry and Grazing With Special Reference to Pakistan

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The Problem

Integration of grazing with forestry is an entirely new concept, at least for the regions covered in this report. Except for the Australasian countries, where the pressure of men and animals on the land and its vegetation has always been very light, all the other countries of older civilizations have suffered more or less grievously, due to unrestricted and uncontrolled grazing since the dim past. In fact, it has been a war of extinction in areas where the growth factors for vegetation are not particularly favourable and where the biological balance, once upset, may never recover. Animals, including man, destroy vegetation by unrestricted felling, lopping, browsing and grazing, and

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then inexorable retribution catches up with them, and they, themselves, slowly but surely get thinned out due to absence of food, fodder and shelter. This has consistently been the history of all the Middle East countries, Pakistan, parts of India, China, etc. Thus, the problem of grazing and forest has been very much in the fore, not for their integration and coexistence, but for destruction of forests first and deterioration of livestock in the end. Uncontrolled grazing has been an anti-forestry force throughout these regions and has ruined forests, destroyed watershed values, induced erosion and changed the face of the earth. Palatable and nutrient grasses, herbs, shrubs and trees go first and give place to thorny, coarse, xerophytic vegetation. Grazing animals, therefore, diminish, and browsers such as camels and goats, who do not spare even this coarse and thorny growth, increase. In course of time destruction is complete.

As has been stated above, the destruction of vegetation has recoiled on the animals themselves. Starving livestock cannot give good yields nor can they resist disease and death. Diminishing yield is a serious thing in countries which are still in the pastoral civilization stage and have not fully changed over even to an agricultural civilization. To these seminomadic people, the only remedy for this malady is to increase the number of stock so that it may compensate for the falling quality. Higher numbers, however, mean greater pressure on diminishing food, and the yields fall further. Thus starts the vicious circle which is such a bane of all the underdeveloped countries and which introduces the complex human and sociological factor into an otherwise technical problem. These old civilizations have marked time during all these centuries. By and large, they have an agri-pastoral economy and are still in the "manual labour" stage of development. The alternative means of earning a livelihood in technical, industrial, scientific and intellectual fields are almost entirely closed to them. The question of rationalising grazing in these regions is therefore linked up with finding out such alternative means of earning a living for the people as the majority could learn and would adopt.

It will thus be amply seen that any integration of grazing with forestry in these regions must aim at saving the forests from a real threat of total extinction. The present-day grazing pressure in most of the countries of this report is extremely heavy, and there is no difference of opinion that the present livestock is excessive in number and inferior in quality. It is also conceded by all hands that a much smaller number of better breeds can ensure even better yields than these countries get today. These countries are amongst those whose people eat about the least amount of food of animal origin in the world. Nor do they export any of this product. As a comparison, the U.S.A. is reported to have doubled its population and trebled the consumption of food of animal origin per capita per annum, but there has been no increase in the number of livestock in the same period. Reduction in number and improvement of quality are clearly the answer. This can succeed, however, only if the whole complex problem of community development is attended to in each such area. In addition to reduction in number and improvement in breed, this program will have to envisage partial mechanisation of agriculture, proper agricultural practices for better yields, giving proper place to soil-improving fodder crops, fertilizers and farmyard manure utilisation, preservation of watershed and wood lots, rotational grazing according to carrying capacity in range and forest lands, alternative means of earning a livelihood, such as cottage industries, craftsmanship, etc.

On the whole, it would be correct to say that no proper work on the problem of integrating grazing with forestry has been done anywhere in the countries of this report. Basic data about carrying capacities in different regions and different types of forests, nutritive value of indigenous grasses, shrubs and herbs, closure periods necessary for full recovery, supplemental feed, etc., are generally not available. It is clear, however, from a look at the areas, that if and when such data are compiled, they will only strengthen the belief that integration of grazing with forestry in these areas would consist of the reduction of the existing pressure of grazing in the forests to allow them to regenerate and attain their full protective and productive potentialities. It will, perhaps, be as well to remind ourselves here that almost all the countries of the report import large quantities of timber for their minimum essential needs and that much of the slowness in their development is due directly to the lack of availability of timber and wood within their borders.

It is, however, heartening to note that almost all the countries have become aware of this urgent national problem and have started researches on different aspects of it. Some countries have already promulgated laws to control grazing. Even multi-purpose, multisided community development plans, with special references to proper land utilisation, are being adopted in some countries. Their progress will be keenly watched by all engaged in similar pursuits. The problem is immense, however, and of vital importance to the well-being of a very large section of the earth and its population. It is also beyond the means of every individual country to tackle it properly. It calls for international cooperation and is certainly a proper case for aid from international organizations.

Pakistan

The country consists of two sections separated by about 1,100 miles of Indian territory. East Pakistan is about 54,000 square miles in area and lies between latitude 21°-26° N. and longitude 88°-92° E. West Pakistan is situated between latitude 24°-37° N. and longitude 61°-75° E, and is about 310,300 square miles in area. Rainfall in East Pakistan is from 50″ to 200″, while in West Pakistan, it ranges from 4″ to 60″. The population, which in East Pakistan is about 42 million and in West Pakistan 34 million, is predominantly agricultural, 80% of it depending on the land. Wheat, rice, sugar cane, jute, cotton, tea and tobacco are the principal crops. The cultivated area per head of population is about 1.1 acres in West Pakistan and about .5 acres in East Pakistan.

The forests in East Pakistan cover an area of 8,551 square miles and comprise the following types:

1. Evergreen, semi-evergreen and moist deciduous forests consisting mainly of *Dipterocarpus* spp., *Swietenia floribunda, Artrocarpus chaplasha, Amoora wallichii, Mesua ferrea, Dischopsis* spp., *Albizzia* spp., and *Sterculia* spp., with an undergrowth of bamboo. Area about 5,793 square miles.

2. The tidal forests consisting mainly of *Heritiera minor, Rhizophora mucronata, Ceriops* spp., *Excaecaria agallocha, Sonneratia* spp., *Amoora* spp., and *Carapa* spp. Area about 2,341 square miles.
3. The low-level plains *sal* forests consisting mainly of *Shorea robusta* with *Albizzia, Terminalia Cassia,* etc. Area about 417 square miles.

In West Pakistan, the forest area is 9,883 square miles. The following types of forests can be distinguished:

1. *Coniferous forests.* Area 1,869 square miles, elevation 3,000′ to 13,000′ and rainfall from 30″ to 60″. The main species are *Cedrus deodara, Pinus excelsa, Pinus roxburghii, Abies spectabilis* and *Picea morinda.* Broadleaved species include oak, maple, willow, horse chestnut, poplar and walnut.
2. *Dry high hill forests.* Area 390 square miles, elevation 5,000′ to about 10,000′, and rainfall 15″. The main species are *Juniperus macropoda* and *Pinus gerardina.* Crop is open and regeneration absent. About half of this area is treeless, having grass or bare rock.
3. *Sub-montane forests.* Area about 3,290 square miles, elevation up to about 3,000′, and rainfall is 20″ to 30″. The main species are *Acacia modesta* and *Olea cuspidata* associated with *Prosopis spicigera, Dodonia viscosa* and *Zizyphus* spp. Canopy is open. Grasses and fodder species are common.
4. *Plain scrub.* Area 1,511 square miles. Rainfall less than 15″. They have scattered growths of xerophytic species such as *Prosopis spicigera, Salvadora oleoides* and *Capparis aphylla.*
5. *Riverine forest.* Found along the banks of the larger rivers. Width on either side is limited to area inundated during floods. *Acacia arabica* is the most common species, usual associates being *Prosopis spicigera, Tamariz* spp. and *Populus euphratica.*
6. *Irrigated plantations.* Area 500 square miles. *Dalbergia sissoo* is the principal species. *Morus alba, Acacia arabica* and *Melia azedarach* are also grown.
7. *Coastal forests.* Area 1,182 square miles. Rainfall about 7″. Along the Arabian sea coast. Stunted forms of *Avicenia* spp. and other mangrove species occur.

The livestock population is about 48 million, of which 25 million are in West Pakistan as shown below:

Cattle	8,665,154
Buffaloes	5,680,288
Sheep	5,773,366
Goats	4,458,493
Horses	432,243
Mules	26,889
Camels	520,668
Total	25,557,101

In spite of this heavy population of livestock, Pakistan is one of the poorest countries in the matter of protein and animal food for its inhabitants. This is obviously due to far too many livestock for the available feed.

Grazing and the Forests

East Pakistan: An area of 3,453 square miles of unclassed forests is open to uncontrolled shifting cultivation and grazing by the hill tribesmen. Soil erosion caused by shifting cultivation is a much greater source of damage here than grazing. The large compact areas of the rest of the evergreen and moist deciduous and tidal forests have very little human population. There is, therefore, very little grazing in these forests. The *sal* forests of Dacca and Mymensingh Divisions, on the other hand, are situated in thickly populated areas and are therefore damaged because of the heavy population of livestock which cannot find anything to eat when the surrounding fields are cultivated. At present, about 40,000 livestock graze annually in about 20% of the area of the reserved forests.

West Pakistan: The forests of West Pakistan have to bear an immense pressure of grazing. Specific figures about grazing intensities for different areas are not available. However, figures are known for about 4,000 square miles of forests for 1957-58. The following livestock grazed in this area:

	No.	Conversion factor	Grazing/animal units
Buffaloes and Camels	80,617	x2	161,234
Cows and Bullocks	494,600	x1	494,600
Goats and Sheep	225,094	÷5	45,020
Other animals (Horses, Donkeys, etc.	10,000	x1	10,000
TOTAL:	810,311		710,854

This gives an average intensity of grazing of about 3.5 acres per animal unit. As rainfall in this area ranges from 10″ to 60″ and the ground vegetation is extremely depleted, the carrying capacity would barely be about 5 acres per animal unit in the humid parts, grading down to about 100 acres per animal unit in arid areas. The average intensity of grazing of 3.5 acres per animal unit is, therefore, far in excess of the grazing capacity. The actual intensity of grazing is even higher because the above figures of livestock do not take into account the migratory herds of the Pawindas, and livestock grazed illicitly. The latter figure is likely to be quite appreciable due to a perpetual scarcity of fodder elsewhere.

Due to this pressure of grazing, the natural regeneration of conifers is not coming along satisfactorily. The broadleaved species have been lopped to extinction. The crop is deteriorating and becoming inferior after each felling.

The intensity of grazing is severer in the sub-montane, dry, evergreen scrub forests where, at places, there is only half an acre for each animal unit. This has almost completely inhibited the regeneration of these forests.

In the dry, high-hill *juniper* and *Pinus gerardiana* forests, heavy grazing has stripped the hillsides of ground vegetation, causing severe soil erosion and culminating in the exposure of bedrock over about one-third of the total area.

In the dry "scrub" forests, the severe climatic conditions are further aggravated by a heavy pressure of grazing resulting in complete lack of regeneration.

Integration of Grazing with Forestry

In view of what has so far been said, the integration of grazing with forestry would consist of the reduction of the existing pressure of grazing in the forests to allow them to regenerate and attain their full protective and productive potentialities. This is an immense task in view of its sociological and economic implications. In this country agriculture, too, is in a precarious state, having the lowest yields per acre. Its causes are many and apparently contradictory sometimes. We suffer from drought and floods, waterlogging and very low sub-soil water levels, and alkalinity and leached-out sterile soils. The prime cause which explains these diverse and apparently contradictory maladies is excessive erosion all over the country, which has upset water and soil regimes. For centuries now, due to the absence of firewood, cattle dung and farmyard manure is burnt as fuel, and soils are devoid of nitrogen, phosphorous and organic matter. This has forced us to cultivate every acre for food grain and nothing for fodder, and also to bring as much land under the plough as possible for food grain production. Thus, uneconomic agriculture is being practiced on many lands which properly are only range or forest lands. This reduces the feed for the livestock further and causes a decrease in quality and an increase in disease and mortality. This again leads to the suicidal policy of making good by quantity what one loses in quality. The fact is that Pakistan is overpopulated for its present production level. The real solution is family planning and drastic reduction of livestock, which perhaps points to a change in the social habits and lesser dependence on the agri-pastoral economy which is the be-all and the end-all of this society today.

The change envisaged above would take a long time to be brought about. Today, our attempt is to visualize a plan to bring each acre of our country to this full productive level. This includes an overall reduction of livestock so that more and better feed may be available per acre for fewer but a better type of livestock. It would also suggest some shifting of population from the areas where excessive pressure causing excessive erosion is threatening the very well-being of the whole country, to other regions in the plains where the inevitable damage could be localized and would be amenable to partial cure by proper agronomical practices. Here, the manure from the livestock will be a welcome addition to the nitrogen-poor soils, instead of being wasted over extensive, depleted ranges. As it is, food produced in the hills is barely enough for the needs of the people for about a couple of months in the year. And this is at the cost of losing the land altogether through soil erosion. Technically, therefore, it should be quite feasible to remove the excess human and livestock population from the hills to the cultivated land in the plains, whose exceptionally low productivity should be increased considerably through the use of scientific farming.

Progress in the Integration of Grazing and Forestry

On account of the drastic social changes involved, the problem of integrating grazing with forestry in the hills has not yet been tackled on any appreciable scale. Reduction or shifting of livestock is not possible unless such alternative means of livelihood are offered to the people, as they would be able to adopt. The first step was taken in this direction in 1953 when the Government appointed a High Powered Commission to report on the proper management and development of the North Western Himalayan hills round about Murree. The Commission's report clearly indicated that the real solution was the shifting of part of the population. The report could not be adopted as a whole due to practical difficulties. Another attempt to rationalize grazing in the dry hills of the Quetta/Kalat region was made when a big project was started in 1954. A total of about 200,000 acres of these hills were fenced and are being treated under the best advice available. There is, however, no tree growth now left in these selected areas, and the attempt here is more in the nature of range management than of integration of grazing with forestry.

The Forest Service has now attempted to draw up a model scheme for a selected and limited area of about 13,000 acres at Bhurban (6,000 ft. above sea level), in the vicinity of Murree in the North Western Outer Himalayan ranges. This incorporates all the ideas listed above, but it would be some years before judgment could be passed on it. This scheme is at present awaiting final sanction.

In the sub-montane forest regions, including the uplands, the problem of grazing is perhaps the most acute. In addition to geography, history has also played an important role in determining their present state of extreme erosion. This zone has been the playground of all the horses and invaders who had been pouring into the Indo-Pakistan sub-continent from the North West from times immemorial. The present-day form of this invasion is the up-and-down movement of hundreds of thousands of Pawindas (foreigners), with their innumerable herds, who come to these regions every year for six months' free grazing. All this has contributed to give a nomadic and pastoral outlook to the people who inhabit these zones. Vegetal cover and soil conservation are just foreign to their way of thinking. The *coupe de grâce* to any idea of soil and vegetation conservation in this zone was given by the foreign rulers during the last 100 years of their rule, when, due to the miltary importance of the "North West," they purposely and exclusively kept this area as the recruiting ground for their forces. This never allowed the people to develop interest in the land, which is essential for its proper husbandry. In fact, the numerous "Camel Corps," which were the only means of locomotion and transport in those days, were all stationed in these sub-montane forests to graze and browse freely. The result of all this should only be seen to be realized. It is a vast, more or less barren area with some stunted over-browsed thorny shrubs here and there and with deep ravines and gullies all over, claiming about 40% of the area. The remaining area is under heavy sheet erosion. This is the centre to spread sand in the plains and silt up rivers. A major portion of this region is the "Salt Range," with immense deposits of pure salt (sodium chloride). The covering soil has thinned out all over, and at many places outcroppings of rock salt are extensively visible. The runoff in such places becomes saturated brine and ruins the lands below.

Attempts to rationalize grazing in these regions have been made repeatedly but with little success. More than a technical, it is a human problem. The recent attempt has been to ban goats from these areas. The next step

will be to do away with camels. This is expected to change the mode of life of the population, when positive treatment will be applied. No attempt has yet been made to control grazing in the arid scrubs on the plains. It is, however, proposed now to select 6 representative big areas this year (1960) for introducing rotational and deferred grazing for demonstration purposes. The riverine forests are good grazing grounds and are generally kept open to grazing once the forest crop is big enough to avoid damage. In southern regions, however, the *Acacia arabica* crop in these riverine forests grows too thick to leave much grazing under the closed canopy. Here, another form of integration is practised. The acacia pod is a much desired fodder for goats. Goats are let in during the season for feeding on the pods. No lopping of branches or browsing is allowed, but grazing is permitted. The herds remain in the forests during these days. The herdsmen have to supply to the Forest Department an agreed quantity of seed of the acacia which they collect from the droppings of the goats. This seed is used for sowing because of the softening of the hard testa by gastric juices.

The irrigated plantations have remained free from any uncontrolled grazing.

Australia

Grazing properties often comprise very large land areas, privately owned, and there are, for example, no peasant proprietors grazing perhaps a few head of stock in the forests under close supervision. Again, range (pasture) management as practised, say, in North America, as an important adjunct to forestry, is largely unknown in Australia. There are in eastern Australia, notably, certain island areas carrying scattered savanna forests where seasonal grazing may be practised. In the case of some cypress pine (*Callitris* spp.) areas under Forest Department control, however, it has been found necessary to prohibit grazing in order to secure natural regeneration.

Consequently, there has been little occasion, so far, for any detailed investigation into forest grazing, and no data are readily available on the subject.

The following amplifies the above:

1. Australia, including the island State of Tasmania, comprises in all an area of nearly 3,000,000 square miles. In the north, the tip of Cape York Peninsula just crosses latitude 11° S., and Tasmania nearly reaches latitude 44° S.

2. Area distribution, according to rainfall, is as follows:

Average Annual Rainfall		Area in Square Miles
Under	10″	1,007,357
	10-15″	603,605
	15-20″	358,458
	20-25″	308,881
	25-30″	225,885
	30-40″	213,195
Over	40″	11,247

Of the total area, nearly 40% (comprising over 50% of Queensland, over 37% of Western Australia and over 50% of Northern Territory) lies within the tropics. Climates range from characteristically tropical in the north to essentially alpine at the higher altitudes of the Great Dividing Range in southeastern Australia. The heaviest rains are along the Pacific coast to the north of latitude 30° S.

Commonwealth Year Book No. 45 (1959) gives the following estimated population totals and distribution for the year 1958:

	Human	Cattle	Sheep
Total	9,951,618	16,892,000	149,315,000
New South Wales	3,725,686	3,736,000	65,410,000
Victoria	2,770,919	2,750,000	27,090,000
Queensland	1,424,818	7,187,000	22,274,000
S. Australia	907,992	597,000	15,236,000
W. Australia	713,583	997,000	15,724,000
Tasmania	346,545	371,000	3,298,000
Northern Territory	19,122	1,244,000	27,000
A.C.T.	42,953	10,000	256,000

Population densities correspond very generally to the occurrence of forest and savanna in the eastern part of Australia, but on State forest areas grazing is a relatively minor item in departmental revenues. Thus, in the Queensland Forest Department Annual Report, 1957-58, an item "rents and grazing dues" represents only 0.36% of the total revenue.

Iraq

The climate is semi-arid with an average of 400 mm. rainfall, though maximum in the high hills is 1,300 mm. All rain occurs in winter. The population is 7 million, mostly concentrated in the valleys of the Tigris and the Euphrates.

Forests are confined to the north and northeastern hills, with an area of 17,000 sq. km. i.e., 3.3% of the total area of the country. Only 36% of the forests are well stocked. The following main types of forests are recognised:

1. The hill forests with pines, oaks, maples, *Celtis pistacia, Crataegus,* etc., found scattered in an area of 500 sq. km.

2. Riverine forests, locally called "Ahrash," along the Tigris and the Euphrates. Plants found here are the *Populus euphratica, Salix* spp. and *Tamarix* spp. in an area of 200 sq. km.

Livestock population figures (1956) are as follows:

Asses	492,500
Mules	99,800
Horses	234,500
Camels	192,600
Buffaloes	280,900
Cows	1,535,000
Goats	2,639,300
Sheep	9,221,400

Grazing by goats, sheep and cattle is intense in all forests except for some very small areas. The people are semi-nomadic and do not allow any area to be protected. Forests suffer very seriously. Grazing intensifies range from about 200 to 100 animal per sq. km. This is extremely heavy.

No work regarding integration of grazing with forestry has been done, but the following proposals are being for-

mulated so that grazing may not interfere with more important functions of forests:

1. Grazing lands to be separated and fenced for a reasonable number of animals.

2. To reduce grazing in natural forests to the barest minimum under a proper permit system. The idea is to prohibit it altogether finally.

3. To compensate for the loss of grazing in the forests, it is to be legislated that 10 to 15% of the agricultural land given to farmers under agrarian reforms should be used for raising forage and leguminous fodder as crop rotation.

India

In India, 24.7 million cattle grazed in the 117,489 square miles of government forests open to grazing during 1947-48. This gives an intensity of grazing of about 3.1 acres per animal for the country as a whole. The figure varies widely from place to place from about .9 acre per animal in the Punjab to about 178.8 acres per animal in Assam. The proportion of the total cattle population of an area to the population using the forest for grazing depends on the accessibility of forests, the type of forests as regards the availability of good quality forage and the availability or otherwise of alternative areas in the vicinity which can be used for grazing. This proportion varies from as little as .05% to as much as 94.5%.

Controlled grazing is an efficient tool in silviculture and can be used with advantage in reducing undecayed humus for securing regeneration of certain species and for reducing fire hazard by decreasing inflammable material on the forest floor. In most areas, however, the control of forest grazing as regards numbers becomes difficult. This is inherent in the nature of forest distribution over the greater part of the country. Forests mainly occur in large compact blocks with dense population all round but very little in the interior. Consequently, the periphery of the forests is overgrazed, and the forage resources of the interior are not utilized fully. In order to integrate grazing with forestry, several States have started cattle pens in the interior of the forests. Efforts are being made to remove the drawbacks which are hampering the widespread use of the interior of the forests for grazing, and suggestions are being made for improving communications in the interior of the forests, developing water and conducting antimalarial operations. Efforts are also being made to improve the grazing capacity of forests through re-seeding with indigenous and exotic plants of superior forage value.

Jordan

The Hashemite Kingdom of Jordan is situated between 34° 52′-39° 12′ E. longitude and 29° 17′-33° 23′ N. latitude and has a total area of 96,720 km².

Jordan may be divided into four climatic areas:

1. *The dry tropical zone.* 4,752.64 km², extending from lake Tiberias to the Dead Sea. Annual rainfall is about 400 mm. in the north, becoming less southwards to 10 mm. in Aqaba. Irrigated plantations of eucalypts, cypress, poplars and tamarisks are in this region.

2. *Mediterranean zone.* 8,186.01 km². The mountain ranges of east Jordan. It has dry, hot summers and humid, mild winters. It lies between the 350-750 mm. rain belts. Pine and oak forests are the main types.

3. *Semi-arid zone.* 11,095.20 km². It borders the Mediterranean climate. Rainfall ranges from 100-350 mm. Forests are scrub type, having stunted oak, *Pistacia, Ceratonia,* etc.

4. *Arid zone.* 72,586.13 km². Annual rainfall is less than 150 mm., which usually comes as torrents in winter. Bushes of *Atriplex* and *Haloxylon* are found.

The human population is 1,500,000. The livestock population is 1,290,110, of which 25,000 graze in the forest areas. Grazing capacity in the dry tropical area under irrigation is 1½ dunums per head of cattle. In the semi-arid area, which is considered the main grazing area, it varies from 75 to 100 dunums per head per year. In the desert, it might be considered as 500 dunums per head. Grazing is very harmful to the natural regeneration, especially in pine forests. Rotational grazing is always taken care of in the oak forests which are subject to a 40-year programme, but in drought years, all the oak forests are opened to grazing to save the livestock from perishing, but no such practice is applied in the newly reforested areas.

Sudan

It has an area of 967,500 square miles. It is bounded by latitudes 21° 55′ N. and 30° 53′ N. and longitudes 21° 48′ E., and 38° 30′ E. Except for the Red Sea coast, rains occur between May and October. Annual rainfall varies from 0 to 5 mm. in the north to about 1,600 mm. in the south. The Red Sea coast receives 90 mm. per year.

Though exact figures are not available, it is estimated that Sudan has a human population of 10,263,000 and a livestock population of 21,601,000. Anywhere between 15% to 40% of the total population could be classified as nomads who practise free grazing extensively.

No information is available about the grazing capacity of each type of forest. The only reliable data obtained so far is regarding the livestock population within the savanna woodland type where 1,930,000 head of cattle, 1,150,000 sheep and 38,000 camels graze over an area of 400,000 square miles.

Grazing in the semi-desert area has always been extensive and destructive. In the woodland savanna, the grazing sometimes means full destruction of land. In the drier parts of the woodland savanna, grazing checks the development of forests in most cases. In the wetter parts of the woodland savanna, grazing, if well controlled, has a desirable effect on forest growth and improves the general health of the livestock.

Removal of the soil cover through destructive grazing in the plains and sand dunes has led to the loss of large quantities of agricultural soil by sweeping winds, desiccation of land and sinking of water levels in many areas.

Except for the forest reserves, free range grazing is almost the rule in Sudan. The creation of these forest reserves can justly be considered the first practical step in the control of grazing. Here in the forest reserves grazing is allowed only by permits. Unfortunately, the area reserved so far does not exceed ½% of the total area of the Sudan.

The total livestock population in the various Muhafazat is approximately 8,317. Livestock actually grazing in the

forest zones are sheep, cattle, goats and camels. A law has recently been passed (1958) which forbids grazing by goats or camels in the forest zones. Only cattle and sheep are allowed in the forest zones. Grazing is completely forbidden for 10 years in all newly afforested areas.

To ensure better forestry and grazing practices, the feasibility of shifting the human and livestock population of villages near forest areas to other localities is being examined.

Turkey

The total area is 767,119 km.^{2}, and the population, according to the census of 1955, is 24,112,000, of which 7 million is urban. The country can be divided into seven climatic zones:

1. *The Black Sea zone.* This is the influence of the Black Sea. Rainfall ranges from 450 to 2,510 mm. Fir, spruce, pine, beech, chestnut and alder are the species in the forests.
2. *The Marmara zone.* Rainfall ranges from 547 to 792 mm. Oak and beech forests predominate.
3. *The Aegean zone.* Oak, valonia, pine, pistachio and juniper are the main species.
4. *The Mediterranean zone.* The Taurus mountain ranges form the boundary of this zone. Rainfall ranges from 619 to 1,056 mm. Oak, cedar, fir, juniper and pine are the main species.
5. *Central Anatolia zone.* Has arid summers and damp, cold winters. Rainfall ranges from 336 to 419 mm. Australian and Scotch pines and oak forests are found here.
6. *East Anatolia zone.* Is high and rough. Winters are very cold. Rainfall ranges from 500 to 550 mm. Scotch pine, oak, beech, juniper and poplar are the species found.
7. *Seventh zone.* Rainfall ranges from 495 to 709 mm. Oak is the dominant species.

The following table shows the areas covered by various forest types:

Productive high forests	2,205,848	hectares
Unproductive high forests	2,816,911	"
Productive coppices	1,661,953	"
Unproductive coppices	3,898,975	"
Total:	10,583,687	hectares

According to the census of 1958, the animal population all over Turkey is:

Goat	24,232,600
Sheep	30,823,400
Ox, buffalo	13,646,000
Horse, donkey, mule	3,326,000
Total:	72,028,850

For four months summer grazing, one cow per 1.5 acres of range on bottom land with a canopy ratio of 70% is enough in the Black Sea climatic zone. On the boundary between the Black Sea and Central Anatolia climatic zones, 4 acres of range is needed for one cow for the same period. On high plateaus in the Mediterranean zone, black goat breeding has great importance.

Scientific research for determining grazing capacities of forest ranges in other parts of the country and for integrating grazing with forestry have not yet been completed.

Tripoli, Libya

The total area is approximately 35,000,000 hectares, which is mostly desert. About 3,500 square km. are cultivated. The population is 738,000. The livestock population, which is floating, is as follows:

Cattle	31,000
Sheep	300,000
Goats	308,000
Camels	58,000
Donkeys	27,000
Horses	5,400
Total:	729,400

The forest area is nominal, being only 15,000 hectares in area. Except for a few scattered damaged *Pistacia*, *Acacia* and *Zizyphus*, nothing better is found. Grazing has been prohibited in the forest reserve, but elsewhere it is an extremely serious problem and has caused serious denudation and erosion.

United Arab Republic, Syrian Region

The area of the Syrian Region is about 184,000 sq. km. Deserts cover ⅔ of this area.

Generally speaking, the Syrian Region is under the climatic effects of the Mediterranean. Going from east to west, the following climatic zones can be distinguished:

1. *The arid zone.* Precipitation is less than 200 mm. per annum. This covers 67.7% of the total area.
2. *The semi-arid zone.* Precipitation is between 200 mm. and 500 mm. per annum. It represents the best pastures in the region. This zone is 18.7% of the total area.
3. *The semi-humid zone.* Precipitation is 500-800 mm. It is the main farming area and covers 9.2% of the total.
4. *The humid zone.* Precipitation exceeds 800 mm. per annum. Most of this zone is covered by natural forests.
5. *The zone under irrigation.* The area of this zone is 3.2% of the total area of the region.

The population of the Syrian Region is estimated at 4,397,184, sixty percent of which is rural. Eighty percent of the population lives in the humid and semi-humid zones. Data regarding livestock, its distribution and the carrying capacities of different areas are not available at present. The area under forest is 78,600 hectares.

RESUMES

Progrès réalisés relativement à l'intégration de la forêt et du pâturage en ce qui concerne en particulier le Pakistan

La région faisant l'objet de la présente étude est celle de l'Asie du Sud-Est et le Moyen Orient, mais malheureusement, le délai qui nous a été imparti pour la réaliser s'est révelé insuffisant. Un questionnaire a été envoyé à l'Afghanistan, à l'Iran, à l'Inde, à l'Irak, à la République arabe unie, à la Jordanie, au Liban, à la Libye, au Maroc, à l'Australie, à la Nouvelle-Zélande, au Soudan et à la Turquie, mais six seulement de ces pays (auxquels nous adressons nos sincères remerciements) nous ont fait parvenir une réponse.

La présentation de ce document a été dictée en partie par les rapports des pays, et en partie par le fait que l'auteur a dû avoir recours surtout au Pakistan pour les détails pouvant être con-

sidérés comme servant de type pour ces régions, à l'exception de l'Australie. Après une discussion préalable du problème considéré dans son ensemble, nous fournissons des détails plus complets pour le Pakistan et terminons en mentionnant de façon plus succincte, et par ordre alphabétique, les pays ayant fourni un rapport.

Le problème de l'intégration du pâturage et de la forêt n'a été abordé de façon scientifique par aucun des pays ayant fait rapport, du moins pour une période ou une superficie appréciable. Exception faite des pays d'Australasie, le pâturage est partout abusif et est généralement incompatible avec les principes de la sylviculture en leur état actuel d'application. En conséquence, une intégration appropriée consistera surtout à contrôler et à rationnaliser le pâturage dans ces régions, afin de donner aux forêts, qui sont généralement extrêmement dégradées, la possibilité de coexister.

La plupart des pays de cette région se livrent actuellement à des recherches et à des expériences en ce qui concerne l'intégration du pâturage et de la forêt. Les efforts tentés au cours des dernières années ont été illustrés par des détails puisés dans le rapport du Pakistan. Ceux fournis par les autres pays ont également été résumés. Il s'agit là d'un problème d'une ampleur immense et d'une importance vitale pour le bien-être d'une section très importante de la population du globe. Il dépasse également les moyens d'action des pays pris en particulier; il ne peut être résolu que par la coopération internationale et constitue certainement un cas où l'aide des organisations internationales serait appropriée.

Progresos de la Integración de la Silvicultura y el Pastoreo con Especial Referencia al Pakistán

A los efectos de este estudio, las áreas especialmente consideradas fueron las regiones comprendidas en el sudeste de Asia y el Medio Oriente. No sólo se anunció el comienzo de este estudio, sino que se hizo circular un cuestionario en Afghanistán, Irán, India, Iraq, República Arabe Unida, Jordán, Líbano, Libia, Marruecos, Australia, Nueva Zelandia, Sudán y Turquía. Sin embargo, se recibieron respuestas únicamente de seis países, a los que se expresan las más sinceras gracias.

Las normas de este trabajo fueron impuestas, parcialmente, por los informes de los países en cuestión y en parte también por el hecho de que el autor hubo de depender mayormente de Pakistán respecto a aquellos detalles que pueden tomarse como prototipo para estas regiones, excepto Australia. Por consiguiente, después de las discusiones preliminares del problema, en forma general, este informe ofrece los detalles más completos sobre Pakistán, con referencia por orden alfabético más breves a los países que rindieron informes.

El problema de la Integración del Pastoreo con la Silvicultura no ha sido acometido científicamente en ninguno de los países comprendidos en el informe por un tiempo ni en un área apreciables. Salvo a los países Australasiáticos, el pastoreo está demasiado excesivo y es generalmente incompatible con la silvicultura en su actual intensidad. Por consiguiente, cualquier integración adecuada tendrá que consistir principalmente en controlar científicamente el pastoreo de estas regiones de modo que los bosques, que por lo general son my deficientes, puedan también tener la oportunidad de coexistir.

Casi todos los países de la región llevan a cabo investigaciones y ensayos respecto a dicha integración. Los esfuerzos hechos en años recientes quedan plenamente ilustrados en el informe de Pakistán. Se han resumido también los informes de otros países. El problema es, sin embargo, inmenso y de vital importancia para el bienestar de una enorme porción del plantea y de su población. La solución adecuada de dicho problema es tarea superior a los esfuerzos de cada país en particular. El asunto exige la cooperación internacional y es ciertamente un caso llamado a recibir asistencia de las organizaciones internacionales.

Progress in the Integration of Forestry and Grazing —The United States and Canada

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Because of the special emphasis on problems of multiple use of forests and associated lands at this Fifth World Forestry Congress, it is fitting that attention be given to the progress in integrating forestry and grazing in several world regions. Emphasis will center on forest lands where grazing is a major forest land practice.

Illustrative of progress in integrating forestry and grazing are papers to be presented reviewing problems in three world regions, namely: (1) Pakistan and surrounding countries with similar problems; (2) South America, with special attention to problems of Argentina; and (3) the United States and Canada.

This paper will review progress in the United States and Canada in meeting problems of integration of forestry and grazing on forest and associated lands used by domestic livestock and wildlife, especially big game.

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The United States and Canada

Not too many years ago, foresters in the United States and Canada condemned or, at best, tolerated grazing on forest lands. There was good reason for this, because grazing on forest lands at the outset was largely unregulated and unrestricted. Overgrazing generally prevailed, directly injuring tree reproduction and causing site deterioration through trampling and accelerated erosion. But in more recent years, as the art of range management developed through research and practice and timber-harvesting methods improved, forestry and range and wildlife habitat management endeavors have become more harmoniously wedded.

Not all forest lands can be safely grazed. Also, many forests are too dense and support too little underbrush or herbaceous vegetation for economical grazing use, and some forest lands are too steep for livestock grazing. But, for the most part, where grazing is possible and properly regulated, especially as to number of animals and season of use, forestry and grazing are compatible. In some in-

stances, foresters feel that grazing of forest lands is beneficial for adequate regeneration of the tree species.

The degree to which forest lands may be grazed and forestry and grazing integrated varies with several factors. Among these are the nature of the forest stands—species, density, and growth form—the palatability of the tree reproduction, the composition and amount of the herbaceous and browse vegetation present, the accessibility and season of use of the forest land, the class of livestock grazed and the system and intensity of grazing. These factors vary from one part of the region to another.

To present the relationship of forestry and grazing, it seems best to review problems and progress being made in four broad forest and associated types: (1) the southern pine forests of the United States; (2) the western mountain forests; (3) the hardwood forests of central and northeastern United States and southeastern Canada; and (4) the northern conifer forests of Canada, including the tundra and adjacent forest fringe (fig. 1).

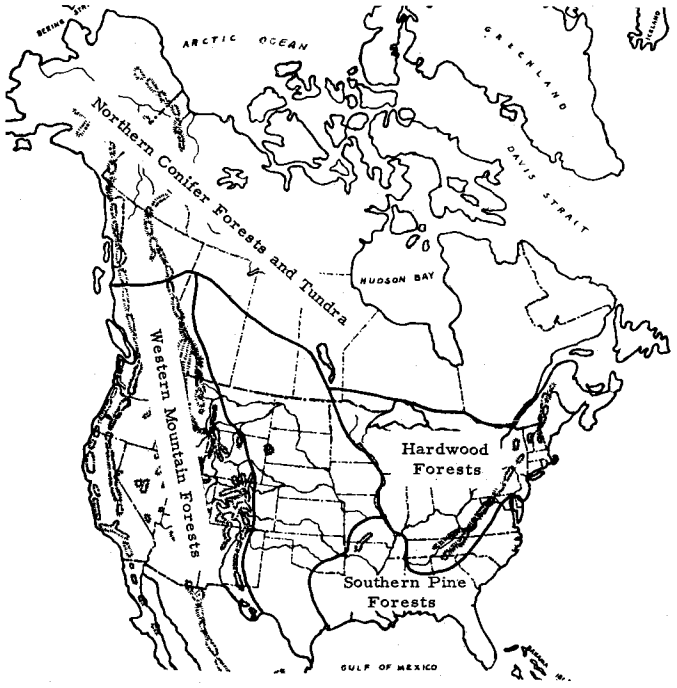


Figure 1. Broad forest types of the United States and Canada.

The southern pine forests and the western mountain forests are important for grazing by both game animals and domestic livestock, and will receive greater attention. The other types are included because of grazing by wildlife, especially big game.

The Southern Pine Forests of the United States

The southern pine forests of the United States extend from Virginia and Delaware to eastern Texas and Oklahoma and are a part of the humid eastern portion of the United States (Williams et al., 1955). Precipitation ranges from approximately 45 to 60 inches annually, most of which falls during the warm season of April to September. Relative humidity averages above 60 percent most of the year, and average annual temperature varies from 60°F. to 70°F.

The commercial forest area is nearly 194 million acres, two-thirds of which is in small ownerships of less than 5,000 acres (U.S. Forest Service, 1958b). The area supports the largest uniform forest in the United States (Cheyney, 1942). Bottomlands, on which are found some 50 hardwood tree species, and swamps occupy not more than 20 percent. Southern pines—longleaf,[1] shortleaf, slash, and loblolly—cover the remainder of the area. These often occur in mixed stands with various hardwoods, but the pines are usually dominant. Timber growing is a major land use over much of the area, and most forest lands are several times more valuable for timber production than for the production of native forage for livestock (Cassady and Shepherd, 1948). In recent years, much land that was planted to cotton, tobacco, and other crops has been turned into hay and pasture. Excluding Texas and Oklahoma, beef cattle numbers have doubled in the past 10 years. It is believed the future of southern agriculture lies in producing stocker and feeder animals for the Corn Belt and for local markets (Hughes, 1959).

Intermixed with the forests are several forage types (table 1) which are an important source of livestock forage for all or part of the year (Williams et al., 1955).

Most native grass on southern forest ranges furnishes good forage for livestock for about 3 months in the spring and a few weeks in early fall (Cassady and Shepherd, 1948). During the rest of the year, these ranges usually furnish roughages only. Native wiregrass forage supplies only about two-thirds of the requirements of digestible nutrients for wintering beef cattle (Halls et al., 1957). In central Louisiana, minor elements of three common forage grasses are adequate for cattle grazing in spring and summer, while phosphorous and crude protein are often inadequate (Duncan and Epps, 1958).

Supplemental feeding is necessary to prevent severe winter death losses of cattle (Biswell et al., 1942; Brasington, 1949; Shepherd et al., 1953). Without supplements, cows suckling calves on wiregrass-pine ranges lose considerable weight, particularly during fall and winter, and as a result, calf crops are poor and beef production is low (Halls et al., 1957). Crude protein averages 9.8 percent in the spring when young green growth is abundant but only 5.0 percent in the winter. On bluestem-pine ranges similar changes in forage nutrition result in severe weight losses of mature animals, and calf crops of only about 50 percent prevail; moreover, calves seldom weigh more than 300 pounds in the fall (Campbell and Cassady, 1951).

Range seeding and fertilizing aim to increase the amount of forage, to lengthen the season of good grazing, and to provide grazed firebreaks through forest stands (Campbell and Shepherd, 1952). Also, there is a great upsurge in pasture development and improvement. Coordinated use of forest range and improved pastures and supplemental feeds can double or triple beef production per cow.

With certain outstanding exceptions, properly managed grazing is compatible with timber management and other uses of forest lands (Halls, 1959a; Williams et al., 1955). However, successfully combining timber and range live-

[1] A list of common and botanical names of plants mentioned appears at the end of this paper.

Table 1. Associated forage types with dominant vegetation, acreage, and important problems of management

Forage type, acreage, and major forage species	Important management problems	
	Forestry	Grazing
WIREGRASS-PINE—24 million acres		
Pineland three-awn	Use and timing of fire	Use and timing of fire
Curtiss dropseed	Low-value shrubs	Low nutrition of cured forage
Bluestems	Open range grazing	Low-value shrubs
Carpetgrass	Woods hogs	Grazing capacity, forage use, and production throughout a timber rotation
Panicums	Poorly stocked stands	
Paspalums	Regeneration of cutover stands	
BLUESTEM-PINE—76 million acres		
Little bluestem	Use and timing of fire	Use and timing of fire
Pinehill bluestem	Low-value hardwood trees and shrubs	Low-value hardwood trees and shrubs
Pineywoods dropseed	Open range grazing	Poor livestock management
Cutover muhly	Woods hogs	Low nutrition of cured forage
Panicums	Poorly stocked stands	
Paspalums	Regeneration of cutover stands	
Other bluestems		
Legumes		
BOTTOMLAND HARDWOODS AND CANE—36 million acres		
Switchcane	Grazing of sprouts of valuable tree species	Proper stocking
American cyrilla	Low-value hardwoods	Season of grazing
Laurel greenbrier		Distribution of animals
Black tupelo		Use of fire
Sweetgum		
Sweetbay		
Swampbay		
Sprouts of hardwood overstory species		
BLUESTEM-PINE-UPLAND HARDWOODS-CEDAR—47 million acres		
Little bluestem	Watershed values	Low-value shrubs
Switchgrass	Low-value shrubs and trees	Watershed values
Indiangrass	Grazing of sprouts of valuable tree species	Forage supplements
Eastern gamagrass	Poorly stocked stands	Distribution of animals
Sideoats grama		
Panicums		
Native legumes		
Other bluestems		

stock production requires some adjustments in the management of both activities (Bond and Campbell, 1951). Properly coordinated, forest grazing, cultivated pastures, farming, and forestry can provide higher incomes for southern farms (Cassady and Shepherd, 1948).

Integration of timber growing and grazing involves the protection of forests from fire and grazing damage as well as the efficient use of native forage (Campbell, 1955). Because the land and the livestock often belong to different individuals, satisfactory integration of the two uses requires careful planning. Adequate fire protection is essential to good forestry. Constructive measures in forest protection include grazed firebreaks and moderate cattle grazing to reduce the grass fuel. Grazed firebreaks are essentially improved pasture strips 50 or more feet wide around and through timbered areas (Nieland, 1954). Grazing reduced herbaceous fuels by 24 percent on wiregrass-pine ranges. Prescribed burning reduced herbaceous fuels by 42 percent. The two practices together reduced herbaceous fuels by 72 percent (Halls et al., 1952).

Cattle may damage seedlings in newly established pine stands where forage is scarce, particularly during the winter and early spring. Sheep, hogs, and goats should be excluded until the trees are above the reach of browsing animals (Hopkins, 1951; Maki and Man, 1951). Hogs are particularly damaging to longleaf pine.

In the bottomland-hardwood type, valuable hardwood timber reproduction must be protected from excessive grazing damage (Cassady and Shepherd, 1948). Grazing in winter is preferable because the danger of browsing is greater in spring and early summer (Campbell and Shepherd, 1952). The wide variety of plants makes the bottomlands usable in the winter (Campbell and Biswell, 1945).

Prescribed burning can be used to draw cattle away from pine reproduction because cattle concentrate on recently burned areas where the forage is more palatable and nutritious (Halls, 1959a). Chemical repellents sprayed on newly planted slash pine seedlings have reduced grazing damage, although the spray applications were costly (U.S. Forest Service, 1958a).

Many accepted forest management practices on most commercial timber holdings in the South now help to maintain forage growth and grazing capacity (Campbell, 1955). These practices include hardwood control for site preparation and timber stand improvement and frequent thinnings before final harvest cuttings.

Herbage steadily declines as timber stand density increases, but it has been shown that 300 to 400 pounds per acre (ovendry) of wiregrass forage can be produced in natural stands of longleaf and slash pine having basal areas of 90 square feet (Halls et al., 1956). Beyond the stage when tree canopies completely shade 20 to 25 percent of the ground, herbaceous vegetation declines sharply to the point where grazing values become negligible (Halls et al., 1952). Other studies in both natural and planted longleaf pine stands show essentially the same relationships for longleaf pine-bluestem ranges (Bond and Campbell, 1951; Gaines et al., 1954). Southern forestry is definitely moving toward a system of thinning at 5- to 10-year intervals to maintain rapid growth (Campbell and Shepherd, 1952). Each thinning may temporarily increase grass growth.

Many forest lands are presently understocked. However, with intensified forest management and replanting, more fully stocked stands will mean less grass and fewer animals on forest lands (Campbell and Shepherd, 1952). However, better management, including adequate year-long nutrition for the animals and seeding of improved forage species on logged areas and firebreaks, should enable owners to produce as much beef and actually increase their incomes from the livestock enterprise.

With more intensively managed forests, costs and returns of wildlife production need to be recognized (Burke, 1956). Game has increased and is continuing to increase rapidly (Hickie, 1954). Although the smaller farm forests are important for squirrels and other small game, they are often too small or too close to human habitation to attract larger game. The bulk of the increase of large game will therefore be found on the larger tracts of forest land—the lands of greatest value for commercial timber production (Burke, 1956).

Every management practice for timber growing or domestic livestock grazing in the forest affects game food and cover (Campbell, 1957). Moreover, each game species has its own habitat requirement, and conditions that are best for one animal will not necessarily be optimum for another species (Goodrum and Reid, 1954). The forester must know the tolerance of his forest types to grazing and browsing, and how to recognize when game stocking is near the damage point. He must also know the cost of the silvicultural practices used to favor game (Burke and Blair, 1957).

The greatest threat to wildlife in pine stands is short rotation forestry (Stoddard, 1957). When even-aged stands are extensive and fully stocked, as is desirable with forests handled primarily for pulpwood, there is little undergrowth for forage. The acreage in such forests is increasing as more and more pulp and paper mills move into the area.

Southern hardwood forests require little compromise for integration of game and forest management (Miller, 1957). Most are being managed for saw logs and veneer. Selective cutting, which is rarely heavier than 40 percent of the gross volume, stimulates desirable ground-cover food plants for game.

The Western Mountain Forests

The western mountain forests, considered here, extend from Mexico on the south to the middle portion of the province of British Columbia in Canada on the north, and from the Great Plains on the east to the Pacific Ocean. The area embraces some of the steepest and roughest land in North America. Most of the precipitation falls as snow. Temperatures are variable; the growing season ranges from about April 1 to October 1. In general, forests are at the higher elevations. In the valleys and lower elevations are grasslands and shrub vegetation. Often at the same elevation grasses will predominate on south exposures and trees on the north exposures. The suitability of these two sites for the different types of vegetation appears to be related to the difference in the moisture regime on the two aspects. Similar situations exist in the northern part of the area where grasslands are on the more exposed sites and trees on the more protected sites.

There are about 300 million acres of forest land in the area. About 63 percent is under public ownership or control. The commercial timberlands of 117 million acres furnish the bulk of the softwood timber that supports the western forest industries.

About 70 percent of the forest land is usable for grazing (Dutton, 1953). For the most part, the herbaceous and shrub species growing in the forests are palatable and nutritious for livestock and big game. A high proportion of the livestock in the western United States and Canada depend upon the western mountain forests for summer forage. Moreover, forests furnish a home for wildlife, especially big game species. While grazing and timber production generally are compatible when proper management practices are followed, problems differ somewhat in integrating these uses in the various forest types.

The native vegetation of the forest may be grouped into five major types (McLean and Holland, 1958; Shantz and Zon, 1924). Several of the types occur at the same latitude, but at different elevations (table 2).

Southwestern Coniferous Woodland

The southwestern coniferous woodlands are at elevations between 3,000 and 5,000 feet. Annual rainfall varies from 12 to 18 inches, and the main growing season for perennial grasses is during July, August, and September.

Table 2. Major forest and associated types of the Western mountain forests of the United States and Canada

Vegetation type	Elevation		Suitability for livestock grazing	
	U. S.	Canada	U. S.	Canada
	Feet	Feet		
Southwestern coniferous woodland	3,000- 5,000	....	yes	..
Western pine forest type	3,000-10,000	2,000-4,000	yes	yes
Northwestern coniferous forest	1,000- 5,000	2,500-3,500	yes	yes
Northern coniferous forest	3,000-11,000	4,000-6,500	no	no
Alpine grassland	11,000+	6,500+	yes	yes

The woodland is composed chiefly of pinyon pine and juniper. Except for limited use for fence posts and fuel, the present commercial timber value is negligible. Interspersed throughout the type, however, are open parks containing a variety of grass and browse species valuable for livestock grazing. These lands are some of the most heavily used game ranges, because deer tend to concentrate in them in the fall, winter, and spring.

Prior to the introduction of livestock, most of the stands of pinyon-juniper were found on rocky ridges and poor, shallow soils or occurred as savannah on the better sites (Parker, 1948). During the past half century these trees, especially the juniper, have spread into adjacent grasslands. Reproduction has filled in the openings between the mature trees. These invasions have been attributed to two causes: improper grazing practices and protection from fire. As trees thickened, grazing capacities decrease. Efforts to control encroachment and reestablish forage production on lands already invaded are fruitful (Arnold and Schroeder, 1955). Studies of juniper clearing indicate that the grazing capacity can be increased. Air-dry herbage yields average 200 pounds per acre for untreated woodland areas. This yield can be increased to 600 pounds per acre after the removal of juniper. Once the juniper areas are cleared and desirable grasses restored, good range-management practices must be employed to maintain the grazing values.

Western Pine Forest Type

The western pine forest type is found at elevations between 3,000 and 10.000 feet in the United States and between 2,000 and 4.000 feet in Canada. The principal tree species are ponderosa pine, Douglas-fir, and white pine, all of which occur in both dense and open stands. The ponderosa pine and mixed pine forests furnish most of the livestock grazing. Interspersed with the forests are open grassland parks of high forage value, containing a variety of grasses, forbs, and shrubs.

On the commercial forests, which have a higher value for production of wood products than for forage, it is often necessary to graze on a flexible basis (Connaughton, 1948). If the forest cover increases under management and thereby reduces available forage, livestock and game numbers should be adjusted to avoid damage to tree reproduction. By coordination, grazing values can be realized to the fullest within the limitations of the prevailing objectives of growing trees.

Grazing in the ponderosa pine type is probably the best illustration of this principle. This type which grows in open stands, is widely and successfully grazed by sheep, cattle, and big game. Where rates of stocking are such that the forage is not overgrazed, there is little damage to the trees. However, with good fire protection and timber management, the number of trees may increase and occupy space that formerly produced forage. When this happens, rates of stocking must be adjusted. Otherwise, overstocking will result, with damage to both trees and forage.

Considerable grazing research has been conducted in the western pine forest type, which has aided in the integration of these uses. Shortly after the turn of the century, studies of grazing and natural regeneration of ponderosa pine were begun in Arizona and New Mexico (Hill, 1917). Suitability of the forage to the class of livestock, the amount of palatable forage available during the grazing season, especially during June and July, and the manner in which livestock are handled, all have an important influence on the amount of damage to timber reproduction. Where shoots of grazed young ponderosa pines are damaged, substitute buds and shoots are produced (Cooperrider, 1938).

In later studies (Pearson, 1950) it was found that: (1) livestock usually browse only the current year's growth; (2) shoot browsing is most severe during late June and early July when the weather is hot, when stock waters are few, and when early growth of forage plants has ceased and is becoming dry and grazed out within easy walking distance of water; and (3) browsing injury, if recurrent, seriously retards the height growth of young trees. Browsing of shoots begins when shoot elongation is in progress. It ceases under damp conditions and during and following rains. Shoot browsing by cattle and sheep occurs mainly under dry conditions. This fact furnishes the basis for range-management practices to minimize damage to pine reproduction. Herbaceous density and grass yields decline with increasing density of pine canopy, and logging is detrimental to the understory (Arnold 1950, 1953). Influences that affect adversely the herbaceous cover include: (1) surface disturbances caused by skidding and the construction of logging roads; and (2) heavy accumulations of slash.

In Idaho, moderate grazing of herbaceous vegetation by sheep on cutover western white pine forests (Young et al., 1942) is beneficial to white pine reproduction and has little effect on other coniferous species. The loss of coniferous seedlings due to sheep trampling is greatest in the first-year class, and decreases in succeeding years until there is practically no loss at 5 years of age. Grazing may assist the seeding of an area to white pine forest if the livestock are removed from the area for a period of 2 to 3 years. Under such conditions, the herbaceous understory is reduced and the soil bared for the establishment of the pine seedlings. Grazing of cutover forest vegetation at a comparatively early stage is apparently important in the silvicultural management of cutover

stands. In other parts of the northern Rocky Mountains, livestock grazing affects pine reproduction adversely in certain situations and beneficially in others (Morris, 1948). Overgrazing on coarse-textured soils facilitates reproduction by reducing competition from herbaceous species. On fine-textured soils, overgrazing compacts the soil and encourages bluegrass to sod.

In Oregon and Washington, it is doubtful whether well-managed grazing has any detrimental effect on ponderosa pine reproduction (Reid, 1948). However, close grazing along stock driveways keeps reproduction from becoming established. When grazing is curtailed, germination and survival of pine seedlings are good. Harvesting ponderosa pine has a profound effect on soil and forage (Garrison and Rummell, 1951). Tractor logging disturbed 26 percent of the ground surface and reduced the shrubby and herbaceous plant cover 33 percent. Seeding to good perennial grasses and legumes, spreading of surface run-off, and removing livestock temporarily can all speed rehabilitation of logged areas.

In the commercial timber types of California there is little opportunity of increasing forage, since the production of wood products is of first priority (Hormay, 1948). Most of the grazing capacity in the forests is created when the overstory of trees is removed or thinned by logging, fire, or insects. It is created at the expense of tree growth and is of relatively short duration. In the Redwood Region, for example, grazing on logged-over areas usually lasts less than 5 years because forage plants are crowded out by tree and brush growth. In the pine and mixed conifer types, grazing may last 15 or 20 years in some areas, depending on the degree and nature of disturbance to the timber stand.

In northeastern California, grass competition reduces the establishment, survival, and growth of pine seedlings (Tackle and Roy, 1953). A total of 33,000 pine seedlings per acre were recorded the first year on bare soil and only 6,000 in medium to heavy grass cover. The number of trees per acre surviving at the end of 4 years was 11,017 on bare soil and only 231 in heavy grass; the grass also reduced height growth by half. In another area, 56 percent of the planted pines survived on bare soil, 35 percent in a light cover of grass and sedge, 9 percent in medium cover, and none in heavy cover (Roy, 1953). When pine is planted, patches of grass and other vegetation should be avoided.

Studies in the Sierra Nevada and southern Cascade Mountains show that on burned or logged areas, improvement of grazing capacity through seeding grasses is worthwhile on ponderosa pine, aspen, and red fir forest ranges (Cornelius and Talbot, 1955). Grass seeding controls erosion or checks the invasion of undesirable plants.

In British Columbia, pinegrass and several other species preferred by cattle decline in abundance and vigor under heavy grazing. Reproduction of Douglas-fir, lodgepole pine, and aspen is also affected (Tisdale and McLean, 1957). Under moderate grazing, little or no change in undercover vegetation or tree reproduction is detected. Grazing by wildlife is not excessive, but winter use of aspen and willow shoots is heavy in some areas.

In western pine forests there is often competition for forage between domestic livestock and big game. But competition is not a major problem on properly stocked forest ranges in good condition (Hall, 1955; Morris, 1956; Smith and Wilbert, 1959). Usually, different kinds of animals graze different species of plants. Deer, for example, relish succulent grasses early in the spring and consume palatable parts of forbs when they are available; shrubs constitute the bulk of their diet. Cattle and sheep select mostly grasses and forbs and utilize shrubs to a much lesser degree. Elk are more versatile feeders. They consume more grass and forbs but less browse than deer.

Deer may become so abundant on some forest ranges that tree seedlings are heavily browsed. Some seedlings are killed outright; others are deformed. Young Douglas-fir trees in a plantation within an area of high deer population in Washington had been browsed repeatedly (Staebler et al., 1954). Despite this use, survival was not appreciably reduced. About 70 percent of the surviving trees were deformed. Ponderosa pine reproduction is also heavily damaged by deer when numbers become excessive (Neils et al, 1956; Pearson, 1950).

Logging practices may materially improve the habitat for game animals, particularly deer, by setting back plant succession from timber to brush (Longhurst et al., 1952). On critical winter ranges it may prove worthwhile to deliberately cut the timber heavily and burn undesirable brush to increase better forage species for deer. Periodic opening up of ponderosa pine stands by commercial logging is a distinct asset to deer on both summer and winter ranges (Leopold et al., 1951).

Northern Coniferous Forest and Alpine Grasslands

The northern coniferous forest grows at elevations between 3,000 and 11,000 feet in the United States and between 4,000 and 6,500 feet in Canada.

Within the dense stands of Engelmann spruce, subalpine fir, and lodgepole pine there is little forage for livestock grazing although considerable browse for game is present. However, within the forests are extensive stands of aspen which contain palatable grasses, shrubs, and weeds that are relished by livestock and game. Here, conflicts arise between grazing and the production of aspen.

The understory of most aspen stands has been greatly altered by years of overgrazing (Houston, 1954). The canopy is opened by the continued destruction of aspen reproduction and may eventually result in conversion to a herbaceous type. Management of aspen stands requires that the understory be conservatively grazed to avoid damage to aspen reproduction. Where aspen has been clear cut, it is often necessary to discontinue grazing of the logged-over areas by sheep for a period of 3 to 5 years in order to allow the aspen to become reestablished and grow out of reach of the livestock.

An early study of the effect of grazing upon aspen reproduction (Sampson, 1919) showed that leafage, young twigs, and branches of aspen reproduction are browsed by both cattle and sheep. To avoid destruction of young aspen cover following logging on sheep range, the sheep should be excluded for three successive seasons following logging, or grazing should be exceedingly light. Such drastic adjustments in stocking are not necessary on cattle range, provided stocking is not too heavy and cattle are not permitted to concentrate in the cutover area.

A conflict exists in the coniferous forests growing near timberline (Ellison, 1954). Instances have been reported

where coniferous reproduction is found beneath shrubs such as yellowbrush and sagebrush rather than in open areas. The restriction of the young trees to areas beneath shrubs has been attributed to overgrazing.

The Hardwood Forests

The hardwood forests of northeastern United States and southeastern Canada are characterized by oaks and hickories in the south and central portion, and by birch, beech, and maple in the northern portion. They have high commercial value for timber products.

Grazing livestock in the hardwood forests has been considered by foresters to be incompatible with forestry (Denuyl, 1948). Many tree species are palatable to livestock, and under grazing, tree reproduction is deformed or killed. Also, compaction of the soil by trampling is believed to affect tree growth by making moisture conditions less favorable. Grazing of farm woodlots is a widespread practice, but recommendations to improve production of forest products usually include protection from livestock. Growth in farm woodlots can be doubled by protecting the forests from grazing.

One-third of the deer in continental United States are found in this area. Small game are also abundant. Much more progress has been made in the integration of forestry and wildlife than of forestry and domestic livestock grazing. Generally, logging and pulpwood cutting improves the wildlife habitat.

In many areas, game populations, especially deer, have gone through a cycle related to forest cutting. The usual pattern is that cutting opens the forest, improving deer habitat. This results in an increased deer productivity and an overpopulation which, in turn, destroys tree reproduction. Proper correlation of timber production and deer management is essential to overcome this problem. Turkeys, a valuable game bird in the area, have the opposite response to extensive cutting. The mature forest provides the best habitat. Extensive cutting leaves only young trees that are low in mast production; hence, turkey populations decrease. Then as the trees mature, turkeys again increase.

Good correlation between timber and wildlife production requires cooperation between the forester and the game manager. Silvicultural practices with short cutting cycles that periodically open the forest and maintain enough edge to provide good habitat benefit game production. Location and maintenance of timber access roads should meet the needs for game harvest. The game manager should regulate game harvest to prevent populations from reaching numbers that will destroy tree reproduction.

Practices for deer and pulpwood production can be compatible in northern Maine (Gill, 1958). Fairly dense stands of mature conifers are needed to provide adequate winter shelter but are low in browse production. Openings in the forest provide better forage but little winter shelter. Group-selection cutting in irregular patches and strip clear cutting where coniferous species predominate on a short cutting cycle provide good food and shelter and hence a stable deer population. Shelterwood clear cutting and scattered seed-tree systems are unfavorable for deer because of the long cutting cycle. Tree-selection cutting of coniferous forests is also unfavorable because cutting heavy enough to produce browse may open the stand too much for good winter shelter. Group-selection and strip clear cutting are recommended for hardwoods. Cutting cycles of 10 to 15 years maintain reasonably stable browse. Winter cutting will produce more sprout growth than summer cutting.

Northern Conifer Forests

The northern conifer forests include the dense spruce forests of central Canada and Alaska. Principal coniferous species are white, Engelmann, and black spruce. Some broadleaf species, such as aspen and white birch, are also prominent. To the north of the dense forests, a parklike dwarf forest of black spruce, aspen, white birch, balsam poplar, and willows form a transition with the tundra that extends northward to the Arctic Ocean.

Cattle grazing in this area is limited to recent introductions on some of the Aleutian Islands.

Between 1881 and 1902, some 4,800 reindeer were introduced into northern Alaska and adjacent Canada. They grazed on tundra ranges in the winter and shrubs of the fringe forest in the summer. Numbers increased until in 1932 there were more than 600,000 head. However, overgrazing of the lichen range near settlements and wolf predation gradually decreased numbers to 25,000 in 1952 (Hanson, 1952).

Big game, including moose, caribou, and bear are numerous. Moose browse heavily on white birch, willows, and balsam fir; hence pulpwood cuttings that increase tree reproduction benefit moose. On the other hand, too many moose may damage the forest (Pimlott, 1959). Woodland caribou graze chiefly on mosses and lichen which grow in mature stands of conifers. Cutting or burning the forest destroys their forage. Therefore, caribou are not expected to remain in managed forests but may be limited to the unmerchantable forest in the north (Cringan, 1957). Fire protection in this area will benefit caribou.

Good coordination of forestry and wildlife production in the area is still to be developed.

Future Integration of Forestry and Grazing

For the most part, forest lands in the United States and, to an increasing degree, in Canada are no longer hinterlands but are important integral parts of the overall land-use economy. The rising population will continue to increase the demands on and pressures for the several uses of these lands. Hence, a more intensified integration of the several forest uses in a well directed multiple-use program is evident.

In such a stepped-up multiple-use program of forest lands, not only will forestry and grazing endeavors need further integration but also these practices must be correlated with the rising demands for other forest uses, especially forest recreation in its broadest sense. Gross management, or management by the mountain, will be supplanted by more intensive per-acre management. Unit production will need to be increased to offset higher production costs for economical operations. This will require more intensive methods both for growing and harvesting the timber and forage crops. However, with research and extension leading the way, forestry and grazing should continue on a productive integrated basis in multiple-use forestry.

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Common and Botanical Names of Plants Mentioned

Aspen	*Populus tremuloides* Michx.
Beech	*Fagus grandifolia* Ehrh.
Birch	*Betula* L.
Birch, white	*Betula papyrifera* Marsh.
Bluegrass	*Poa* L.
Bluestem	*Andropogon* L.
Bluestem, little	*Andropogon scoparius* Michx.
Bluestem, pinehill	*Andropogon divergens* (Hack.) Anderss. ex Hitchc.
Carpetgrass	*Axonopus affinis* Chase.
Cyrilla, American	*Cyrilla racemiflora* L.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Dropseed, Curtiss	*Sporobolus curtissii* (Vasey) Small ex Scribn.
Dropseed, pineywoods	*Sporobolus junceus* (Michx.) Kunth.
Fir, balsam	*Abies balsamea* (L.) Mill.
Fir, red	*Abies magnifica* A. Murr.
Fir, subalpine	*Abies lasiocarpa* (Hook.) Nutt.
Gamagrass, eastern	*Tripsacum dactyloides* (L.) L.
Grama, sideoats	*Bouteloua curtipendula* (Michx.) Torr.
Greenbrier, laurel	*Smilax laurifolia* L.
Hickory	*Carya* Nutt.
Indiangrass	*Sorghastrum nutans* (L.) Nash.
Juniper	*Juniperus* L.
Maple	*Acer* L.
Muhly, cutover	*Muhlenbergia expansa* (DC.) Trin.
Oak	*Quercus* L.
Panicum	*Panicum* L.
Paspalum	*Paspalum* L.
Pinegrass	*Calamagrostis rubescens* Buckl.
Pine, loblolly	*Pinus taeda* L.
Pine, lodgepole	*Pinus contorta* Dougl.
Pine, longleaf	*Pinus palustris* Mill.
Pine, pinyon	*Pinus edulis* Engelm.
Pine, ponderosa	*Pinus ponderosa* Laws.
Pine, shortleaf	*Pinus echinata* Mill.
Pine, slash	*Pinus elliottii* Engelm.
Pine, white	*Pinus monticola* Dougl.
Poplar, balsam	*Populus balsamifera* L.
Sagebrush	*Artemisia* L.
Spruce, Engelmann	*Picea engelmannii* Parry
Spruce, black	*Picea mariana* (Mill.) B. S. P.
Spruce, white	*Picea glauca* (Moench) Voss
Swampbay	*Persea borbonia* (L.) Spreng.
Sweetbay	*Magnolia virginiana* L.
Sweetgum	*Liquidambar styraciflua* L.
Switchcane	*Arundinaria tecta* (Walt.) Muhl.
Switchgrass	*Panicum virgatum* L.
Three-awn, pineland	*Aristida stricta* Michx.
Tupelo, black	*Nyssa sylvatica* Marsh.
Willow	*Salix* L.
Yellowbrush	*Chrysothamnus* Nutt.

RESUMES

Progrès réalisés dans l'intégration du pâturage a la sylviculture aux Etats Unis et au Canada

Il n'y a pas tellement longtemps qu'aux Etats Unis et au Canada les sylviculteurs condamnaient le pâturage sur les terrains boisés, ou tout au plus le toléraient. A mesure que les méthodes d'aménagement des terrains de parcours ont été mises au point par la recherche et la pratique et l'amélioration des méthodes de récolte du bois, la sylviculture et le pâturage dans les forêts et les terrains connexes sont en train de se lier plus harmonieusement. Ce n'est pas que toutes les terres boisées pourraient être utilisées en toute sécurité pour le pâturage; en outre, beaucoup de forêts ne sont guère rentables pour le pâturage. Le degré dans lequel les forêts peuvent être mises sans danger en pâturage et que la sylviculture et le pâturage peuvent être intégrés est fonction de plusieurs facteurs, notamment la nature de la forêt, la sapidité des pousses des arbres, la composition et la quantité de la végétation herbacée et de fourrage présente, le degré d'accessibilité et la saison d'utilisation de la forêt envisagée, le genre de bétail qu'on fait paître et le système et l'intensité du pâturage.

Bien que les forêts de pins du sud soient beaucoup plus précieuses pour la production du bois que pour la production locale de fourrage pour le bétail, le nombre des bovins a augmenté et les forêts de parcours, ainsi que les prairies améliorées sont devenues un but économique. Pour les forêts, le pâturage est bénéfique en réduisant la substance inflammable que l'herbe représente. Le bétail peut abîmer les jeunes plants dans les peuplements de pins récemment établies, où l'herbe est rare. Les ovins, les porcins et les caprins en devront être exclus jusqu'à ce que les arbres aient poussé au delà de la portée des animaux. L'amélioration des peuplements et de fréquentes éclaircies sont avantageuses à la production de fourrage pour le bétail et le gibier.

Dans les montagnes de l'Ouest environ 70% des forêts peuvent être utilisées pour le pâturage. Les espèces d'herbes et d'arbustes poussant dans cette région sont savoureuses et nutritives pour le bétail et le gros gibier. Dans la plupart des cas, culture de la forêt et pâturage sont compatibles si l'on applique des méthodes rationnelles de pâturage, tout particulièrement quand le nombre des têtes de bétail et l'intensité du pacage sont satisfaisants. Dans les forêts commerciales, présentant une valeur plus élevée pour la production de bois que pour celle de fourrage, le pâturage doit reposer sur une base flexible. La quantité de bétail et de gibier doit être fixée de manière d'éviter tout dégât dans la reproduction des arbres. Dans certaines régions de forêts à but commercial, particulièrement en Californie et dans les Montagnes Rocheuses du nord, il y a peu d'occasions d'augmenter le fourrage pour le bétail local, du fait que c'est la production du bois qui a une priorité de premier rang. Le pâturage doit être adapté au schéma de croissance et de récolte du bois. Le pacage ne saurait y être excessif sinon les jeunes pousses seraient endommagées. On doit surveiller le nombre du gros gibier, des cervidés surtout, pour empêcher le fort broutage des jeunes plants.

Les forêts de conifères du nord, à l'exception des peuplements de tremble, ne sont pas importantes pour le pâturage du bétail domestique. L'aménagement des peuplements de trembles nécessite qu'on fasse pâturer le sous-bois de manière conservatrice, pour

ne pas porter atteinte à la reproduction des trembles. Si les trembles viennent de faire l'objet d'une coupe à blanc, il faut souvent suspendre pour une période de 3 à 5 ans le pâturage des zones dénudées d'arbres, afin de permettre aux trembles de se retablir et de pousser hors de la portée du bétail.

Les sylviculteurs ont considéré le pâturage dans les forêts de feuillus comme étant incompatible avec la sylviculture. Beaucoup d'essences sont appétissantes pour le bétail et, sous l'action du pâturage, la reproduction des arbres est déformée ou tuée. En ce cas, la faune et la flore sont plus importants. Les méthodes sylvicoles, employant des cycles de révolution courts, sont salutaires à l'habitat de la faune.

Le pâturage dans les forêts de conifères du nord est limité. Cependant, le gros gibier, notamment l'élan du Canada, le caribou et l'ours, y abonde. Comme la coordination de la sylviculture et de la production de la faune reste encore à aménager dans ces régions, la coupe du bois à pâte est avantageuse pour l'habitat de la faune.

Les demandes croissantes et les pressions pour l'utilisation multiple des terres boisées indiquent le besoin d'une intégration plus forte de la sylviculture au pâturage et la corrélation de ces emplois avec d'autres valeurs forestières.

Progresos en la Integración de Terrenos de Bosque y de Pasto en los Estados Unidos y Canadá

No hace muchos años, los silvicultores de los Estados Unidos y el Canadá prohibían, o a lo sumo apenas toleraban el pastoreo en los terrenos de los bosques. Pero a medida que el arte de la administración forestal ha ido desarrollándose merced a los estudios de investigación y la experiencia y han ido mejorando los métodos de extracción de la madera, la silvicultura y el apacentamiento de terrenos de los bosques o adyacentes a éstos han conseguido armonizar sus propósitos. No todos los terrenos de bosque pueden ser utilizados con seguridad para pastos; esto último puede incluso ser antieconómico en muchos bosques. El grado hasta el cual los terrenos boscosos pueden ser utilizados para pastos y pueden integrarse las actividades forestales con las de pastoreo, depende de varios factores. Entre éstos se cuentan la naturaleza de los rodales forestales, el sabor de los arbolitos, la composición y cantidad de la vegetación herbácea y de ramoneo existentes, la facilidad de acceso y época de uso del terreno forestal, la clase de ganado de pasto y el sistema e intensidad de pastoreo.

Aunque los bosques de pino sureño son mucho más valiosos para la producción de madera, que para la de forraje fresco para el ganado, el número de cabezas de ganado vacuno ha aumentado y ahora el pastoreo en bosques, con el mejoramiento de los pastizales, resulta ya económico. El pastoreo beneficia al bosque, reduciendo las hierbas combustibles, aunque el ganado daña a veces las plantas tiernas de pinos recientemente establecidas, cuando el forraje es escaso. El ganado lanar, porcino y cabrío no debe soltarse a pastar hasta que los árboles estén fuera del alcance de los animales que ramonean. La mejora de los rodales madereros y los aclareos frecuentes son beneficiosos a la producción de forraje para el ganado y la caza.

Cerca de un 70% de los bosques montañosos del oeste pueden utilizarse para pasto. Las especies herbáceas y los arbustos que crecen en estas regiones, son apetitosos y nutritivos para el ganado y la caza mayor. El bosque y el pastoreo son compatibles, en la mayoría de los casos, cuando se siguen buenas prácticas en el manejo de pastos y especialmente cuando el número de cabezas de ganado y la intensidad del pastoreo están debidamente proporcionados. En los bosques comerciales, que tienen más valor para la producción de madera que para el forraje, es necesario organizar el pastoreo sobre bases flexibles. El número de cabezas de ganado y la caza, deben ser proporcionados, para evitar daños a los árboles de renuevo. En algunas áreas de bosques comerciales, especialmente en California y las Montañas Rocosas Septentrionales, hay poca oportunidad de aumento de forraje para el ganado, porque la producción de madera tiene preferencia. El pastoreo debe adaptarse a las necesidades del crecimiento y corta de los árboles. El pastoreo no puede ser excesivo, porque si lo es se dañan los arboles jóvenes. La caza mayor, especialmente los ciervos, hay que controlarla para que no sea muy numerosa y así prevenir el excesivo ramoneo de los árboles tiernos.

Los bosques de coníferas septentrionales, con excepción de los rodales de álamos temblones, no son importantes para el pastoreo de animales domésticos. Para el manejo de este tipo de bosques es necesario utilizar el piso inferior con ciertas precauciones al dedicarlo al pastoreo, con objeto de no perjudicar a la renovación del rodal. En los lugares donde se ha cortado el álamo a mata rasa es necesario a menudo descontinuar el pastoreo en las áreas cortadas, por un periodo de tres a cinco años, para permitir la renovación de los árboles y dejarlos crecer fuera del alcance del ganado.

El pastoreo del ganado en los bosques de hoja ancha, ha sido considerado por los silvicultores como incompatible con la silvicultura. Muchas especies de árboles son agradables a los animales y el pastoreo deforma o impide completamente el crecimiento de los árboles. Lo más importante en estos bosques son los animales silvestres. Los métodos de silvicultura con ciclos reducidos de corta, son beneficiosos para la fauna silvestre.

El pastoreo en los bosques septentrionales de coníferas es limitado. Sin embargo, la caza mayor, incluyendo alces, caribús y osos, es numerosa. Auque el desarrollo del programa de silvicultura y el del fomento de la fauna silvestre en esta área, no han sido coordinados todavía, las cortas para la producción de pulpa de madera benefician el ambiente en que viven los animales selváticos.

La insistente y creciente demanda para la utilización en múltiples formas de los terrenos de bosque, indican la necesidad de una integración más intensiva de la silvicultura y el pastoreo y la correlación de estos usos con otros valores forestales.

Advances in Reforestation and Afforestation Practices In Arid and Semi-Arid Zones

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For over half a century, the efforts of afforestation in arid zones have also been a failure from the economic point of view. The lands used for planting forest trees were only those left over by all other land users: they were steep, rocky or dry soils. It became a virtue for foresters to make use of poor lands, and, partly for this reason, it has been accepted that forestry must not be expected to yield any return on capital.

Great efforts were made to improve the technique of planting in such areas. Better plants were grown in the nurseries, selected species and better cultivation methods were used. Yet the final results were usually great mortality after planting, slow growth and loss through drought, fires and insect attack. The cost of potting, transporting, planting and protecting was high. When all this was weighed against the slow growth of the inferior timber produced, the balance was tipped against the advisability of further planting.

Plantations were usually on eroded watersheds, which had or could have a detrimental effect on the agricultural lands below through flooding. Such planting was continued and made possible by considering the expense of planting as a means of protecting the water and agriculture of the valley below. The value in money of this protection has not yet been computed.

The greatest advances in reforestation and afforestation in semi-arid and arid areas in the last decade were the consequence of a change in the forester's outlook on silviculture and land-use in such areas.

There has been a general failure to develop forests by silvicultural methods from the natural scrub vegetation or degraded forests in semi-arid and arid zones, to improve substantially those natural forests known as maquis and garigue (France), chaparral (United States), bush (South Africa), campo de carrascaes (Brazil), savannah (Africa) and choresh (Israel). This has induced the foresters to resort to afforestation and reforestation proper.

The returns from these natural scrub forests did not come up to expectation. The soils were poor, the climate severe and the yields were very low. Moreover, the original natural forest, poor as it was, was disappearing almost everywhere as a result of human action. These scrub forests, however, produce the only accessible wood in the region.

In addition, it is believed that the protective value of these plantations is not always better there than that of the other vegetative cover, such as bush or grass. In fact, some believe that the vegetation of a well-managed pasture will protect a watershed just as well as does a tree plantation. In arid zones, a pasture may have a favorable water balance, allowing the excess water to filter down to the valleys below.

Thus, foresters in the past have accepted poor lands as their domain and financial deficits as the results of their efforts.

Now, better land is planted—land which, when planted with selected quick-growing species and given special silvicultural treatment, is expected to give a good return on the investment. Plantations on poor sites are a waste of money. On good land, with proper standardized methods of cultivation and using a few quick-growing species, it was found that forestry can pay as handsomely as farming.

With these factors in mind, the forester has started to shift his plantations to better pasture land and agricultural land—to land which, until recently, a forester could not hope for. Such lands were known to produce good agricultural crops and were out of bounds for forest plantation: foresters had to apologize if they trespassed over their boundaries. But now, by the use of particular species and cultivating practices, forest crops yield greater returns per hectare per year than many other agricultural crops. This means that forestry in arid and semi-arid zones is shifting towards the use of agricultural and pasture lands and resorting to semi-agricultural, semi-silvicultural treatment. This treatment is necessary until the trees grown and the crop produced are superior to those from natural stands or from the planting of the poorer slopes.

Such afforestation aims at forest products related to the demand in the area. This cannot be expected from natural forests or from plantations on steep, rocky and depleted lands. Artificial forest plantations on better lands thus seem to offer the opportunity of producing wood of the quality and price required by an expanding economy. For such plantations, new techniques are being further elaborated.

It is apparent, therefore, that the increase in specialized production in arid zones is mainly dependent on the improvement of tree-farming methods. Generally, tree-planting on arable lands is done by farmers. The owners of the lands themselves consider such planting an economic venture and find the new silviculture recommended much easier to understand and practice than the old orthodox type of complicated silviculture recommended for the scrub forests or for planting in poor land: the trees are regarded as crops. To these farmers,

eucalyptus, poplars and pines appear to be more profitable than other crops.

The principles and techniques involved in planting are those well known to the progressive farmer: selection of the species (clones and hybrids); provenance; the planting material (cuttings or seedlings); selecting the field to which the tree is best suited; the spacing of trees; intensity cultivation for aeration; elimination of weeds; in some cases, irrigation; fertilization; pruning; and disease control. These practices are analogous to those which the farmers have already learned and appreciate and which they apply to forest trees without great difficulty, provided that guidance is given.

Pruning is an old-established practice in horticulture. Yet the pruning of fruit trees and flower shrubs is based on different principles. In fruit trees, branches are left that will provide the buds which produce more flowers and fruit. The other branches are pruned because they produce woody branches that keep the sun out from the center of the plant and produce too much wood at the expense of flowers and fruit. Forest trees, however, are pruned to get a clear-boled tree. With guidance as to what, when and how much to prune, the farmer with a pruning shear or saw should be able to do the necessary pruning to perfection.

The methods of felling in many arid zone forests are not well known to farmers, but a precise method of felling to ensure even aged stands is simple. The main characteristics of such plantations will be abundance, uniformity, quality and easy accessibility of the timber needed for the forest industries in such areas.

In most arid zones, there is a hunger for arable land. The lands in these marginal areas have been usually overexploited, and what is left is usually needed for agricultural products. Yet the hunger is not only for agricultural products: there is hunger for forest products too, mainly saw-wood, but also for poles, posts and other accessory products.

These products, if not available and grown in the region, have to be imported from outside. As they are bulky and are expensive to transport, their production in the region may become more attractive financially. In such circumstances, it may be asked whether the straightforward adoption of tree plantations on the better soils should not be an important objective in every dry zone country. It is probable that such plantations alone will be capable of supplying the wood and wood products required in such areas, which now are either extracted from the depleted natural forest, or imported from outside the zone or, because of lack of funds, are unfortunately not obtainable at all by the rural population.

Only a small fraction of the arable land should be allotted to forest tree planting. In arid zones, agriculture windbreaks and shelterbelts are essential, and land has to be set aside for the protection of agricultural products.

Forest trees are also planted along canals and roadsides. In addition, small areas of these arable lands should be planted as woodlots. The whole area planted to quick-growing forest trees should cover about two percent of the arable land of such regions.

The need to protect agricultural crops and pasture land from wind is now widely accepted, but if the windbreaks are properly planted and managed, they can be cut and the timber used without much reduction of their sheltering effect. The wood will help to meet the annual requirement of the region: the rest will be mainly cut from woodlots. The farmers' needs are great: the need of the market for wood is also great. These needs can be met by planting quick-growing species. Woodlots of quick-growing species can be combined with agricultural crops. Intercropping may be temporary and may be discontinued as soon as the crowns of the trees grow too close together. In some cases, the trees may be spaced so as to allow continuous combined production of forest trees and agricultural crops.

The technique of preparing the soil for forest tree-planting is similar to its preparation for horticultural trees.

Arable land set aside for planting quick-growing trees may have to be bulldozed, terraced or leveled. It must then be ploughed deeply—say, 50 to 60 centimeters. Such reclamation and development costs are not considered part of afforestation expenses, just as they are not considered part of the expenses of agricultural production in development areas.

The production of quick-growing forest trees using modern silvicultural techniques has gained momentum in the last twenty years. Native species need not be used: the species should be those most likely to be profitable. Quick-growing species, even if exotic, are what are selected for planting nowadays. Some examples of the results obtained with quick-growing species are as follows:

Eucalyptus

Planting of eucalyptus trees in arid zones on arable land on a large scale is a new venture, and the demand for wood is, at present, greater than the plantations can supply. Though many of the eucalyptus species have been tried in most arid and semi-arid zones, only a few species have remained in use. At the top of the list is *Eucalyptus camaldulensis*. It has many uses and is planted extensively on arable lands in five continents.

On fair agricultural lands, with 400-600 mm. of rainfall, it yields 10-15 cubic meters per hectare per year. With irrigation, the yield is over 25 cubic meters per hectare per year. In arid zones, where wood is scarce, the net return may be equal to those of other agricultural products. Risks in dry years are lower, as other crops may fail partly or completely. Such plantations may be irrigated during the rainy season when there is little use for the rain water running down the gullies.

Eucalyptus gomphacephola has replaced *Eucalyptus camaldulensis* in some arid saline areas, but the results with the older trees show that *Eucalyptus camaldulensis* of some provenances can withstand the same rigorous conditions better.

In more humid zones which are not too affected by frost, *Eucalyptus viminales, Eucalyptus globulus* and *Eucalyptus tereticornis* are used extensively.

Too much time is given to experimenting with all the 618 species of Eucalyptus in hundreds of nurseries and thousands of sample plots. Only the more successful species emanating from different provenances should be tried.

Poplars

Poplars are planted on arable irrigated lands as windbreaks, along water canals and water courses, and as woodlots. They are also planted in combination with agricultural crops. There has been careful selection of species: clones suitable for the particular soil and climate have been propagated; and the technique of rearing, planting and managing these plantations is now at a high level. Yields of over 40 cubic meters per hectare per year have often been recorded on good soil, well irrigated and fertilized. Because of specialization in the selection of clones and proper silvicultural treatment, a high percentage of standing timber is used for saw logs. There is little waste from good plantations.

Poplars are very responsive to climate, particularly to high temperatures. Within limits, the hotter the temperature the faster they grow, provided that adequate moisture is available. In arid zones, there is a dieback if water is not supplied continuously.

Pines

Of the quick-growing pines, *Pinus insignis* heads the list for large-scale planting in semi-arid zones. *Pinus maritima* is also planted on a large scale in sandy and sandy loam areas. The cultivations of *Pinus insignis* have been greatly increased on agricultural and pasture lands. The financial returns from these plantations are in places three times as high as from pasture and are even higher than from maize and lucerne.

Advances in Technique

Nursery Problems

The main differences between nurseries in temperate zones and arid zones are in the extent of shading of the seed beds and transplants, in watering, and in the use of balled plants.

The use of shading has been greatly exaggerated in the past, and permanent heavy lath houses have been built at great expenses. It is now customary to make light removable cane screens which are placed on wire stretched at about one meter above the ground on wooden posts. These screens are removed as soon as they are not necessary. Heavy shading was not only too expensive but caused plants to be spindly.

Every forester and every nurseryman working in arid zones tried to eliminate the costly use of balled plants, but repeated experiments have shown that in zones with less than 600 mm. annual rainfall, naked rooted plants can be planted only at great risk. One is often shown a completely successful plantation of eucalyptus, planted years earlier with naked rooted plants, but the many unsuccessful plantations of naked-root plants are not shown.

The use of pots holding about 0.7-0.8 dm.^{3} of good nursery soil is the best. The substitutes for the conventional earthenware pots are numerous—tin cans, felt paper, veneer. But it now appears that a cheap, strong polyethylene bag will replace all other containers in the near future in most countries. The bags can be ordered or prepared from sheets in a suitable size and shape for each tree species. They are cheap; they are not brittle; they are light in weight and not bulky, thus reducing their transport cost. The necessary holes for drainage are easily made. There is no adverse effect on the roots. They are easy to handle and are not affected by watering. The bags with the plants are easily lifted and transported to the field. The balled plant is planted together with the bag, which is slit with a knife prior to planting.

Where the plants are kept a short time in the nursery before planting, pressed-earth balls of different shapes are made and the seedling or seed is planted in a hole made in the ball.

Growing seedlings in pressed soil or peat without a container is coming more into use: it is a simple, efficient and cheap way of producing a balled plant. From the silvicultural and economic point of view, this method is very convenient, the balled earth being planted in the forest with the seedling. The cost involved is only that of the labor required for their manufacture, provided suitable cohesive soil is available near the nursery. The roots of the seedling spread in the ball strengthen the root system. The balls are formed in casts of different shape, and many balls may be cast in one press. Before casting, a suitable amount of water is added until the soil mixture reaches a plastic condition. When it is at the right consistency, the mud is squeezed gently into the form and retains its shape. Then the balls are sun-dried. If the shape of the mould is hexagonal, the balls are arranged in beds without any spaces between the balls.

As roots are likely to grow from one ball into the next, and root pruning is difficult, the use of the pressed balls is therefore advisable only where plants are left in the nurseries for not more than 4-6 months.

Root Pruning

In order to prune the roots of seedlings grown in tins and boxes and to avoid lifting the boxes every time the roots have to be pruned, the boxes or tins are placed on long and narrow platforms, slightly raised above the ground. Roots are pruned with a strong wire pulled under the platform from each side of the bed by two workers.

Planting

It is claimed that the soil under a pure stand is impoverished and that only in natural, long-term orthodox silviculture is biological balance maintained and the fertility of the forest conserved. But this culture is extremely slow, and the intensive silviculture advocated demands methods to raise the fertility of the soil which are immediate and effective. This is done through cultivation and the use of fertilizers, whether the planting is on poor soils or on good arable land. To prepare these soils for planting, the soil is tilled as deeply as possible in shallow soils, and up to 60-80 mm. in deeper soils. Such tilling will make the most use of the rainwater available. To enable one year's water to be stored for use in succeeding years, there must be a sufficient depth of top soil to hold it. This also causes the accumulation in the soil of the nitrogen from the rain water, mainly in the form of ammonia. It stimulates biochemical reaction in the soil with resulting improvements in the yield. Cultivation thus does not cause a decrease in the organic content of the soil. Certain soils in arid zones need additional fertilizers, such as nitrates, in suitable quantities to increase the yield of trees.

Spacing and Thinning

By using data of the rate of growth of quick-growing species in arable land, one can calculate the appropriate distances between the trees at various ages which would allow the trees to grow to timber size in the most profitable manner. As a result of such studies, the trees are now not only spaced out more widely, but they are thinned more drastically than hitherto. As a result of this, there are no suppressed trees in the plantations; all the trees are dominants or co-dominants.

Trees need space, both for their crowns and their roots. The rate of growth in thickness or volume is determined by the growing space of each tree. Trees compete for root space soon after they have been planted; first with weeds, later with the trees planted near them. If some of the nearby trees are removed, the roots of the remaining trees spread further and can secure a larger supply of water and mineral salts. Where competition for water is keen, as it is in arid zones and during a long dry spell, the growth of the trees is influenced by restriction of rooting space.

Foresters now agree that the giving of more growing space to a tree allows it to increase in diameter more quickly. With a reasonable range of thinning, the high growth of trees is not materially influenced by their density. With fewer planted and heavier thinning, the same increment is derived from a smaller number of trees, and the volume of timber per hectare is not lost, provided there are no considerable gaps in the canopy.

Thus the density of planting and the rate of thinning depend on the quality of site, the rainfall and the extent and method of cultivation.

For fair arable land with about 400-700 mm. of rainfall during five months of the year, the best spacing of plantations of eucalyptus and pines is 3 x 3 meters. The trees may be thinned to 600 per hectare after the sixth year. The rotation of such a plantation is based on 12 years growth.

Forest and Tree-Planting
In the Low-Rainfall Zones

Trees in the low-rainfall zones have an important role in the production of timber and fuel. They give supplementary fodder and serve as shelter for livestock. New techniques offer some promising prospects for special forms of afforestation. Such development involves large investment, though much could be done by hand labor.

The practice now used is to modify the conditions of the surface of the soil by stirring the soil deeply with angledozers and bulldozers. At times, isolated embankments or ridges are built up by heaping together the soil. The trees are then planted in the soil that has been worked. The ridges act as windbreaks and also affect the micro-climate of the soil.

In the low-rainfall steppe it is possible to use similar methods by increasing the width of the embankments and the space between them. In addition, a network of channels may be established between two successive ridges, which will direct the rain water down to the lower embankments. This network collects rain for the trees.

In this way it is believed that it will be possible to reclaim large areas of the steppe with trees, by concentrating all the usable soil and water in strips spaced according to the amount of the annual rainfall.

This practice is still young, and time is needed to prove that it justifies the cost of ridging in its different forms.

It is still too early to compare this system with that of working the soil with a rooter and arranging a simple network of ridges leading the rain water to the trees. It is, however, certain that the soil must be worked deeply.

Diseases and Pests

In general, pure stands are more liable to attack than isolated trees or mixed stands. The management, however, of pure stands can be so arranged as to get a standard form of trees in a standard form of a plantation. In such cases, it is easy to adopt plant protection methods which result in higher yields of timber in pure plantations. There is no evidence that pure plantations have led to any major disaster, so long as the tree species have been properly chosen for the particular site. Poplar plantations have almost completely disappeared from some regions, as the species selected were not suited to the locality.

Sand Dune Fixation

Formerly, it was held that successful sand dune planting depended on expensive pre-fixation of the area with fences or sand-binding grasses, or a cover of brushwood: indeed, it is still part of the standard method used. Early failure on bare sand occurred largely because the plants used were usually small, and the plant was either buried, or its roots exposed, by the movement of the sand.

With these facts in mind, a new technique has been developed which seems to render pre-fixation unnecessary. When large plants (0.80 to 1.20 meters) are planted, with 40 to 60 centimeters in the sand and about 40 centimeters above ground, the normal movement of the sand is rarely enough to cover the plant or to shift the sand from under it. The plant, such as *Acacia cyanophylla,* should be grown in nurseries located in the dunes, where water is available and where there is protection from the wind.

Plants are grown in receptacles filled with a mixture of soil, sand and manure. Plenty of water should be given. By the end of the year, the plants should be more than a meter high, and the receptacle filled with a mass of roots and soil. Early in the second half of the rainy season, the plants can be transported to the planting sites, and, after removing the plant from the receptacle, the ball of roots is soaked in water and placed at the bottom of a pit 40 to 60 centimeters deep, which is then filled with sand. About 40 centimeters of the top twigs are left exposed above the sand, and the spacing before plants is about 2.5 x 2.5 meters, with about 1,500 plants to the hectare. If successful, such planting fixes the dunes in the second or third year.

RESUMES

Progrès réalisés dans l'application des méthodes de reboisement et d'afforestation dans les régions arides et semi-arides

Dans les régions semi-arides et arides, les tentatives pour mettre les forêts en valeur par les méthodes sylvicoles, en partant de broussailles naturelles ou de forêts dégénérées ont en général échoué.

Ces forêts naturelles de broussailles n'ont pas donné le résultat que l'on en attendait. Le sol était pauvre, le climat sévère, de sorte que le rendement s'est avéré très faible.

Du point de vue économique, less efforts effectués depuis plus d'un demisiècle en vue de l'afforestation des régions arides n'ont pas, eux non plus réussi. Les terrains sur lesquels on a planté des essences forestières étaient des terrains de pente prononcée, rocheux ou secs, que les autres usagers n'avaient pas jugé bon d'utiliser. Il est donc évident qu'on ne s'attendait pas à ce que cette tentative permît de rémunérer les capitaux investis. Des plantations de ce genre ne se justifiaient qu'en raison du fait qu'elles occupaient en général des pentes érodées qui, en rendant les inondations possibles, pouvaient avoir un effet nuisible sur les terres cultivées situées à un niveau inférieur. A l'heure actuelle, des espèces sélectionnées à croissance rapide sont plantées sur des terrains plus fertiles et le traitement sylvicole qui leur est appliqué permet la rémunération satisfaisante des capitaux.

Les principes et méthodes intéressant la plantation sont les suivants: sélection des espèces; choix de la provenance des espèces plantées; méthodes de propagation (graines, plants, boutures); choix du terrain le plus approprié à la plantation de chaque espèce; espacement des arbres; culture intensive; irrigation; emploi des engrais; élagage et lutte contre les maladies.

Les produits de ces plantations sont volumineux et les frais de transport qu'ils occasionnent sont élevés. Il s'ensuit que la production de bois d'oeuvre dans des régions éloignées des centres de production de ces bois se révèle intéressante au point de vue financier.

Ces plantations peuvent comprendre des brise-vent ou des rideaux protecteurs et constituer des boqueteaux situés sur de bonnes ou assez bonnes terres. Ce mode de plantation se justifie par la nécessité de satisfaire les besoins des agriculteurs et des marchés de la région en bois et en produits forestiers. L'on estime que de 2 à 5 pour cent de la superficie occupée par les terres arables, devrait être complantée d'arbres à croissance rapide. Ces terres peuvent très bien être des terres irriguées.

Les principales espèces d'arbres plantés dans ces régions sont l'eucalyptus, le peuplier et le pin.

Dans les pépinières, on préfère maintenant une protection légère contre la lumière plutôt que l'emploi des claire-voies épaisses utilisées auparavant.

Lorsque les plants ne demeurent en pépinière que peu de temps, on préfère maintenant empaqueter les racines dans une boule de terre tassée.

On se sert beaucoup actuellement de sacs en polyéthylène qui, en de nombreux endroits, tendent à remplacer les autres genres d'emballages.

Le labourage profond ou sous-solage avant la plantation et l'espacement des plants sont actuellement préférés et recommandés lorsqu'il s'agit de planter des espèces à croissance rapide dans les régions arides.

Des buttes destinées à diriger l'eau de pluie vers les arbres sont élevées sur les superficies complantées. Parfois des fossés sont creusés dans le même but.

Les insectes et maladies sont plus faciles à combattre dans les plantations bien tenues à peuplement pur et où les arbres sont tous du même âge.

Pour la fixation des dunes de sable on utilise de gros plants. Ceux-ci sont placés dans des trous profonds creusés dans le sable; une partie du plant dépasse la surface du sol de manière que le plant ne soit pas enterré et que ses racines ne soient pas mises à découvert par les mouvements du sable. Dans certaines régions, cette façon de planter réduit l'importance des travaux préliminaires de fixation fort coûteux qui précèdent la plantation.

Adelantos en las Prácticas de Reforestación y Plantación de Bosques en Terrenos Aridos y Semiáridos

Han fracasado, en general, todos los ensayos de reforestación que se han hecho mediante métodos de silvicultura aprovechando para ello la broza natural y los bosques empobrecidos en las regiones semiáridas y áridas. Las utilidades provenientes de estas brozas naturales no han sido las que se esperaban. Los suelos de estos bosques no son fértiles, el clima es extremoso y el rendimiento exiguo.

Por más de un siglo, los ensayos de plantación de bosques en regiones áridas han fracasado por completo, desde el punto de vista económico. Los terrenos que se aprovecharon para plantar árboles fueron tan sólo los que habían sido abandonados por los antiguos usuarios debido a su topografía escarpada, pedregosa y reseca. En consecuencia, no era de esperarse que los bosques de esta clase rindieran utilidades en proporción con el capital invertido. Esta clase de plantaciones se juzgaron convenientes debido a que se hicieron en cuencas desgastadas por la erosión que hubieran causado daños por las inundaciones de los terrenos situados más abajo. En la actualidad se están plantando mejores tierras con especies de arboles bien seleccionados y de rápido crecimiento y los procedimientos de silvicultura que se siguen rinden buenas utilidades a la inversión.

Los principios y los métodos que se siguieron en la plantación fueron: selección de las especies; selección de la procedencia de las especies; métodos de propagación (semillas, plantas de semilla y estacas de plantar); selección de los terrenos más apropiados para las especies; espaciamiento de los árboles; intensidad del cultivo; riego; abono, poda y lucha contra las enfermedades.

Los productos de estas plantaciones son voluminosos y los precios de transporte que ocasionan son altos. En consecuencia la producción de madera de construcción en las regiones alejadas de los centros de producción resulta interesante desde el punto de vista financiero.

Estas plantaciones pueden formarse con árboles que sirvan de abrigo contra el viento o de pared de protección y, en los terrenos pequeños, con arboledas en terrenos agrícolas de mediana calidad. Esta manera de plantar se justifica para satisfacer las necesidades de los agricultores y de los mercados regionales de madera y de productos forestales. Se ha creído que de 2 a 5% de los terrenos labrantíos deben plantarse con árboles de crecimiento rápido. Estos terrenos pueden ser de regadío.

Las principales especies que se plantaron en las regiones de referencia fueron: eucaliptos, álamos y pinos.

La luz tenue se prefiere ahora en los viveros, en vez de los claros espaciados utilizados con anterioridad.

Las plantas con cepellón, en terrenos apisonados, se aprovechan en general cuando las plantas permanecen por corto tiempo en el vivero.

Las bolsas de politileno se aprovechan extensamente en algunos lugares en vez de otros tipos de receptáculos.

El arado profundo, el desfonde del suelo, y la anchura del espaciamiento están siendo aceptados como métodos apropiados para preparar la plantación, así como la de especies de crecimiento rápido en terrenos áridos.

Se levantan caballones en los plantíos para llevar el agua a los árboles. En ocasiones se aprovechan acequias con el mismo objeto.

Se combaten, con mayor facilidad los insectos nocivos y las enfermedades en arboledas de una sola especie de la misma edad. Para estabilizar los médanos se aprovechan plantas grandes, las cuales se colocan en hoyos profundos en la arena y se deja parte de ellas en la parte superior de manera que no queden completamente enterradas y las raíces por fuera, debido al movimiento de la arena. En algunas regiones esta clase de plantaciones reduce el costo de los antiguos métodos que se seguían para estabilizar médanos.

Progrès dans les méthodes de boisement et de reboisement dans les zones arides et semi-arides

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La doctrine

Le climat

Xérothérie et végétation. Sous les climats arides et semi-arides les difficultés éprouvées par le planteur d'arbres tiennent moins souvent à la faiblesse en valeur absolue des précipitations atmosphériques qu'à leur répartition défavorable dans l'année. Lorsque la saison sèche coïncide avec les jours courts, c'est-à-dire sous climat xérochiménique, la végétation bénéficie en même temps de la chaleur et de l'humidité. Même peu durable, cette conjonction est toujours bénéfique. Lorsqu'au contraire la sécheresse porte sur les jours longs, les deux conditions indispensables à l'activité végétale se trouvent disjointes et, même sous des isohyètes élevées, l'aridité peut être grande. Ce climat, si défavorable en principe, est dit xérothérique et nous appelons xérothérie son caractère distinctif.

Grâce aux données météorologiques, il est facile d'obtenir la représentation schématique des périodes de végétation active sous un climat déterminé, à la condition d'admettre deux hypothèses. La première est que le sol, squelettique ou peu profond, ne constitue qu'un faible réservoir d'eau. La seconde est qu'en l'absence de couche hydrophobe l'évapotranspiration de base représente, en ordre de grandeur et en millimètres par mois, le double de la température moyenne de ce mois exprimé en degrés centigrades.

Si l'on trace pour les 12 mois de l'année la courbe des moyennes thermiques et sur le même graphique, à échelle moitié moindre la courbe des précipitations mensuelles, la saison sèche ou morte-saison d'été sera définie par l'excès figuré des amplitudes thermiques sur les amplitudes hydriques. La morte-saison d'hiver correspondra à la période pendant laquelle n'est pas atteinte la température d'entrée en végétation. Cette application pratique des concepts de H. Gaussen permet de saisir et de mesurer, par la brièveté des saisons favorables, le caractère dangereux de la xérothérie. Mais il est encore aggravé par le fait que des deux périodes en principe utiles, une seule l'est en réalité, celle qui correspond à l'ascension thermique.

Sans même qu'il soit besoin de tracer les courbes, on vérifie également, par le seule référence au principe de leur construction, qu'à pluviométrie égale les régions les plus septentrionales et les régions d'altitude, en raison de l'abaissement de la courbe thermique apparaissent les plus défavorisées. La saison d'hiver y retarde le départ en végétation et l'activité printanière, à peine entamée, s'achève dans les ardeurs sèches. C'est ainsi qu'autour du bassin méditerranéen le problème du boisement des hautes plaines semble le plus difficile à résoudre.

Les principes théoriques du boisement

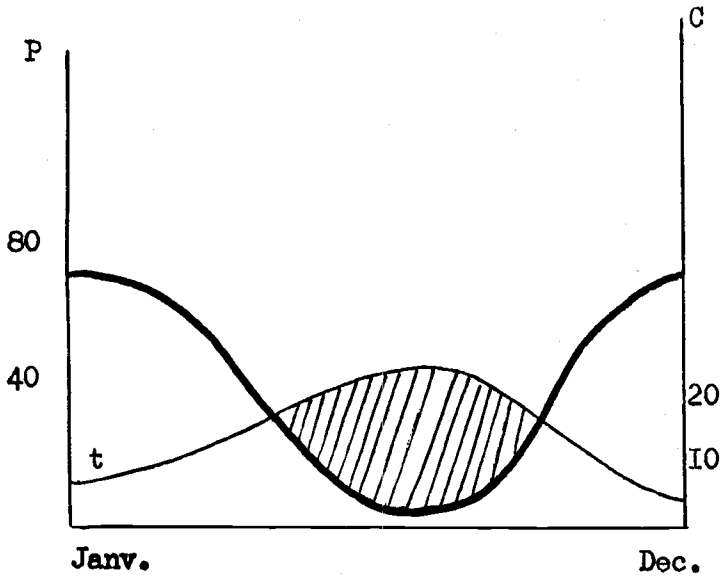
L'eau et le sol. Les sols squelettiques, quoique très répandus par le fait d'un long passé de dégradation imputable au feu, à la charrue et au troupeau, ne sont cependant naturels que dans des stations très déclives ou dans le désert véritable. Le palliatif de la xérothérie tient normalement en l'existence d'un sol qui recueille les eaux pendant la saison froide et les restitue pendant la saison sèche. Le sol idéal serait celui qui, sous une végétation non disturbée, retiendrait intégralement dans sa structure toutes les précipitations d'hiver non évaporées pour en dispenser l'acquis aux plantes durant l'été. Il y a des raisons de croire que ce sol présenterait le caractère de l'équilibre climatique. On peut se donner une idée de son épaisseur en divisant par la capacité de rétention moyenne de l'unité de volume de terre, au dessus du point de flétrissement, le volume d'eau tombé hors saison de végétation sur l'unité de surface, après déduction de sa fraction évaporée sous protection complète.

Toujours dans l'idée de s'informer, soit schématiquement soit en vertu d'expériences précises, il est également possible d'effectuer sur le diagramme ombrothermique un transport des volumes d'eau tombés hors saison de végétation en les distribuant pendant la saison de végétation. C'est étendre à l'emploi de toute la réserve d'eau le schéma de distribution que l'on établit généralement pour tenir compte des précipitations neigeuses. Ce travail effectué, on constate à quel point la xérothérie peut se trouver réduite, du fait d'un sol profond, susceptible d'emmagasiner toute l'eau précipitée.

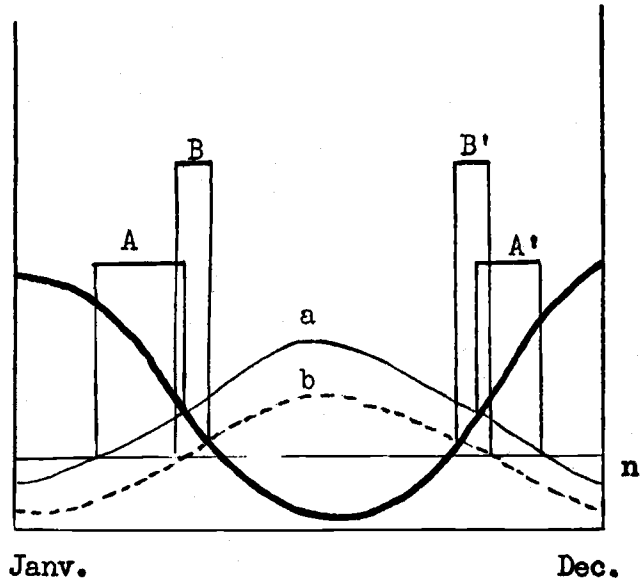
On constate également que sur ce sol profond, à égalité toujours de précipitations, la remontée en latitude et en altitude en allongeant la morte-saison réduit d'autant la période de végétation possible et abaisse la xérothérie réelle; c'est le contraire de ce qui a été dit précédemment. Les hautes plaines ne sont si défavorables à la forêt, voire même à la culture agricole, que parce que l'homme en a trop usé à des époques lointaines. Elles lui étaient trop accessibles. Elles n'ont plus de sol.

Le principe fondamental du boisement et du reboisement est la constitution d'un sol profond.

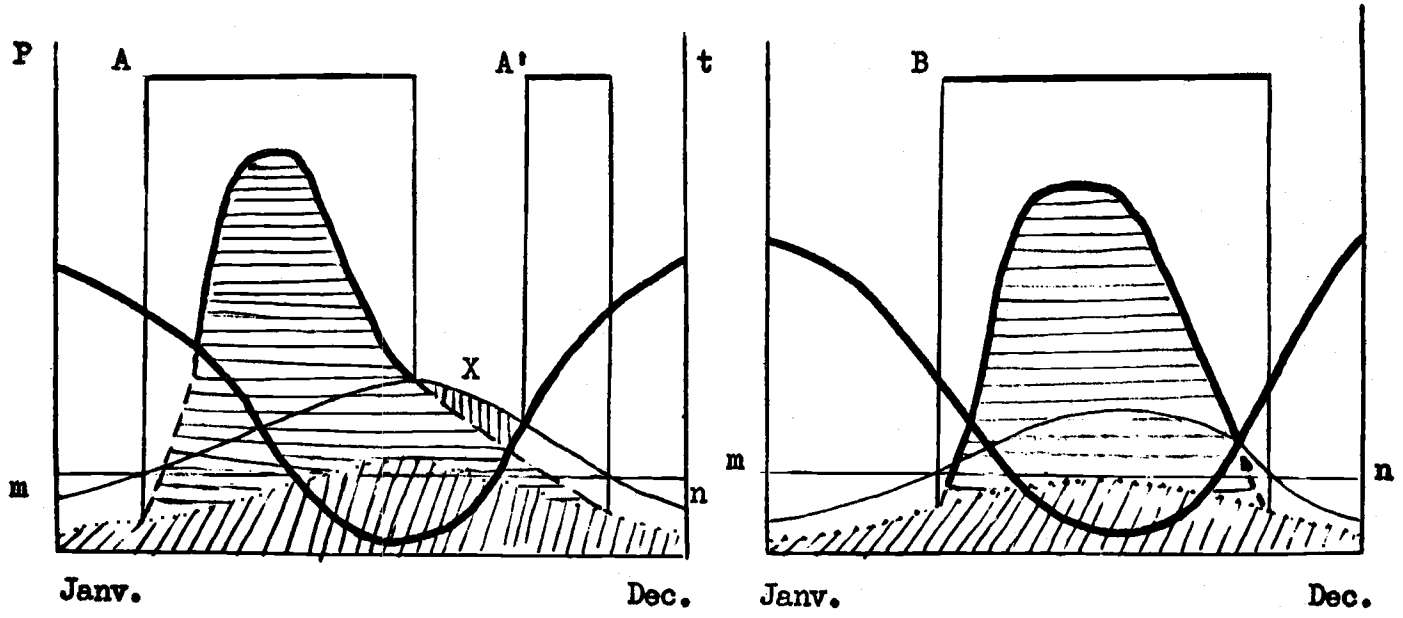
L'oxygène et le sol. Le chevelu nourricier des arbres a pour tendance de se rapprocher de la surface du sol dans toute la mesure où le lui permet le maintien de l'humidité, nécessaire à la vie. On ne sait pas encore jusqu'à quel point ce chevelu superficiel peut compenser



Type de climat xérothérique
courbes ombrothermiques
selon Gaussen et Bagnouls



Saisons de végétation
à pluviométrie égale sur sol dégradé
AA′ avec chaleur forte (courbe a)
BB′ avec chaleur faible (courbe b)
m n : ordonnée du départ en végétation



Action du sol-réservoir sur le climat xérothérique

(Transport en saison de végétation possible de l'eau retenue hors saison)

A A′ — saisons de végétation avec chaleur forte (basse altitude)

B — saison de végétation avec chaleur faible (haute altitude)

m n — comme ci-dessus ///X — xérothérie résiduelle

/// évaporation du sol protégé ≡ transpiration végétale

Plan I. Rôle théorique du sol-réservoir sous climat xérothérique

par les racines suçoirs plongeant en profondeur le déficit hydrique de l'horizon où il se maintient en activité. Le fait est que sous une litière abondante ou sous des graviers, il atteint la surface elle-même et que sa densité y est en proportion inverse de la porosité des couches sous-jacentes. Il arrive qu'à défaut de litière et prenant appui sur ses parties mortes il parvienne après plusieurs années à constituer de lui-même la couche poreuse qui lui convient.

Cette véritable marche à l'oxygène, avec tout ce qu'elle comporte de tropismes et d'élaborations structurales est apparemment le moins étudié des points majeurs de la sylviculture. Son importance est masquée sous les climats tempérés et dans les forêts déjà hautement auto-protectrices parce que même en sols compacts, une moiteur suffisante permet toujours à un certain chevelu aérophile de demeurer en activité. Ce n'est pas le cas sous climat xérothérique et sur un sol encore nu parce que l'oxygène ne sert plus de rien dans des horizons trop desséchés.

Ainsi se révèle sous ce climat, la nécessité impérieuse de mettre à la disposition des arbres plantés, et quelles que soient les ressources en eau disponibles et même accessibles aux racines en profondeur, un horizon de surface brisé ou protégé, une surface amortie, propre à répondre aux besoins de la respiration.

Le second principe du boisement exige le maintien d'une structure superficielle parfaite.

Les aliments minéraux. Après l'eau et l'air intervient l'aliment minéral. En matière de sylviculture on ne s'intéresse que depuis peu à ce troisième facteur limitant. A tort ou à raison une forêt déjà constituée, même sur des sols très pauvres, est souvent considérée comme trouvant sur place les éléments minéraux qui lui sont nécessaires grâce au développement de ses racines en profondeur, grâce à la fermeture du cycle de l'humus. Cela ne peut être le cas lorsqu'un boisement s'installe. Il est impératif de lui apporter les ions assimilables utiles lorsqu'ils manquent aux terres travaillées.

La difficulté est de réaliser cet apport, troisième principe du boisement, sous des formes judicieuses et au moment exact que définissent les exigences du climat.

Caractère impératif des principes. Ce premier tour d'horizon montre qu'au fond des choses les principes théoriques du boisement sous climat xérothérique ne se différencient pas de ceux qui devraient partout présider à la plantation des arbres. Mais ici leur application est plus impérative, ce qui oblige à les concevoir d'abord clairement. Pour être éliminés, les facteurs limitants doivent être d'abord bien définis. Par la suite le conditionnement du substratum ne supportera pas d'insuffisance.

Pour placer les arbres en position de reprendre et de croître sous un climat à longue saison sèche et chaude, il convient d'apporter d'office le capital énergétique et le remaniement structural qu'en des lieux plus privilégiés la remontée biologique naturelle consentirait d'elle-même assez vite. Il ne faut pas compter ici sur des dons de la nature. Celle-ci ne dispose ni de la souplesse ni du potentiel qui, sous les climats tempérés, autorisent le reboisement à s'aligner sur la loi du moindre effort. Elle sanctionne de suite l'erreur ou la négligence et la parcimonie des moyens se traduit en stérilité.

Théorie de la préparation du sol

Mise en culture et amortissement superficiel. Démarche immémoriale du cultivateur, la mise en culture a pour effets d'amortir la surface de séparation entre l'atmosphère et le sol, d'apporter aux racines d'une plante toute la fourniture d'air et d'eau à laquelle sont susceptibles de répondre ses possibilités spécifiques et individuelles de développement. Parce qu'il est lent à s'établir et que les moindres infidélités du climat lui sont de lourdes menaces, le jeune plant forestier exige que cette mise en culture soit parfaite autour de lui. Sous le climat qui nous occupe cet ameublissement doit être assez étendu pour qu'aucune limite ne soit opposée à l'extension radiculaire mais aussi pour que l'eau maintenue par cet ameublissement ne gagne pas par diffusion capillaire, au cours de la saison sèche, la zone périphérique non traitée et plus rapidement desséchée dans ses horizons supérieurs.

La mise en culture a pour second objet de permettre la diffusion rapide des racines, dans tous les sens, en tant que charpente initiale. Cette considération se relie à la nécessité de l'ameublissement en profondeur.

Le troisième objet de la mise en culture est l'élimination de toute concurrence. Les herbes, non seulement consomment de l'eau mais aussi entravent l'aération du sol sous-jacent et, la sécheresse venue, facilitent les pertes hydriques en interdisant la constitution d'une couche hydrophobe. De leur côté les essences vivaces et le maquis, même recépés, présentent un potentiel de regénération radiculaire tel que le sol ameubli pour le bénéfice de l'arbre planté ou semé est colonisé beaucoup plus vite par leurs racines nouvelles que par celles du jeune sujet.

L'expérience a montré partout, sous climat xérothérique, que l'éviction de la concurrence était indispensable d'abord à la reprise, plus tard à la croissance.

Défoncement et réserves hydriques. Le défoncement réalise l'extension en profondeur de l'ameublissement. Son but est multiple.

Il permet en premier lieu la constitution rapide et profonde d'une bonne charpente radiculaire; par la rupture des horizons profonds il régularise la zone d'habitat des racines et homogénéise le peuplement; ouvrant l'accès à un grand volume de sol et de roche mère il accroit les disponibilités immédiates en éléments minéraux; il confère enfin aux racines un vaste réservoir hydrique accessible en plein.

Ce dernier rôle est majeur.

L'absorption de l'eau par les racines répond à deux lois très différentes selon qu'elle est réalisée à partir d'une masse de sol accessible en plein et où leur réseau pompe dans un volume ou bien à partir d'une surface qu'elles tapissent sans pouvoir y pénétrer librement. Dans le premier cas l'arbre est maître de satisfaire ses besoins au rythme qui lui convient. Le métabolisme hydrique est actif. Dans le second cas l'arbre ne peut recevoir que ce que lui apporte par diffusion capillaire la roche sous-jacente. Le métabolisme hydrique est passif.

On comprend que sous climat xérothérique le métabolisme hydrique sera actif au printemps et passif en été. Le défoncement jouera un rôle essentiel en accroissant le volume de sol permettant le métabolisme actif, donc la croissance et la production ligneuse.

Le raisonnement montre aisément que le métabolisme passif est essentiel aux arbres pour passer la fin de la

saison séche ce qui oblige, si la xérothérie est accentuée, de disposer toujours en profondeur d'un réservoir inaccessible en plein: Les horizons inférieurs inclus dans la profondeur mouillée doivent être compacts. La nature répond à cette condition en créant des horizons illuviaux argileux. Dans un sol entièrement accessible en plein, toute l'eau serait consommée avant la fin de l'été et les arbres ne sauraient atteindre un équilibre.

On en déduit que sous faible pluviométrie et saison sèche durable le défoncement doit épargner un réservoir estival inaccessible en plein, susceptible, pendant plusieurs mois, de libérer chaque jour une quantité d'eau pouvant atteindre au maximum un millimètre. Il serait donc imprudent, par exemple, de défoncer à 80 cm un sol compact où la profondeur mouillée n'excéderait que de peu cette limite.

Dans la zone méditerranéenne le signal de prudence s'inscrit aux abords de l'isohyète des 400 mm. Ill est alors indispensable de tracer les courbes ombrothermiques et de calculer la profondeur mouillée maximum en année moyenne, car celle-ci risque de ne pas atteindre les quelque 1,30 cm en deçà desquels la préparation du sol avec les gros engins exige un changement de méthode.

Association du défoncement et du billonnage. Cette limite atteinte, le problème est résolu par un subterfuge. D'un relief régulier, entrainant une profondeur mouillée partout égale, mais insuffisante, on passe à un relief fait de bourrelets ou talus plus ou moins espacés. En raison de la pente des talus l'eau de ruissellement s'accumule dans les intervalles. La profondeur mouillée est réduite sous les billions et accrue dans les espaces intercalaires. Le défoncement profond de ceux-ci devient possible tout en ménageant un réservoir convenable, inaccessible en plein aux racines et qui permettra de passer l'été.

La méthode présente d'autres avantages. Les billons coupent le vent et constituent de puissantes accumulations de terre meuble où la reprise et la croissance sont satisfaites au mieux. Le tassement y est ralenti, l'aération en conséquence bien ménagée. Le jeune sujet y trouve le contingent optimum d'air tandis que ses racines, à très faible distance, s'introduisent dans l'espace défoncé riche en eau. Cette disjonction appelle la meilleure conservation du sol, une pedogénèse active, la plus logique utilisation des ressources.

La souplesse théorique du procédé lui ouvre un domaine d'application presque illimité. On peut en effet jouer à volonté sur le profil des reliefs et des creux ou espacer ces reliefs en sorte de séparer les zones d'infiltration maximum par des impluvia réduits à un rôle passif de suralimentation en eau. Ainsi du boisement en plein, réalisable encore sous 400 mm de pluie est-il possible de s'écarter peu à peu en espaçant d'abord les lignes plantées puis en conférant aux impluvia une importance relative de plus en plus grande. Aboutissement logique de cette adaptation aux basses pluviométries, le réseau des talus permettant par récupération des eaux ruissellement l'irrigation d'appoint des bandes défoncées devient assimilable par son dessin au réseau classique des terrasses de contour. Son rôle toutefois est à l'inverse puisqu'il ne s'agit pas de conserver le sol des intervalles mais au contraire de concentrer sur des lignes toutes les ressources du sol et du climat.

Il n'est pas impossible, théoriquement, de s'avancer ainsi très près du désert véritable, celui-ci étant défini par une telle insuffisance et une telle infidélité des précipitations que même les talus les plus espacés y perdraient toute assurance de recevoir dans l'année le contingent voulu d'eaux de ruissellement.

Théorie de la culture

Adaptation des plants d'arbres. A un sol préparé pour équivaloir d'office à une puissante remontée boilogique et amortir les infidélités du climat, mais cela pendant une période limitée, il convient d'assortir des plants d'arbres susceptibles non seulement d'en tirer immédiatement tout le parti mais encore de relayer l'action de l'homme avant qu'elle s'efface.

La théorie exige que le plant soit parfaitement adapté c'est-à-dire cultivé sous le climat des lieux d'emploi, mis en place avec un réseau de racines complet et immédiatement fonctionnel. Toute influence dépressive est évitée par la plantation exécutée en début d'ascension thermique. Le plant doit être développé au maximum pour disposer du plus grand potentiel possible de colonisation.

Une fois le réseau radiculaire bien en place, on n'aura plus à craindre les conséquences du tassement naturel du sol défoncé mais seulement à intervenir pour que l'extension superficielle du chevelu ne rencontre pas d'obstacles.

Il est vrai que la double nécessité de plants bien développés et d'un réseau radiculaire primitif absolument intact introduit dans la pratique une contradiction difficile à résoudre mais, dans la théorie, il existe deux solutions. La première est d'élever les plants dans des logements conçus pour que le chevelu ne puisse souffrir aucune injure, le second est de pallier l'inconvénient d'un système radiculaire, fortement développé mais plus ou moins meurtri, par la réduction ou le recépage des organes aériens.

La solution du semis direct sera écartée dans le principe parce qu'elle exige une structure parfaite du sol, une adaptation très fine aux circonstances locales, parce qu'elle rend difficiles et coûteux les travaux d'entretien. Dans la pratique cependant elle n'est pas exclue, entre les mains d'un bon spécialiste, car aucun enracinement ne vaut l'enracinement naturel, aucune sélection en pépinière la sélection sur le terrain.

Entretien initial. L'entretien parfait du sol doit assurer son état superficiel d'amortissement en attendant que l'ombrage l'ait recouvert et que les racines y aient achevé la colonisation de l'horizon supérieur. Il permet également d'éviter le retour des plantes concurrentes.

Sous d'autres climats que xérothériques la question pourrait se poser de se borner à un fauchage très ras et très fréquent des plantes adeventices afin de constituer comme cela se pratique dans certaines plantations fruitières, une couverture vivante et morte, dense et régulière que coloniserait peu à peu la remontée du chevelu des arbres. Mais il y faudrait un sol non pierreux et des précipitations abondantes dont le climat à saison sèche et chaude est le plus souvent avare. On se contente de façons culturales régulières parcourant autant que possible tout le terrain, rasantes et coupantes mais ne retournant pas les horizons, pratiquées jusqu'à ce que le couvert soit en grande partie constitué.

La culture accélérée. A cette phase de premier entretien, qui entre dans les opérations de première mise, peut faire suite un abandon complet des interventions sur le sol ou succéder au contraire, sans interruption, la phase de culture. On parle alors, et seulement dans ce cas, de sylviculture accélérée. Jusqu'à la date de son exploitation l'arbre est traité comme une plante de culture agricole. L'ameublissement superficiel est renouvelé périodiquement mais la théorie invite à ce que les intervalles des façons culturales soient assez brefs pour éviter l'implantation solide de grosses racines dans la couche travaillée. Au contraire les chevelus légers, qui s'y reforment en quelques semaines après le passage des instruments sont constamment renouvelés et rajeunis tandis que la litière, incorporée au sol à chaque passage, est minéralisée entièrement.

La théorie de la culture accélérée est encore trop récente pour avoir entraîné une adhésion générale mais ses succès, notamment en Espagne, sont spectaculaires, et il n'y a pas de raison de croire que ce qui est bon pour une vigne ou des abricotiers soit dangereux pour des arbres forestiers. Il faut alors songer à pousser l'assimilation à son terme, en accompagnant la culture accélérée des arbres d'amendements et d'engrais.

Citons également les mélanges d'essences comme destinés à l'amélioration culturale du sol. Une essence principale dont seule la production est prise en considération serait alors accompagnée d'une essence accessoire n'ayant d'autre but que de faciliter le métabolisme de la première.

Nous rappellerons pour mémoire qu'une plantation forestière conduite comme une culture demeure sensible à l'érosion en nappe et que le maintien, dans le boisement, d'un réseau de banquettes ou terrasses de niveau est indispensable.

La densité des plantations. Le dernier point théorique est celui de la densité. Par suite du coût élevé des plantations, de la nécessité de larges entretiens, pour tenir compte également de la rapide croissance des arbres, il est impossible de les planter serrés. L'expérience a confirmé qu'il fallait, en général, pour les plantations de bois d'industrie, ne jamais dépasser 2.000 sujets à l'hectare et se contenter le plus souvent de 1.000, en plantation pleine.

Ce dernier chiffre est un maximum quand on emploie la méthode des billons. Lorsque ceux-ci s'espacent, en direction du désert, le terme de densité n'a plus de sens, puisqu'il ne s'agit plus que de lignes d'arbres.

La pratique

Le matériel végétal

Les essences de boisement industriel. Nous nous limiterons au cas de l'Afrique du Nord et à l'essentiel.

Le choix des essences est guidé par l'adaptation au climat, la rapidité de croissance et les qualités technologiques.

Dans les boisements conventionnels ne figuraient autrefois, parmi les essences citées ci-dessous que *Pinus halepensis,* rarement *Pinus pinaster, Pinus canariensis, Cupressus sempervirens* et quelquefois *Cedrus atlantica. Eucalyptus globulus* et *E. camaldulensis* étaient plantés dans les meilleurs sols, *Acacia cyanophylla* fixait les dunes. L'immense majorité des vieux boisements artificiels ne comportent que *Pinus halepensis*, l'espèce la plus résistante du pays.

On doit signaler l'échec presque général de *Quercus suber* par les méthodes conventionnelles.

Grâce a l'introduction des méthodes modernes, d'abord le semis de *Quercus suber* s'est révélé possible sur les bourrelets de banquettes puis le défoncement et la culture en plein ont montré que beaucoup d'espèces réfractaires aux méthodes conventionnelles devenaient susceptibles de figurer avec avantage dans les plantations.

A l'heure actuelle la diffusion porte sur les espèces suivantes.

En dehors des pins méditerranéens *Pinus halepensis* Mill., *Pinus pinaster* Sol., plus rarement *Pinus clusii* Clem., on n'a guère expérimenté avec succès que *Pinus coulteri* D. Don, *Pinus radiata* D. Don, *Pinus canariensis* C. Sm.

Cedrus argentea Renou (=*C. atlantica* Man.) est le seul cèdre utilisé.

A *Cupressus sempervirens* L., devenu véritable essence de boisement depuis quelques décades, se joignent aujourd'hui *Cupressus atlantica* Gaussen et *Cupressus glabra* Sudway, plus résistants à la sécheresse. *Cupressus macrocarpa* Hartw. est peu répandu.

Parmi les eucalyptus et malgré la multiplicité des introductions on n'utilise encore en grande culture que les *E. camaldalensis* Dehnh., le plus commun, *E. globulus* Labill., *E. gomphocephala* DC. L'attention se porte cependant sur *E. sideroxylon* Cunn., *E. melliodora* Cunn., *E. cladocalyx* F. Muell. (un des mieux formés) ainsi que sur les espèces susceptibles de résister au climat semi-aride froid des hautes plaines dont *E. gunnii* Hook. f. est le plus représentatif.

Outre *Acacia cyanophylla* Lindl., *A. cyclops* Cunn., et *A. pycnantha* Benth. sont employés sur les dunes. *A. mollissima* Willd. est planté pour le tanin de son écorce ou bien en sous-étage d'eucalyptus comme essence associée améliorante.

Les essais de boisement les plus méridionaux utilisent *Tamarix articulata* Vahl.

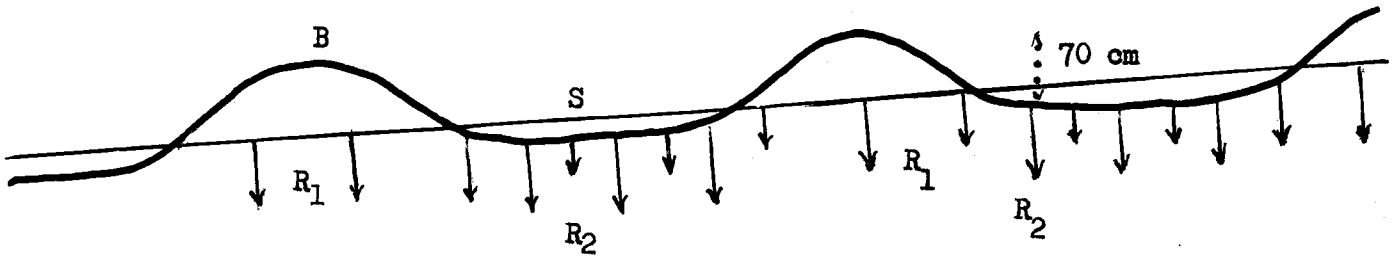
Arboretums et semences. Les arboretums déjà anciens et susceptibles d'apporter une information certaine sur des essences autres que les précédentes sont malheureusement rares et situés en des stations de climat trop favorable. Ils fournissent peu de graines.

Depuis une quinzaine d'années, de nouvelles collections ont été constituées et installées dans les régions les plus variées. Il existe ainsi des vergers à graines véritables dont certains, au Maroc, entrent déjà en production. D'autres, en Algérie, sont riches en espèces mais encore trop jeunes pour produire.

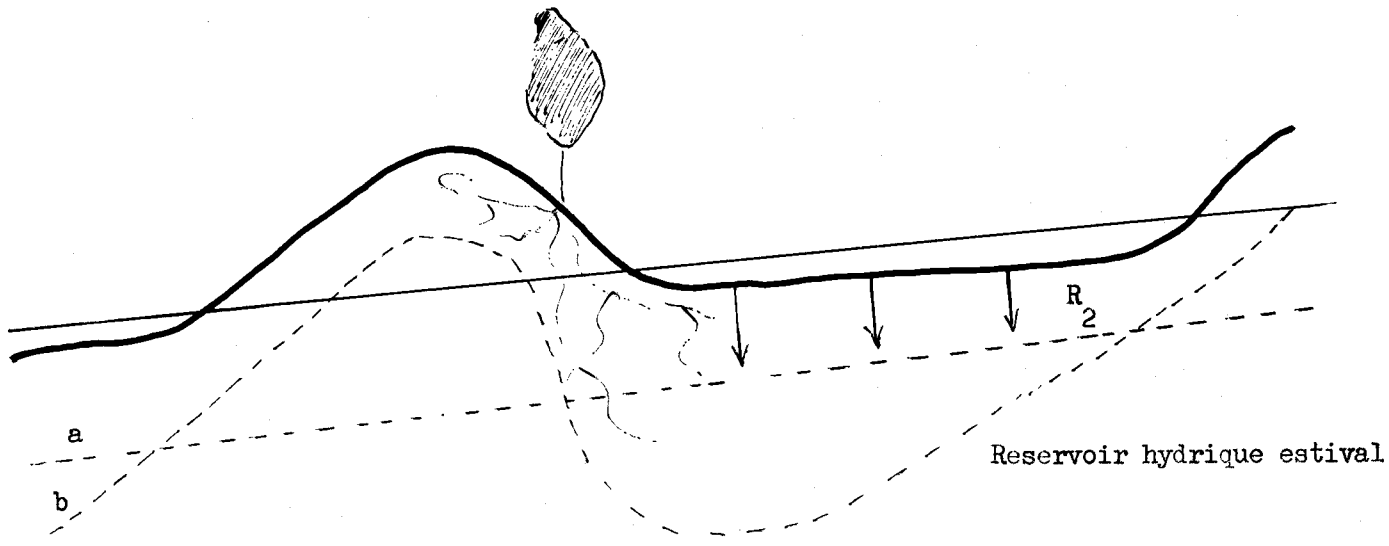
La Station de recherches forestières du Maroc a innové en Afrique du Nord le tri des semences, leur centralisation et leur conservation en chambre froide.

L'élevage en pépinière. L'élevage des plants se pratiquait jadis dans des pépinières locales qui n'étaient pas à la mesure des grands reboisements. On entretient aujourd'hui des pépinières plus vastes dont plusieurs sont susceptibles de fournir chaque année jusqu'à un million de plants.

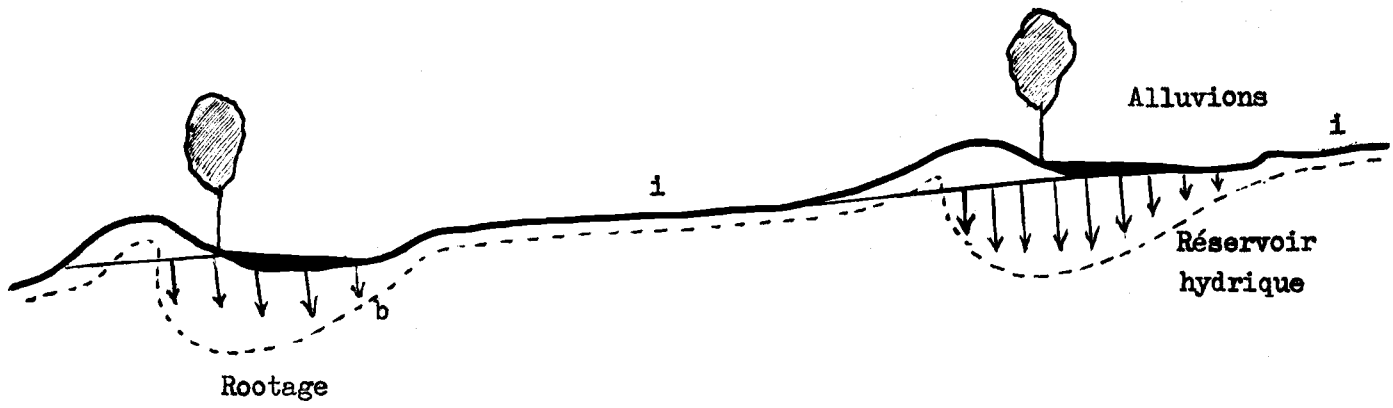
Le problème d'obtenir des sujets bien développés et d'enracinement parfait est résolu le plus souvent par l'emploi de godets de terre cuite, de 7 à 10 cm de diamètre et de profondeur égale, où l'arbre demeure



Profils du boisement "steppique." R_1, rootage initial; R_2, rootage final.



Evolution théorique de la profonde mouillée (a) avant, (b) après. Le défoncement profond R_2 n'est possible qu'après profilage.



Méthode steppique extensive avec impluvia (i).

Plan 2. Méthode steppique de boisement

pendant une saison d'élevage s'il s'agit d'eucalyptus, une ou deux saisons dans le cas des résineux. La pratique de cet élevage est coûteuse, surtout à cause du transport des godets sur les lieux de plantation, mais parfaitement au point.

On recherche aujourd'hui une solution plus souple et moins onéreuse par l'emploi de manchons en film de polyéthylène. De nombreuses expériences ont eu lieu et la méthode commence à se propager. Le meilleur logement semble devoir être constitué par des tubes de 25 cm de hauteur, d'un diamètre de 6 cm et dont le film a 38 microns d'épaisseur. Les racines y prennent une forme plus naturelle que dans les pots. Pour éviter les nombreuses difficultés entrainées, lors de la plantation, par la nécessité de percer ou de lacérer le tube, on convient d'utiliser un film présentant de nombreuses petites perforations circulaires, à tous les niveaux. Sur un sol bien ameubli la plantation au trocart est facile.

Les cornets en bois déroulé ne sont pas employés en Afrique du Nord et pas davantage les mottes moulées à la presse.

L'eucalyptus est quelquefois élevé et planté à racines nues. La réussite exige des sujets bien développés, que l'on recèpe au collet après plantation. Ainsi est évité le dèséquilibre entre un feuillage abondant et des racines forcément mutilées.

Méthodes modernes de boisement

L'évolution des méthodes. Sur le terrain, la préparation conventionnelle du sol par simples potets cubiques à l'arête de 30 ou 40 cm ne s'emploie plus que dans les parcelles inaccessibles aux engins mécaniques et spécialement dans l'intervalle de véritables banquettes de niveau, en réseaux serrés, qui portent les arbres à mi-hauteur de leur bourrelet aval. Ces banquettes sont ouvertes aux outils manuels.

On utilise également, dans les mêmes conditions, des éléments de banquettes ou de petites placettes défoncées. Le plant est quelquefois protégé par une épaisse litière de feuillage et de branches provenant du recépage du maquis.

Toutes ces méthodes sont très coûteuses; leur application complique les travaux d'entretien; elles n'ont pas d'avenir. Le boisement des montagnes qu'il est impossible de pratiquer d'une autre façon ne pourra être réalisé dans le futur que par les méthodes de la sylviculture naturelle, une fois que la civilisation pastorale, laquelle à présent en interdit l'extension, aura suffisamment évolué.

Partout où cela est possible, on s'oriente aujourd'hui vers la préparation en plein par labour profound avec ou sans défoncement au rooter, suivi d'entretiens culturaux au polydisque. Au-dessous de l'isohyète des 400 mm le billonnage semble indispensable.

Nous nous contenterons d'évoquer la méthode du défoncement par rootage en plein et la méthode du billonnage, dite méthode steppique.

Méthode du rootage en plein. Le rootage en plein s'oppose au rootage par traits espacés, qui revient au creusement de potets longitudinaux, maintient des crevasses dangereuses en été et n'est plus appliqué pour cette raison.

On utilise des tracteurs de 100 CV à 200 CV et des rooters de 3 à 7 T. La profondeur atteinte en moyenne est de 70 cm. Les appareils peuvent travailler sur lignes de niveau jusqu'à une pente de 20-25%. Au-dessus, on organise les virées en sorte de faire travailler les engins à la descente.

Le rootage se pratique en passages contigus, simples, redoublés ou chevauchants, à deux ou trois dents, selon la dureté du sous sol. Au préalable la végétation un peu forte doit être recépée et incinérée. Des chantiers de charbonniers s'en chargent généralement.

Le rootage exige de 3 à 4 heures par hectare, rarement davantage.

En sol dur, anfractueux ou peuplé de végétation vivace l'opération est suivie du passage de la rasette. La rasette est une lame transversale qui équipe deux dents de rooters insérées sur des prolongements arrière du bati. La fenêtre ainsi constituée entre lame et bati évite le bourrage. La lame travaille entre 20 et 50 cm de profondeur selon le cas, détruit toute végétation vivace, comble les cavités et assure un ameublissement parfait. Son travail demande 3 heures à l'ha.

Après préparation du sol le tracteur est équipé en angle-dozer et trace, s'il y a lieu, un réseau de banquettes destiné à contrôler l'érosion.

Une fois les arbres plantés sur lignes de niveau espacées de 3,5 m, le bénéfice du rootage serait en partie perdu si par des façons culturales couvrant toute la surface on ne réalisait la croissance la plus rapide. Les entretiens, toujours sur lignes de niveau, peuvent être effectués au polydisque, mais on a intérêt, surtout sur les anciens maquis, à entretenir le sol avec des rasettes légères portées à l'arrière de tracteurs de 45 CV.

Méthode steppique. Après rootage en plein et la pelle toujours du même côté, l'angle-dozer passe deux fois sur une même ligne de niveau pour élever un bourrelet. La manoeuvre peut être effectuée de plusieurs façons mais doit se traduire par un travail continu. La crête de chaque bourrelet, après tassement des terres, s'établit à la dénivelée de 70 cm par rapport aux intervalles. La largeur de chaque intervalle est celle de la pelle, soit 3-3,5 m. La base du bourrelet mesure 2-2,5 m. Après édification des bourrelets, qui sont distants d'axe en axe de 5 à 6 m, on peut avoir avantage à passer de nouveau le rooter dans les intervalles. Pour élever les bourrelets, de 3 à 4 h sont nécessaires par ha. Le rootage définitif demande 1½ h.

Chaque bourrelet peut porter une ligne axiale ou deux lignes latérales de plants. Le collet des arbres doit être placé en sorte que le déchaussement par érosion soit évité.

La méthode permet de nombreuses variantes: soles déversées accumulant l'eau au pied des bourrelets, bourrelets réduits au dégagement des terres herbeuses de surface, très espacés et dont les intervalles sont traités ensuite au rooter et boisés en plein, talus élevés de 1 m et davantage placés en lignes de niveau interrompues ou non, ou bien en chicanes. Enfin, pour le traitement des terres sub-désertiques, on se propose d'élever de forts talus espacés par de larges impluvia et couvrant chacun une bande défoncée de 5 à 10 m de large, suralimentée par les eaux de ruissellement.

La méthode steppique n'en est qu'à des débuts puisqu'on l'a expérimentée pour la première fois il y a six ans. Elle donne des résultats satisfaisants. Sa souplesse est grande. L'espoir est permis, par son emploi, de

peupler d'arbres forestiers des espaces très arides où aucune plantation n'apparait réalisable par d'autres moyens. On envisage même la possibilité, grâce à son application, d'introduire dans les confins sub-désertiques des essences à gousses fourragères, telles que féviers et caroubiers, susceptibles par leurs fruits de bouleverser les principes de l'élevage traditionnel des grands pasteurs.

RESUMES

Progress in Methods of Afforestation and Reforestation in Arid and Semiarid Regions

Modern principles of afforestation and reforestation should be based on knowledge of the climate. An idea of the difficulties to be overcome in arid and semi-arid regions, particularly where the climate is xerotheric, that is to say, characterized by the coincidence of dryness and long days, and the theoretical means of doing so can be gained from studing the ombrothermic curves. In order to extend the growing season, it is essential that the rain that falls at times other than the growing season be retained in the soil, where it will be available to the trees, so that they may have an adequate water supply during the dry period.

Deep plowing is often necessary for this purpose. This makes it easier for the water to sink in and be retained, and for the plants to develop and take root well.

In low-rainfall areas, however, the depth of the plowed strips should be carefully judged because a certain amount of water should be kept in reserve until the end of the summer in layers, located beneath the plowed layer, that are not directly accessible. If the roots have free access to the entire water table, they might completely drain the soil before the end of the dry season.

To have at the same time deep soil that is directly accessible and a hard-to-reach reserve, in low isohyets, that is, in order to activate the vegetation without using up the indispensable reserve, we have found that the plowing should be accompanied by intense profiling or ridging of the soil. This is the principle of the "steppe" method which has been tested in Algeria and Israel during recent years.

To activate the vegetation, it is also necessary to allow the roots to put out abundant aerophilic root-hairs. This means that at the outset reforestation should be considered cultivation of the entire soil surface. This cultivation may be limited to the time when the trees are being set out, but there are more and more experiments in "accelerated silviculture" that tend to make this cultivation permanent.

In the steppe method, superficial aeration is provided both by mechanical maintenance of the area between strips and by the rapid drying off of the ridges.

Lastly, it seems highly advisable to use fertilizers in accelerated silviculture. They should be used in any case to make it easier for the trees to take root.

Once these measures have been applied, afforestation and reforestation become complete agronomic operations that should not be carried out without proper plant material. The plant should derive full benefit from the labor and money invested. Therefore, healthy, well-developed seedlings, likely to take root immediately, should be produced, and care should be taken to avoid any traumatism in transporting them.

The species used should be fast-growing. At present, we are using only xerophilic cypress and pine, cedar, and a few types of eucalyptus that have long since proved their worth. Current experiments, however, cover a number of species, and arboretums have been started in many places.

In practice, terra cotta pots are most frequently used in cultivation, at least in North Africa, but perforated polyethylene bags are being widely tested and seem very promising.

Heavy machinery is coming into general use for working the land so as to ensure thorough and deep breaking-up of the soil where necessary. Up to 200 HP tractors and 3- to 7-ton rooters, with or without levelling blades. In the steppe method, ridges averaging 70 cm. in height are built up by an angle-dozer or bulldozer, according to the profile and the land. Light levelling blades attached [to tractors] may be used for maintenance.

In the more arid but not entirely desert areas, the practice of building ridges can lead to the construction of widely spaced embankments, laid out like the systems of terraces or banks for replenishing the soil. The embankments would be the dividers between the dug-out strips, and hold the run-off water from the intercalary impluvia. In this way, we hope to grow trees on the poorest pasture land and revolutionize there the system of extensive stockraising.

Adelantos en las Prácticas de Forestación y Reforestación en las Zonas Aridas y Semiáridas

La doctrina moderna de forestación y de reforestación se debe fundar en el conocimiento del clima. En las zonas aridas y semiáridas, en particular las de clima xerotérico, carcaterizado por la coincidencia de las sequía y los días largos, el estudio de las curvas ombrotérmicas permite darse una idea de las dificultades y de los medios teóricos de sujetarlas. Para alargar el periodo de vegetación activa lo esencial es conservar en el suelo, a disposición de los árboles, la lluvia caída fuera de la estación de vegetación a fin de que se beneficien de una reserva de humedad suficiente durante el período de sequía.

Al efecto, roturaciones profundas son a menudo necesarias, pues éstas facilitan la infiltración y la retención del agua, el buen rebrote y el desarrollo inicial de los árboles.

La profundidad de las roturaciones, cuando la precipitación es baja, se debe medir porque determinada reserva de agua, en suelos de muy fácil acceso, situados debajo de la capa roturada, debe poderse conservar hasta el fin del estío. Si todo el espesor mojado se deja al libre acceso de las raíces, estas corren el riesgo de agotarlo totalmente antes del fin de la estación seca.

Para disponer a la vez, a base hisohiética, de un suelo profundo plenamente accesible y de una reserva subyacente poco accesible, es decir, para activar la vegetación sin consumir una reserva indispensable de agua, es necesario asociar a la roturación un perfil acentuado del suelo, un caballon. Este es el principio del método "steppique", que se ha venido probando por varios años en Argelia y en Israel.

Para activar la vegetación es igualmente necesario permitir a las raíces el emitir abundantes hebras aerófilas, lo que conduce a considerar inicialmente la reforestación como cultivo de toda la superficie del suelo. Este cultivo se puede tal vez limitar a la fase de instalación de árboles, pero con el nombre de agricultura acelerada, la experiencia adquirida tiende más a hacerla permanente.

En el método "steppique" la aeración de la superficie se asegura con la conservación mecánica de fajas intermedias y el oreo rápido de los caballones.

Parece, en fin, muy indicado emplear fertilizantes en la silvicultura acelerada y, en todos los casos, para facilitar que prendan los árboles.

Después de tomar estas medidas la forestación y la reforestación se convierten en operaciones agronómicas completas que no se deben llebar a cabo sin una cantidad propia de material vegetal. La inversión de trabajo y de dinero que se asigne debe ser plenamente utilizada por la planta, de modo que conviene producir ejemplares perfectamente constituidos, ya bien desarrollados, aptos para prender de inmediato y transportarlos de manera que se evite todo traumatismo.

Las especies utilizadas deben ser de crecimiento rápido. En la actualidad, después de muy largas pruebas, se prefiere la utilización de pinos, de cipreses xerófilos, cedros y varias especies de eucalipto; pero se hacen actualmente experimentos con numerosas especies más y se han establecido viveros en casi todas partes.

En la práctica, en los semilleros, se emplean más comunmente las macetas de barro cocido, por lo menos en el Africa septentrional, pero las bolsitas perforadas de polietileno se usan extensamente en experimentos y, al parecer, son muy prometedores.

En materia de trabajos en el terreno la maquinaria pesada es ya reglamentaria para asegurar, siempre que es necesario, el mullido profundo. Se emplean tractores hasta de 200 CF y desarraigadores de oruga de 3 a 7 toneladas, provistos o no de rejas. En el método "steppique" las caballones, hasta de 70 cm de altura, por término medio, se levantan con robaderas, según sean el perfil y el terreno. En las labores de conservación se pueden emplear rejas ligeras que se transportan.

En las regiones más áridas, pero no enteramente desiertas, el empleo de caballones tal vez evolucione a la construcción de taludes en sistemas espaciados, trazados como las redes de terrazas o de banquetas para la rehabilitación del suelo. Sin embargo, los taludes limitan el uso de las fajas roturadas y retienen las aguas de escurrimiento proveniente de lluvias intercaladas. De este modo se espera criar árboles en líneas distantes de las mas probres tierras de pastoreo y transformar los métodos de arboricutura en gran escala.

SPECIAL PAPERS

Sylviculture dans les terres semi-arides et arides—amélioration des pratiques de reboisement et de boisement

DIREZIONE GENERALE PER L'ECONOMIA
MONTANA E PER LE FORESTE

Italie

Pour parler des implantations forestières dans les zones arides et semi-arides de l'Italie, il y a lieu tout d'abord de qualifier ces zones, d'en établir les indices climatiques, et de rechercher quelles sont les techniques et les espèces forestières ayant une végétation en harmonie avec le rythme du climat.

On pense ainsi aux terrains touchés par le vent de l'Afrique, aux "fiumare" illimitées et pleines de pierres des côtes ionienne et tyrrhénienne, aux dépressions de terrain qui jusqu'à il y a quelques dizaines d'années étaient le siège de palus et de malaria, aux hauts-plateaux calcaires exposés au soleil et calcinés de la longue ondulation des "Murge" des Pouilles, aux puissantes masses—elles aussi calcaires—des Abruzzes tourmentés, et à la succession déprimante de collines et de basses montagnes de la Sicile et de la Lucanie ainsi que d'autres zones des Apennins, presque entièrement privées d'arbres et insidieusement instables en raison du contenu argileux des roches qui les constituent.

Comme on le sait, la caractéristique fondamentale du climat de ces zones est la sécheresse de l'été, qui, dans la classification phytogéographique de Pavari—qui est la classification climatique la plus suivie en Italie par les forestiers—est exprimée par le type à sécheresse estivale tant du *Lauretum* que du *Castanetum* chaud, ayant les limites thermiques suivantes:

1. température moyenne du mois le plus froid: non inférieure à 7° pour la sous-zone chaude du Lauretum, à 5° pour la sous-zone moyenne, à 3° pour la sous-zone froide, et à 0° pour le Castanetum chaud;
2. température minima absolue: respectivement: —4°, —7°, —9° et —12°.

Dès 1939 De Philippis avait proposé de définir *"climats chauds et secs"* ceux qui rentrent thermiquement dans la zone du Lauretum et ont des pluies de printemps et d'été inférieures, respectivement, à 200 et 100 mm., et délimitait la carte du territoire, arrivant à des situations concordant avec la sous-zone chaude de Pavari. Cette sous-zone comprend la moitié environ des deux plus grandes Iles italiennes, la Côte de la Ligurie et toutes les côtes qui se dessinent au sud du parallèle de Rome, gagnant, en altitude, les collines bien exposées, jusqu'à la hauteur de 150-250 mètres. Viennent ensuite les autres sous-zones du Lauretum (jusqu'à 400-700 mètres) et du Castanetum du type chaud (jusqu'à 600-1000 mètres).

Mais dans ces zones le climat ne respecte pas les classifications rigides et, particulièrement en Italie, prend un certain caractère capricieux lié à la mutabilité des vents.

L'aridité du climat ne peut échapper à l'influence adoucissante des précipitations "cachées" et au jeu des édaphismes, qui dans l'ensemble, rendent très ardue la recherche d'arbres pouvant répondre à l'harmonie mentionnée plus haut, entre le rythme du climat et la cadence végétative.

En tous cas, c'est précisément dans ce milieu dénué, sujet à la sécheresse, aux fureurs du vent, et aux longues pauses d'un régime de pluies irrégulier, que le forestier est appelé à apporter l'ombre et la fertilité des nouvelles forêts et l'entrelacement vivant et tenace des racines qui retiennent le sol.

Après avoir fait allusion au milieu physique où sont effectués les reboisements, il y a lieu de donner quelques informations sur le milieu économique pour représenter comme il se doit les réalités actuelles qui circonscrivent et conditionnent l'activité forestière. A cet effet, il faut distinguer l'Italie centro-septentrionale de l'Italie méridionale et insulaire. Les différences de climat, de position par rapport aux grandes lignes du trafic international, d'événements historiques et d'économie, ont déterminé une division véritable de l'Italie en deux parties, l'une (centro-septentrionale) plus industrialisée et ayant un

meilleur équilibre agricole, et l'autre (méridionale-insulaire) plus rurale et ayant un équilibre agricole moins stable. Dans la première, on observe cà et là la descente naturelle des populations de la montagne dans les riches zones de plaine, tandis que dans la seconde ce déflux n'a pas lieu, et la surcharge des villages de montagne, restée inchangée, pose aujourd'hui encore ses problèmes de subsistance avec les maigres ressources de ses territoires moins favorisés par la nature, problèmes qui n'ont pas encore trouvé de solution.

Il s'ensuit que l'oeuvre de reconstitution forestière est recherchée dans les régions du centre et du nord, et suscite au contraire la perplexité des populations montagnardes du sud, dominées par la "faim de terre" et la "faim de pâturage." En tous cas, dans de mêmes régions septentrionales ou méridionales, on trouve des différences en sens contraire, correspondant aux situations locales particulières, dont il ne faut pas manquer de tenir compte lorsqu'on examine, en voie exécutive, la question des reboisements.

Ceci dit, voyons quels sont les types d'implantations forestières réalisées actuellement en Italie:

1. reboisement des dunes, sables mouvants et zones côtières, pour protéger les cultures situées en arrière, et mettre en valeur le sol stérile. Ces travaux, commencés désormais depuis de nombreuses années, ont reçu une grande impulsion après la guerre, et rencontrent l'approbation de toutes les populations locales, lesquelles désirent toujours la valorisation touristique de leurs territoires;

2. constitution de bandes contre le vent dans les terres bonifiées, et dans les entreprises les plus avancées, d'exploitation ancienne ou nouvelle. Dans ce secteur l'eucalyptus et le peuplier ont une grande valeur, respectivement pour le sud et le centre-nord, comme le prouve le réveil spontané de l'initiative privée en leur faveur;

3. transformation du "maquis méditerranéen" au moyen du dessouchage total et de l'implantation d'autres essences, ou de l'élevage des meilleures espèces du maquis (chêne-liège, olivâtre à greffer) et du reboisement des surfaces vides. Des travaux de ce genre ont été effectués en Sicile et, dans une moindre mesure, dans la Maremma toscane;

4. reboisement des éboulis et des bords des rivières en voie d'aménagement hydraulique-forestier. Ces reboisements sont fort recherchés par les propriétaires, qui se trouvent ainsi en possession d'une source de bois à brûler pour les besoins des entreprises agricoles du voisinage;

5. reboisement des hautes pentes des versants endommagés. Et là le problème devient grave, particulièrement en Italie du Sud, où la détérioration est plus aiguë, parce que les nouvelles plantations comportent la réduction du pâturage, fût-ce temporairement. Il faut dire que le reboisement sur de vastes surfaces, comme il serait nécessaire pour un aménagenment valable des hauts bassins versants, ne pourra être effectué tant qu'une réduction raisonnable de la densité humaine ou de l'indice de ruralité ne se sera pas produite; "réduction" seulement, et non abandon total, qui comporterait des dommages aussi graves, bien que de nature différente;

6. reconstitution des bois de châtaigniers économiquement dévalués par la crise du tanin et par la diminution de la consommation de châtaignes. Pour cette reconstitution, des travaux de substitution ou d'enrichissement des châtaigneraies par différentes espèces forestières sont en cours.

A ces types de reboisement, il s'en ajoute d'autres de moindre importance, qui sont liés à la révision des entreprises agricoles.

Mais il est temps de passer à un examen ayant trait plus directement au thème proposé.

La quasi totalité des reboisements étant financés par l'Etat, on a observé après la guerre de profondes transformations dans le secteur de l'organisation, l'Administration ayant créé la concession de *travaux en adjudication.* C'est ainsi que se sont constituées des entreprises spécialisées qui, après quelques années de tâtonnements, se présentent maintenant comme parfaitement aptes à remplir les tâches qu'elles assument.

La création des entreprises forestières a été un motif de progrès, tant en raison de l'augmentation du nombre de techniciens intéressés aux travaux de ce genre (travaux réservés précédemment au petit nombre des fonctionnaires de l'Etat), que de l'amélioration des pratiques de travail, dérivant, en forme implicite, de la dialectique entre l'Administration adjudicatrice et l'entreprise adjudicataire.

Parallèlement à l'institution du système de l'adjudication, a été vivifiée l'institution de la "concession" des travaux aux *Consortiums de bonification de montagne* créés par la loi de la montagne n° 991 du 25 juillet 1952. Ces Consortiums groupent les propriétaires de "Comprensori" de bonification tout entiers, qui correspondent à la partie montagneuse des bassins hydrographiques. Là aussi, d'autres techniciens forestiers entrent en activité, ce qui améliore la situation générale.

Une conséquence directe de la collaboration des entreprises avec l'Administration dans le secteur des travaux forestiers est la *mécanisation:* tracteurs, buldozer, etc., ont été mis au travail partout où la pente ne dépassait pas 30% et où le sous-sol n'était pas très rocheux, ni de roche compacte. Par ces moyens, on a pu procéder à de nombreux travaux spécials, et cela particulièrement dans l'Italie du sud.

Un autre signe important qui annonce de nouvelles tendances dans le secteur des reboisements, est constitué par les interventions de l'industrie de la cellulose pour la formation de forêts de sa propriété. Ces interventions se rapportent surtout à la création de forêts d'eucalyptus en Italie méridionale et dans les Iles, et de forêts de pins strobus, sapins de Douglas, mélèzes du Japon, etc., dans les Bruyères lombardes, ainsi que de peupleraies associées à l'agriculture dans les terrains de la plaine du Pô.

Les préférences quant aux terrains à reboiser ressortent clairement de ce qui est dit auparavant.

Ceci dit, et faisant abstraction de la propriété du Domaine de l'Etat, on observe que la préférence pour les reboisements est donnée aux zones où il n'y a pas de risque évident de préjudice économique pour la population locale.

En conséquence, la première place dans les préférences va au reboisement des dunes, puis à celui des éboulis et des versants instables des torrents; viennent ensuite les

reconstitutions forestières qui ne comportent pas de sacrifices importants pour le pâturage, et enfin, le reboisement des terrains nus et incultes. Pour les zones fortement argileuses, la question se présente de façon différente; les propriétaires voudraient les voir reboiser par l'Etat, mais dans ce cas c'est précisément l'Etat qui, habituellement, refuse, étant donné que l'on ne peut réduire l'argile à accueillir les plantations sans procéder à une transformation structurelle du terrain (qu'il est possible d'obtenir par une longue période de culture agricole), ou sans effectuer des dépenses absolument inacceptables, comme le prouvent les expériences de la bonification de colline des calanques de l'Emilie, de la Toscane et des Marches.

La tendance générale dans le choix des espèces est d'employer des essences qui arrivent rapidement à donner le produit pour lequel elles ont été élevées. C'est le cas des peupliers, des eucalyptus, du sapin de Douglas, du pin strobus, du pin de Monterey, etc.

Dans les régions chaudes, le choix des espèces à planter et à mettre en valeur dans les forêts existantes s'est tourné vers le chêne-liège, l'olivâtre, le caroubier, le pin pignon, qui donnent à la sylviculture méridionale un cachet d'arboriculture.

On a observé en Sardaigne que, alors qu'avant la guerre les reboisements excluaient quasi complètement le chêne-liège, depuis la guerre au contraire cette essence a repris une juste prédominance, avec d'excellents résultats; d'importants travaux de transformations de bois d'olivâtres en bois d'oliviers greffés et cultivés sont en cours également, et des plantations ex-novo de bois d'oliviers sur les pentes calcaires et nues de la région du Latium, sont effectuées par l'Administration forestière.

Dans les endroits plus chauds, on utilise également le caroubier, plante spécifiquement méridionale, d'un grand intérêt pour l'alimentation des cheveaux. La diffusion du pin pignon a fortement augmenté après la guerre, avec l'augmentation des reboisements des côtes et des versants bas.

Depuis le dernier congrès mondial jusqu'à maintenant, a été appliqué, en Italie, le "Libro Nazionale dei Boschi da Seme" (Livre national des forêts à graine) pour les conifères indigènes, c'est-à-dire pour: *Picea excelsa, Abies pectinata, Larix europaea, Pinus sylvestris, Pinus pinaster, Pinus pinea, Pinus nigra*-Villetta Barrea, *Cupressus.*

Les forêts enregistrées sont au nombre de 74 pour une superficie de plus de 14.000 ha. En outre, à l'intérieur de ces forêts, des recherches sont en cours pour la détermination des arbres "plus" pour la formation de souches de race choisie.

Le service de récolte, préparation et conservation de la graine dont a besoin l'Administration forestière, a été confié récemment à l'Azienda di Stato per le Foreste Demaniali qui est propriétaire de la plus grande partie des forêts à graine. Par ailleurs, la récolte n'est pas interdite aux entreprises privées.

L'Administration forestière a quasi terminé la construction d'un séchoir et dépot moderne situé en Italie centrale, pour la préparation des graines de sapin commun et de pin noir.

Les améliorations réalisées dans les pépinières concernent de nouveaux matériels à employer pour l'élevage en vase, comme: "les fitocelle" qui sont de petits sacs de plastique synthétique, aptes à accélérer la végétation et à améliorer la conformation des plantules; les petits vases de tourbe, qui placés à demeure avec les plantules, constituent un matériel de fertilisation des premières années; le mouchoir de plastique ou la toile de jute humectée dont on se sert pour envelopper le "pain de terre" de la plantule pendant le transport; les morceaux de canne (Arundo donax) à utiliser comme petits vases et à placer avec toute la plantule à demeure, etc.

D'autres pratiques, tendant à perfectionner les semailles, les irrigations, le fumage, les transplantations, la culture hydroponique, etc., sont également en cours.

On peut dire qu'au cours de ces dix dernières années, les reboisements des zones arides et semi-arides ont été caractérisés, en Italie, par l'édification de terrasses ("gradoni").

Les terrasses sont nées au début du siècle lors des reboisements des montagnes calcaires des Abruzzes. Le système, qui fut inventé par l'Inspecteur forestier Montanari, a donné d'excellents résultats.

Mais plus tard (1924) en Sardaigne, Allegretti observait que les semailles de chêne ne réussissaient pas lorsqu'elles étaient faites en terrasses ou en trous, en raison de la perte d'humidité du sol, et réussissaient bien, au contraire, sur un terrain ferme. Il mit au point une nouvelle méthode, qui prit son nom, et qui consiste à semer des glands sur un terrain non travaillé, et à couvrir ensuite la semence par un labour superficiel d'une profondeur d'environ 5 cm. Contrairement aux résultats des premières années, les chênes, ayant atteint une hauteur de m. 1,50, n'ont pas continué à grandir, et ont pris un aspect de broussailles. Cela dépend évidemment de l'impossibilité de reboiser avec des essences de chêne des terrains dégradés et par conséquent non fertiles.

Les terrasses sont établies parallèlement aux courbes de niveau et présentent une contrepente vers l'amont: la plantule ou la graine sont placées à la base de l'excavation ou au centre de la surface plane, sauf quand le terrain est "lourd;" dans ce dernier cas, il y a lieu de semer ou de planter sur le remblai.

Ces dernières années, l'opportunité a été confirmée de placer autour de la plantule des pierres grandes et plates, ou, en leur absence, des pierres plus petites ou des mottes herbeuses retournées, qui maintiennent le terrain à quelques degrés au-dessous de la température de l'air, comme l'a démontré récemment, pour le Carso, l'ingénieur forestier yougoslave Jedlowski. Certainement, le placement des pierres sur la terrasse permet d'obtenir les avantages de la méthode Allegretti (dry farming) quant à la conservation de l'humidité du sol, sans perdre l'avantage qui dérive du travail du terrain.

Dans l'affermissement des dunes également, l'Italie a une longue expérience, en raison des réalisations effectuées tant sur le territoire national qu'en Libye. Au cours de ces dernières années, dans les vastes plantations effectuées en Sardaigne, un nouveau matériel a été adopté pour la formation du réseau de claies.

On avait constaté que les treillis de roseaux formaient un système trop rigide, et étaient la cause du regorgement du vent, lequel provoquait le déchaussement desdits treillis et l'accumulation de sable. D'autre part la plantation de rhizomes de Psamma arénaire donnait des groupes de petits roseaux de hauteur trop limitée, qui ne réussissaient pas à contenir rapidement le mouvement des sables.

On recourut alors au *Cistum album,* lié par trois rangs de fil de fer à piquets disposés à 4 m. de distance l'un de l'autre.

Les treillis de *Cistum album,* enfoncés dans le sol sur 20 cm. et sortant sur 60-80 cm. sont semi-élastiques, sont disposés en losanges et rectangles de mesures variant de m. 2,50 x 4, à m. 4 x 20; ils ont bien retenu les sables, permettant l'affirmation des plantules qui y furent placées par la suite, et la germination des pignons. Les plantules (eucalyptus et acacias), presque toutes avec le pain de terre, ont été placées à l'abri des treillis, tandis que les semailles de pignons ont mieux réussi au centre des compartiments, particulièrement si elles étaient répétées deux fois pendant l'hiver, à distance de deux mois.

Sur la Côte Ionienne, on a fait recours au système déjà appliqué, avec de bons résultats, à Chypre et en Israël, c'est-à-dire à la plantation à une profondeur de 50-60 cm. (pour atteindre le sable humide) de plantules d'une hauteur de 60-70 cm., avec le pain de terre. Il s'agit de semis de cyprès "macrocarpa" et de pin d'Alep de deux ans.

Sur la même côte, mais dans des sables protégés par des pineraies environnantes, on a employé le pin d'Alep à racine nue, en groupes de 3 ou 4, avec des résultats magnifiques.

Le progrès de la culture du peuplier se rapporte plutôt au milieu agricole qu'au milieu forestier. Mais, étant donné que ladite culture et les peupliers des champs produiront une augmentation de production de bois qui permettra, sinon de combler, du moins de réduire le déficit dans ce secteur (8 millions de m^3 de bois rond chaque année), le progrès de la culture du peuplier finit par intéresser de très près le milieu forestier.

La culture dont il s'agit se base, non seulement sur le choix rigoreux des "clones" sélectionnés, mais encore sur des pratiques agricoles analogues à celles de la culture des arbres fruitiers, c'est-à-dire le travail du terrain, l'élagage approprié, et les traitements antiparasites.

Les peupliers ainsi traités donnent une production moyenne annuelle de 40-70 kg. de bois par arbre. Diffusés comme ils le sont dans les terres marginales de l'agriculture, ils occupent parfois des terrains agricoles proprement dits, créant ainsi des systèmes alliant la zootechnie à la culture des peupliers.

Après avoir jeté un coup d'oeil d'ensemble sur le milieu physique et économique où prennent corps les reboisements en Italie, après avoir séparé les différents types de plantation, et mentionné certains signes de la transformation des techniques suivies jusqu'à présent, en sorte de déceler les grandes lignes des développements futurs, on peut distinguer dans les reboisements et boisements italiens six tendances:

1. affirmation croissante en Italie centro-septentrionale, et particulièrement dans la Vallée du Pô, de l'arboriculture à bois avec des implantations hors forêt de peuplier, sapin de Douglas, mélèze du Japon, pin *strobus,* chêne rouge d'Amerique, etc.;
2. développement de la culture des oliviers dans les zones nues à culture de céréales qui occupent encore de vastes emplacements des reliefs montueux du Midi de l'Italie et des Iles;
3. diffusion, dans les zones de bonification, presque toutes situées dans le centre-sud, des bandes contre le vent formées d'eucalyptus, de peupliers, de cyprès, etc.
4. reboisement en Italie septentrionale des terrains à pâturage abandonnés, et remise en valeur, au moyen de l'arboriculture à bois associable aux cultures fourragères, des terres agricoles des Préalpes qui étaient laissées incultes;
5. reboisements en Italie méridionale, dans les dunes et éboulis, et dans les terrains où la couverture en arbres est absolument indispensable pour des raisons hydro-géologiques, en attendant d'étendre cette activité quand, une fois améliorées les conditions économiques du pays, une partie des forces de travail locales quitteront la montagne pour se diriger vers d'autres centres d'occupation et de résidence;
6. enrichissement des bois de chataigniers, de chênes et du maquis par des implantations d'autres essences forestières.

RESUMES

Silviculture in the Semi-Arid and Arid Countries—Improvement of the Practices of Reforestation and Afforestation

This is an explanation of the directives followed by the Italian Forest Administration in the improvement and extension of the nation's forests. These directives may be carried out on a larger or a smaller scale, and more or less rapidly and extensively, depending on the evolution of the economic and social factors which influence and determine forestry activities.

Silvicultura en Terrenos Semiáridos y Aridos—Adelantos en las Prácticas de Reforestación y Plantación de Arboles

Se explican las normas que sigue la Administración Forestal de Italia en el mejoramiento y ensanche del patrimonio forestal, normas que se pueden realizar en forma más o menos grande y rápida y en un radio de aplicación más o menos vasto, según la evolución de los factores económicos y sociales que influyen y determinan la actividad forestal.

Rapports entre forêt et pâturage dans la législation forestière italienne

DIREZIONE GENERALE PER L'ECONOMIA MONTANA E PER LE FORESTE

Italie

En Italie, où 35,3% de la superficie territoriale est située en montagne, 41,6% en colline, et 23,1% seulement en plaine, la superficie totale de la forêt et des terrains à pâturage est forcément importante. En conséquence, la valeur des produits que l'on peut tirer, directement ou indirectement, de l'exploitation de ces deux cultures, est considérable, ainsi que l'importance que revêtent la forêt et le pâturage, non seulement du point de vue économique, mais encore du point de vue hydro-géologique, c'est-à-dire de la défense du sol contre l'action érosive, et souvent entraînante, des eaux météoriques.

Sur la base des données les plus récentes de l'Institut Central de Statistique, sur une superficie agraire et forestière totale de 27.806.459 ha. (correspondant à une superficie territoriale de 30.121.780 ha.), les forêts couvrent en effet 5.780.691 ha. (20,8%) tandis que les pâturages et les prés-pâturages (à l'exclusion des prés proprement dits, généralement en rotation et en tous cas situés presque toujours de façon à ne pas entrer en concurrence avec la forêt), couvrent une superficie de 4.232.400 ha. (15,2%).

La superficie forestière est subdivisée ainsi qu'il suit:

Futaies	de conifères .... ha. 1.088.895 de feuillus et mixtes ..... ha. 1.206.540	ha. 2.295.435
Taillis composés		ha. 1.156.891
Taillis simples		ha. 2.328.365
	Total:	ha. 5.780.691

Les futaies représentent, au total, environ 40% de la superficie boisée (19% de futaies résineuses et 21% de futaies feuillues et mixtes), tandis que les taillis sous futaie en recouvrent 20% et les taillis simples les 40% restants.

Dans la Région Alpine prédominent les futaies de conifères et de hêtres, produisant principalement du bois d'oeuvre et de travail. C'est indiscutablement la plus riche région d'Italie dans ce secteur, car dans les Apennins prédomine au contraire la production de bois de taillis.

En général, l'état des forêts italiennes n'est pas bon, en raison, principalement, des utilisations intenses auxquelles elles ont été soumises en tous temps, en mesure variable, et de la pression démographique, toujours trop forte (même si au cours de ces dernières années on a pu enregistrer un exode partiel de la population des montagnes vers des zones économiquement plus développées), de même qu'en raison des périls continuels que constitue le pâturage à l'égard de la forêt.

Presque aussi vieux que l'homme est en effet le différend, pour ne pas dire le conflit, entre la forêt et le pâturage, dans la recherche épuisante d'un juste équilibre entre les deux cultures qui constituent toujours les éléments fondamentaux de l'économie de la montagne et les moyens les plus efficaces pour assurer la défense naturelle du sol en pente.

En effet, si la forêt, en tant qu'élément de défense contre les érosions, est souvent irremplaçable, on ne doit pas sous-évaluer le rôle que peut également jouer dans ce sens la couche herbeuse des pâturages et des prés-pâturages de montagne.

Naturellement, les différents types de végétation présentent une efficacité différente du point de vue hydro-géologique: celle de la forêt est plus grande, celle de la couche herbeuse, moins grande, mais toujours importante. En tout cas, pour l'une comme pour l'autre, l'efficacité est en rapport direct avec le degré d'efficience où elles se trouvent.

En Italie, l'état des pâturages, lui aussi, est plutôt mauvais, tant en raison de la charge excessive de bétail à laquelle les pâturages sont soumis, que des conditions climatiques contraires auxquelles sont soumises particulièrement les hautes pâturages.

Tandis que les prés-pâturages, situés, habituellement, à une moindre altitude, présentent presque toujours une couche herbeuse en bonnes conditions, au moins en ce qui concerne la continuité et la cohésion, dans les pâturages de montagne, qui sont plus élevés, la situation est, de ce point de vue, peu satisfaisante. Cela est dû, outre les causes naturelles auxquelles il a été fait allusion plus haut, à l'action de l'homme qui peut être synthétisée par l'exploitation irrationnelle du pâturage, non seulement par l'excès de charge, mais encore par le fait que les soins de culture sont négligés.

D'où la nécessité, dans l'intérêt général, de mettre fin, partout où ils se produisent, aux phénomènes de dégradation de la forêt et du pâturage, et d'en rétablir l'efficience.

A la base de notre législation forestière se trouve le Décret Royal n° 3267 du 30 décembre 1923, qui contient les normes sur la révision et la réforme de la législation en matière de forêts et de terrains de montagne, et qui peut être considéré comme le texte unique des lois fragmentaires qui étaient en vigueur précédemment, opportunément complétées par les normes réglementaires approuvées par le Décret Royal n° 1126 du 16 mai 1926.

Dans la loi forestière n° 3267, l'art. 1 est fondamental: il soumet en effet au régime forestier les terrains de n'importe quelle nature ou destination susceptibles, contrairement à l'intérêt public, de subir des dépouillements, de perdre leur stabilité et de troubler le régime des eaux.

Il s'agit donc d'une limite posée par le législateur à la jouissance des forêts et des terrains de montagne (surtout des terrains à pâturage), qui sont davantage sujets aux érosions produites par les eaux météoriques sur les terrains en pente; cette limitation est dictée par des raisons d'utilité publique, dans le but de protéger, conserver et étendre, là où cela est possible, la couverture végétale à caractère permanent, non discontinu.

En vertu du régime forestier, il est possible de réprimer tous les délits commis au préjudice du peuplement forestier (coupes abusives, non-respect des rotations minima d'utilisation et des autres normes de sylviculture rationnelle), ou au préjudice de la stabilité du sol (défrichement).

La même loi prévoit également l'aménagement hydraulique-forestier, hydraulique-agraire, et hydraulique des bassins versants, aménagements qui sont effectués à la charge totale de l'Etat et par les soins de ses Organes techniques compétents (Corps Forestier de l'Etat et Génie Civil).

Un tel aménagement comporte l'exécution de travaux de reboisement, de raffermissement, de correction des torrents, de protection des rives, de protection contre la chute des avalanches, de protection des maisons, d'aménagement de la superficie des terrains pour régler l'écoulement des eaux, d'enherbage, ou de constitution de pâturages avec arbres, qui sont estimés utiles à l'aménagement intégral du bassin.

Ces innovations apportées à la législation forestière italienne affirmèrent pour la première fois le principe de la nécessité d'une coexistence pacifique de la forêt, du pâturage et de la culture agraire, comme facteur principal de l'action de sauvegarde de notre montagne.

Pour le reboisement et le raffermissement des terrains placés sous le régime forestier, l'Administration forestière, les provinces et les communes, seules ou réunies en consortium, dans le but de mieux atteindre les buts prévus à l'art. 1 de la loi sus-citée, peuvent donc promouvoir, en dehors des périmètres des bassins versants, les activités y relatives, ainsi que l'amélioration des forêts extremement détériorées et le reboisement des dunes et des sables mouvants.

Parmi les encouragements à caractère facultatif, prévus par la loi forestière en faveur de la sylviculture et de l'agriculture de montagne, on compte, en premier lieu, le concours et l'assistance de l'Etat dans l'exécution des reboisements volontaires, ainsi que de tous les travaux nécessaires à l'amélioration des pâturages de montagne.

Pour l'exécution des reboisements volontaires, l'Etat fournit gratuitement la direction technique, ainsi que des contributions allant jusqu'à deux tiers de la dépense, aux propriétaires des terrains, que ces terrains soient soumis ou non au régime forestier. L'Etat peut également accorder des semences et plantules, dont le coût sera, dans ce cas, deduit du montant de la contribution de l'Etat, laquelle est entièrement versée 5 ans après l'effectuation de l'implantation.

Les propriétaires sont tenus à conserver la nouvelle forêt selon les plans de culture établis par l'Autorité forestière.

En vertu de la Loi n° 991 du 25 juillet 1952, qui comporte des nouvelles dispositions pour les reboisements volontaires, la contribution a été portée à 75% des dépenses.

Les travaux d'amélioration des pâturages de montagne à caractère facultatif, pouvant bénéficier de la contribution de l'Etat, sont les suivants: extirpation des buissons, enlèvement des pierres, asséchement des marécages, irrigation, engrais chimique, semailles de plantes fourragères, construction de locaux pour le personnel, pour la confection et la conservation des produits, de granges à foin, d'étables, de remises; fosses à fumier, abreuvoirs; aménagement de la viabilité, aménagement et raffermissement du terrain, conduites des eaux de pluie et des eaux de source, et en général, tous les travaux visant, avec efficacité, à l'implantation et à l'amélioration de la production, à l'aménagement et l'utilisation rationnels des pâturages de montagne.

Sur la base de la loi n° 991, la mesure de la contribution de l'Etat à l'exécution des travaux sus-dits est fixée à 50% du montant des dépenses.

Toujours en vertu de ladite loi, les travaux d'amélioration des pâturages de montagne à exécuter dans un "comprensorio" de bonification de montagne, quand les pâturages sont d'intérêt commun au "comprensorio" ou à une bonne partie de celui-ci, sont considérés travaux publics de compétence de l'Etat, et peuvent donc faire l'objet d'une contribution de 84 à 92% selon que le "comprensorio" fait partie de certaines régions de l'Italie centro-septentrionale, ou de certaines régions de l'Italie centro méridionale ou des Iles.

En dehors de la gestion rationnelle des forêts et des pâturages qui sont proprieté de l'Etat, laquelle est assurée par l'Azienda di Stato delle Foreste Demaniali qui s'en occupe directement, des aides particulières sont établies par loi pour garantir également la gestion rationnelle des bois et des pâturages appartenant aux Communes et aux Organismes publics.

A cet effet est prévue la constitution d'entreprises spéciales simples ou de consortium, auxquelles est confiée la gestion technique et économique du patrimoine sylvo-pastoral appartenant aux différents organismes, ou aux organismes associés.

Pour le fonctionnement de ces entreprises ou consortiums, l'Etat intervient au moyen d'une contribution allant jusqu'à 75% de la dépense pour les traitements et autres indemnités versés au personnel technique et de surveillance, ainsi que des frais de bureau.

A la base d'une gestion rationnelle des biens sylvo-pastoraux des Communes et autres organismes, la loi forestière place la rédaction d'un plan économique-cultural, ou d'aménagement, approuvé par la Chambre de Commerce, Industrie et Agriculture, et par le Ministère de l'Agriculture et des Forêts, et dont l'application est soumise à la vigilance du Corps Forestier de l'Etat.

Enfin, la loi forestière contient d'autres normes pour réglementer la jouissance des droits spéciaux d'usage (usages civiques) dans les forêts et dans les pâturages, de la part des populations, toujours dans le but de conserver

et d'améliorer, de façon qualitative et quantitative, le patrimoine sylvo-pastoral national, et d'arriver à un équilibre toujours plus parfait entre les deux cultures, dans l'intérêt particulier de l'économie de la montagne.

RESUMES

Relations Between Forest and Pasture in Italian Forestry Legislation

The report emphasizes the relations between forest and pasture land in Italian forestry legislation.

It examines particularly the legislative provisions relating to the improvement and extension of the nation's forests and the improvement of pasture land and the installations thereon.

In Italy, water-and-forest improvement and afforestation and reforestation operations are, as a general rule, entirely at the expense of the State, while the work of land improvement, including the improvement of pasture land, may be performed with the aid of the State (at the rate of 50% of the expense).

The report also emphasizes that the work of reforestation performed outside the scope of public intervention by the State may be subsidized up to 75% of the total expense.

Relación entre el Bosque y el Pastoreo en la Legislación Forestal Italiana

Este informe acentúa las relaciones entre el bosque y el pastoreo en la legislación forestal de Italia.

Se tratan, en particular, las disposiciones relativas al mejoramiento y extensión del patrimonio forestal y el mejoramiento de los pastos y de sus infraestructuras.

En Italia, los trabajos de mejoramiento hidráulica-forestal, de forestación y de reforestación están, por lo general, enteramente a cargo del Estado, en tanto que los de mejoramiento de fincas, inclusive de los pastos, se pueden ejecutar con ayuda del Estado (contribución del 50% del gasto).

Se recalca también en este informe que los trabajos de reforestación que se ejecutan fuera del perímetro de la intervención del Estado pueden obtener una subvención que llega hasta el 75% del gasto total.

Sand Dune Rehabilitation In Western Rajasthan

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India

Introduction

Sand dunes have been a sort of playground of the human race from time immemorial. Sand dunes occur in two distinct habitats, along the coasts of seas and rivers on the one hand, and in the barren, waterless stretches of deserts on the other. It is unfortunate that, owing to their relative inaccessibility, not many studies have been made of the desert sand dunes. This paper mainly deals with the desert dunes, their nature of formation and rehabilitation.

Dune areas once activated tend to increase in size and, if uncontrolled, become destructive to valuable properties. The dunes advance imperceptibly to begin with but ultimately will march on to the forests and even bury them, overriding pastures and extensive areas of fertile land. The menacing nature of the dunes needs no further emphasis. The world-wide awakening to this menace and the recent works on desert afforestation in various parts of the world only show how aware and keen people are to save humanity from the inroads of the deserts. Opinions may differ as to the active spread and rate of marching of the deserts, but it is established beyond all doubt that desert conditions are gradually becoming more prevalent over increasingly large areas, due to biological activities and unscientific use of land resources.

It is also an established fact that the march of the actively menacing sand must be arrested before any betterment of living conditions of the inhabitants of the arid lands is possible. This should be achieved through revegetation before the whole tract becomes a sea of sand.

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Nature and Extent of Sand Dunes

The inland shifting sands are, in general, confined more or less to the hot regions of the world with low rainfall, lying between 20° to 30° North and South latitudes (5)[1]. In West Asia, they extend from India westward from Rajasthan towards the "Thar Desert" of West Pakistan, and then to Arabia, Afghanistan, Iran, Iraq and North Africa. Over and above these, it may be interesting to note that most of the Central Asian countries are to the west and southwest of the Great Indian Desert, which is about 207,025 sq. kilometres in extent. The Great Indian Desert consists of sand hills, sometimes rising 60 to 100 metres from surrounding ground level, which lie in the direction of the prevailing winds. These winds attain very high velocities, and a velocity of 28.7 kilometres per hour has been recorded. The Indian deserts cover an area of over 516,961 sq. kilometres and extend from the Arabian Sea to within a distance of 193.1 kilometres from the Himalayas (6).

Considering the vast quantities of sand that have accumulated on the earth's crust, the question that comes to one's mind is: What is or was the source of this sand? Bagnold (2) is of the opinion that the origin of this sand is the disintegration of quartz-bearing rocks. In most parts of western Rajasthan, where the climate is arid, sand dunes are of very frequent occurrence. It is not uncommon to see, while passing through the area, linear sand hills ranging in height from 60 to 100 metres. They are most prevalent in the districts of Bikaner, Barmer, Churu, Jaisalmer and Jhunjhunu, covering a total area of about 73,984 sq. kilometres, which is about 22 percent

[1] Numbers in parentheses denote the references listed at the end of this paper.

of the total land area of Rajasthan (1). Though most of these dunes are not shifting in nature, yet, due to constant misuse, their crests remain sore spots, especially near habitations, and act as an inexhaustible source of sand supply. Consequently, they contribute to the formation of moving dunes which are most common near villages and habitats where disturbance both by men and cattle is high. These moving dunes are "Barchanoid" in shape. Many stages of barchans, viz, fusing barchans or just high sand hummocks, where the ends of the barchans get blown off due to the combined action of men, cattle and wind, could be seen. Thus, the improper use of these lands has resulted in soil disturbances and blowing and the formation of minor dunes throughout much of the area. There is, however, some doubt whether the major dunes are a direct result of such disturbances or represent a topography established during an earlier period of aridity (4).

Dune Vegetation

Along with the dune-formation process described above, nature is also playing her part in the stabilisation of the moving dunes. Pioneer vegetation, mostly grasses and shrubs, play a great role in the stabilisation process of moving sand dunes by acting as a barrier to the blowing wind, thereby reducing its threshold velocity and consequently its lifting power. Thus, the natural vegetation which comes up acts as "sand catchers" and "sand stabilisers." Studies made by Blatter and Hallberg (3) show that *Calotropis procera, Leptadenia spartium, Crotolaria burhia, Indigofera argentea, Aerua pseudotomentosa, Citrullus colocynthis, Elyonurus hirsutus, Eleusine* sp., and *Panicum turgidum* form the early stage in the colonization of a shifting dune. *Calligonum polygonoides* is another plant with remarkable ability of adaptation to diverse circumstances. It is generally found on the crest of the dunes. At the foot of most of the dunes is usually *Crotolaria. Aerua* extends further up the slope than the *Crotolaria.* Near the crest are a number of grasses, among which *Panicum turgidum* and *Cenchrus ciliaris* are generally seen. *Rhynchosia arenaria* is one of the important legumes which appears in earlier stages of succession and thrives well on shifting sand. This plant is recommended by the Institute for the rehabilitation of shifting dunes.

The commonest sand grasses are several species of *Eragrostis.* Most common among them is *Eragrostis tremula. Eragrostis ciliaris* is also common, usually on moist sand. *Cenchrus catharticus* is another common grass. *Pennisetum prieurii* and *Cenchrus ciliaris* also grow on sand and are common all over the Jaisalmer region.

The following species invade the sheltered dunes: *Calligonum polygonoides, Lycium* species, *Capparis decidua, Sericostoma* species, *Crotolaria burhia, Aerua pseudotomentosa, Tephrosia* species, *Calotropis* species, *Indigofera argentea, Citrullus colocynthis, Cyperus arenarius, Cenchrus catharticus, Panicum turgidum.*

Impact of Sand Dunes on the Socio-Economic Standards of Arid Tracts

The general problem of the sand dune areas in western Rajasthan, with rather a large population incongruous to such a tract, is essentiallv one of human ecology. It is an area which has long been occupied by man. By general arid zone standards, as judged from similar tracts of the world, it has a diverse population density ranging from 6.9 per 2.59 square kilometres (one square mile) in Jaisalmer District to 253.5 in Jhunjhunu District. Its animal population, expressed as cattle units, has an average density of approximately 735 per square kilometre. This density of human and animal population tends to greater intensity of land use with improper control of grazing in some areas, and extensive cultivation on what was formerly reserve or common grazing land. There is much evidence in the region of past misuse of land having a deleterious effect on land and vegetation resources, and it is quite likely that the rate of degradation has been accelerated in the last few decades. This pernicious practice of overgrazing and indiscriminate destruction of vegetation has resulted in the increase of sand dunes, and the trend is that it could still further increase their formation.

That the region as a whole is very sensitive to factors of degradation such as climatic crises or misuse is evident in many ways. The extensive stable sand dune areas which characterise much of the area would indicate a past era of great instability and are probably a product of a more rigorous arid climatic cycle. In course of time, nature had tried to rehabilitate this landscape, but further disturbance and consequent deterioration has caused more retrogression. It is illustrated by the severe sand and dust storms which are prevalent in summer and in the formation of sand hummocks and sand dunes on cultivated land and around villages. The presence of large areas with annual vegetation where perennial species should exist, and the new scars on the old stable sand dunes also indicate this. As mentioned previously, these disturbances are the result of extensive cultivation, misuse of natural vegetation, and excessive grazing and are especially prominent in the vicinity of habitations. Many factors have collectively influenced this age-long operation of degradation of resources, and recently it is further accelerated due to the fact that the erstwhile militant population, who were busy with feudal and interstate wars, have now settled down to peaceful professions, particularly to agriculture and livestock farming, which were further accelerated by the "Grow More Food" campaign.

The impact of these moving sand dunes on the human habitation of these areas is tremendous and alarming. The onslaught of the sand engulfing the agricultural fields has brought an imbalance between the human and animal populations on the one hand, and the plant, water and land resources on the other. As the demand by the former is a perpetual and increasing demand, the resources tend to become depleted, and as depletion proceeds, the stress and strain upon them become even greater. Thus, a process of progressive degradation of resources is set into operation, which is accelerated during famine periods which are frequent, occurring almost every third year. If it continues unchecked, it will lead to permanent damage by the loss of valuable plant species through excessive grazing or cutting for fuel. They will be replaced by barren lands or, at best, bv less useful plant communities. The loss of surface soil by water or wind erosion will be accelerated. resulting in lower soil fertility. Ultimately, it will result also in extensive areas of wasteland or barren sand dunes, which are not only unproductive but may

involve waste of public funds to protect municipal services when they encroach on towns, villages and communication lines.

The cumulative effect of all these processes is to make significant changes in both the hydrology of the region and its micro-climate, ultimately tending towards the creation of a more arid and less productive environment than originally existed in the region. The final outcome, if uncontrolled, must be greater and greater stress on the human population, less return per unit of area and effort, a lower standard of living and, through lower incomes, smaller capital resources to implement remedial efforts where remedy is still possible.

These moving sand dunes have also encouraged nomadism in these areas. These dunes, therefore, must be rehabilitated in order to stabilise the socio-economic structure of the tracts including these nomadic people so as to enable the latter, too, to settle down for a stable subsistence.

Principles of Dune Reclamation

In order to successfully control the sand drift and stabilise sand dunes, it is necessary, primarily, that sand-blowing must be stopped at the source. Sites which are subject to periodic shifting cannot be reclaimed straight away by vegetation alone, because the latter is exposed to the undermining abrasion caused by the moving sand masses. Shifting sands must be stabilised during the period when the strong wind currents blow over them so as to prevent them from being kept in perpetual motion, causing them to engulf any material that may be sown on the site for revegetation. Stabilisation for this purpose is based on the principle of reducing the threshold velocity of the wind at the dune surface by providing obstructions of some kind, such as wooden planks or clumps of shrubs and grasses. A uniform method of reclamation for all sand-drift areas cannot be devised, as conditions vary so widely with different sand drifts, which, in their turn, depend on the degree of aridity, wind velocity, duration of high wind period and availability of material. But in all cases, the procedure is uniform in respect of starting the work, as it should begin, at the source of the sand formation and then proceed along wind direction. Protection of dunes against trespass by men and cattle is very necessary from the very beginning of the operation till the process is satistactorily completed. Continuity of operation in sand-dune fixation work is most important, for premature abandonment or temporary interruption of work will immediately cause the area to revert to its original degraded condition.

Process of Dune Rehabilitation

For the rehabilitation of sand dunes, there are three distinct processes involved, viz: (1) protecting against biotic influences; (2) treating the shifting sand dunes by fixing barriers, starting from the crest down to the heel of the dune; and (3) afforestation of such temporarily fixed sand dunes by (a) direct sowing, and (b) planting.

The area to be sown or planted for fixation of sand should be selected one year in advance and fenced. The best fencing material is 5 strands of barbed wire fixed on angle-iron posts spaced 10′ to 12′ (3 to 4 metres) apart. Fencing can also be done by cut zizyphus thorns, which serve as good fencing material and are locally available and cheap. Repairs by replacement of sections will be necessary in this case in subsequent years because they are easily blown off or get submerged in the sand during the hot summer months. The size of the area should be in keeping with the material and personnel available, so as to ensure intensive works.

The shifting sand must be initially localised before any sowing is done. This is best done by fixing brushwood barriers vertically, starting from the crest down to the heel of a dune. Brushwood is cut and buried vertically, crown downwards, in rows 2 to 5 metres apart. Closer spacing is to be adopted in localities subjected to high wind velocity. *Crotolaria burhia, Leptadenia spartium, Zizyphus* species, *Aerua pseudotomentosa, Calligonum polygonoides, Elyonurus hirsutus* and *Panicum turgidum* have been found economical and useful for erecting such barriers.

The fixing of brushwood should be completed before the monsoon season.

Afforestation

With the scanty rainfall in these areas, it is desirable to grow shrubby, thorny species on these dunes. They will grow well into a thorny jungle, whereby cattle damage will be reduced and the dunes stabilised. In an area with a mean annual rainfall of 30 cms. or more it is possible to raise a plantation of xerophytic species.

Sowings

Direct sowings of grasses and creepers should be carried out between the parallel barriers of brushwood. Sowings should be done in lines 6′ to 15′ (2 to 5 metres) apart. The sowings should be adjacent to the brushwood strip, but not too close to it, as this would cause them to be buried deeply by the sand deposited on the leeward side of the barriers. The spacing of the lines would depend on the availability of seeds and also on the aridity of the locality, closer sowing being resorted to in drier areas.

The following species of grasses and creepers have been found to be promising in sowings:

Grasses—*Elyonurus hirsutus, Panicum turgidum, Cenchrus catharticus,* and *Cenchrus ciliaris.*

Creepers—*Rhynchosia minima* and *Citrullus colocynthis.*

Saccharum munja slips, trimmed and planted during rains, give very good establishment. For the other grasses, it is better to sow them directly. It may be borne in mind, however, that the grasses which are palatable to cattle should not be encouraged, as they would be constantly attracting livestock which are likely to ruin the desired results.

Direct sowings of tree species, though not the surest method, cannot be totally disregarded, as some of the xerophytic species which were sown, germinated and grew well and thus indicated the possibility of growing them by direct seeding.

Sowing should be carried out in lines between the two grass rows. Intimate mixture of various tree species in the same line is not very desirable, since, besides giving a patchy appearance, it will create local competition and

casualties. Different species, therefore, should be sown in separate lines.

Seeds should be sown just before the onset of the monsoon. A second sowing may sometimes be necessary due to a delayed monsoon. Seeds should be mixed with clay containing sodium arsenite, so as to protect the seeds from rat damage. Sowing pretreated and pregerminated seeds during the monsoon, when there is a proper shower of more than 25 mm., will also give good results, provided this is done early in the season.

The species which have succeeded with direct sowings at different places are:

1. Rainfall—40 cms. and above.
   Trees—*Prosopis spicigera*, *Prosopis juliflora*, *Acacia arabica*, *Zizyphus jujuba*, *Acacia senegal* and *Tecoma undulata*.
   Shrubs—*Calligonum polygonoides*, *Cassia auriculata*, *Zizyphus rotundifolia* and *Ricinus communis*.
2. Rainfall—28 cms. to 34 cms.
   Trees—*Acacia senegal*, *Prosopis spicigera*, *Prosopis juliflora*, *Tecoma undulata* and *Zizyphus jujuba*.
   Shrubs—*Ricinus communis* and *Calligonum polygonoides*.
3. Rainfall—15 cms.
   Trees—*Prosopis juliflora*.
   Shrubs—*Calligonum polygonoides* and *Zizyphus* species.

Planting

Better success in sand dunes is achieved through planting well-developed seedlings. Planting should be deep enough so as to lodge the root system in the moist sand pocket which is generally found at 50 to 60 cms. depth. Spacing between plants may vary from 15′ x 15′ to 20′ x 20′ (5 x 5 to 7 x 7 metres).

The following methods of planting with respect to different species have yielded successful results:

Branch cuttings. Direct planting with branch cuttings of *Tamarix articulata*, and *Calligonum polygonoides* is successful, provided it is done with rains or soon after showers. Cuttings of *Tamarix articulata* pre-sprouted in nurseries, when planted out on shifting sands give excellent results.

Stumps. Stumps are prepared from one-year nursery-grown seedlings and planted in tubes and pots in March to sprout. These pre-sprouted stumps are transplanted with the ball of earth at the onset of the monsoon. Pre-sprouted stumps of *Prosopis juliflora*, *Albizia lebbek*, and *Dalbergia sisoo* have succeeded well.

Potted plants. Potted plants of any species and with a ball of earth can ordinarily be planted out. Generally, in potted plants the roots get coiled up, and it is important that the root coils are straightened, if possible, or cut off before planting, for greater survival and better growth. Seedlings with coiled-up roots either fail to establish or, if they do, fail to grow to a proper size. The species tried with success are: *Prosopis juliflora*, *Prosopis spicigera*, *Tecoma undulata*, *Cordia rothii*, *Cordia myxa*, *Eucalyptus rostrata*, *Zizyphus jujuba*, *Azadirachta indica* and *Ailanthus excelsa*.

Planting bricks. Tree species raised in "planting bricks" have proved very successful. These bricks are prepared with the help of a wooden or steel mould, 30 cms. high, 10 cms. and 15 cms. square at top and bottom, respectively. Bricks are made out of a mixture of equal proportions of clay, sand and manure, prepared with the requisite amount of water and moulded and sun-dried, with a cavity at the top, 2.5 cms. in diameter and 15 cms. deep, to take the seed or seedling. These are embedded in sunken nursery beds, and seedlings or cuttings are raised in them. During the planting season the bricks are taken out of the beds, carried to the planting site and planted deep with the brick intact. The success of "planting bricks" depends on the fact that roots are least disturbed during carriage and transplanting. Unless the sand blows away completely around the plants, the roots do not get exposed to hot winds. Besides this, the bricks provide nutrition to the plant in the initial stages and also absorb and retain moisture longer. Species thus raised successfully are: *Prosopis juliflora*, *Prosopis spicigera*, *Acacia senegal*, *Azadirachta indica*, *Dalbergia sisoo* and *Zizyphus jujuba*.

The success of sand dune afforestation depends on choosing the right species, planting sturdy stock, planting in time, planting deep, and timely replacement of casualties in the year following planting.

Future Management Suggested and Prescribed

The most important task in sand dune rehabilitation work is the later management of the rehabilitated dunes, and it may not be out of place to mention here that the success of the work lies in the subsequent management of these dune areas. Consideration must be given to long-term or permanent closure of such areas, particularly near towns, and the objective should be to eliminate grazing completely. This might be achieved if the areas are covered with *Saccharum munja* by planting it at close spacings, as this grass is not palatable to stock but is of high economic value for thatching, cottage industry, etc. Simultaneously, such areas should be covered by thorny tree and shrub species which will not only provide small timber and firewood but also leaf fodder for the local cattle. Such rehabilitated dunes come within the sound principle of soil conservation and can best be managed as fodder and fuel reserves.

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RESUMES

La remise en valeur des dunes de sable en Rajasthan occidental

Les dunes de sable à l'intérieur du pays sont un phénomène courant en Rajasthan occidental. Ces dunes recouvrent une superficie d'environ 73.984 km², soit près de 22,1% de l'ensemble du territoire de Rajasthan.

La façon d'utiliser la terre autrefois a abouti à des perturbations du sol, l'érosion éolienne et la formation de petites dunes de sable dans la plus grande partie de la région. Il subsiste toutefois un certain doute quant à la question de savoir si les dunes importantes sont le résultat direct de ces circonstances, si elles représentent une topographie créée au cours d'une période d'aridité antérieure, ou enfin si elles ne sont que d'épaisses croutes par-dessus des collines rocheuses.

La nature joue un rôle primordial en revêtant ces régions de végétation. Les graminées communes sont les *Panicum turgidum, Elyonorus hirsutus* et *Eragrostis tremula,* alors que les *Calligonum polygonoides, Indigofera argentea, Aerua pseudotomentosa, Rhynchosia* spp., *Citrullus colocynthis, Tephrosia* spp. sont les arbustes les plus courants.

L'effet de ces dunes de sable mouvantes sur la population de ces régions est considérable. L'invasion du sable submergeant les champs cultivés a provoqué un déséquilibre entre la population et la faune d'une part et les ressources en eau et en terre d'autre part. Ceci apporte des changements tant dans l'hydrologie de la région que dans son micro-climat, tend à rendre la région plus aride et moins productive que par le passé, et crée en conséquence de nouveaux déserts.

La technique de la remise en valeur des dunes de sable comporte trois processus distincts: 1) protection contre les influences biotiques; 2) traitement des dunes mouvantes au moyen de barrières de fixation plantées de la crête jusqu'au pied de la dune; 3) mise en place de végétation sur les dunes provisoirement arrêtées au moyen de semailles et de plantations directes d'herbes et d'arbres. La zone en cause est choisie un an à l'avance et clôturée. Des coupes de broussailles indigènes telles que les *Crotolaria burhia, Calligonum polygonoides, Leptadenia spartium* et *Zizyphus* species, et des coupes d'herbes telles que l'*Elyonurus hirsutus* sont fixées verticalement en enterrant la cime avec un espacement de 2 à 5 mètres et en commençant à la crête de la dune pour descendre jusqu'à son pied.

Les semailles directes de graminées et d'arbres se font juste avant le début de la mousson, en lignes alternées entre les rangées de broussailles et à intervalles appropriés pour assurer une bonne couverture. Les espèces qui ont été jugées les mieux adaptées à ce genre d'opérations sont, dans l'ordre de succession, *Elyonorus hirsutus, Saccharum munja, Panicum turgidum, Panicum antidotale* et *Cenchrus ciliaris,* pour les graminées; *Rhynchosia minima,* et *Citrullus colocynthis* pour les herbacées. Les essences forestières retenues pour les semailles directes sont *Prosopis juliflora, Prosopis spicigera, Acacia arabica, Tecoma undulata,* et *Acacia senegal.* Parmi les espèces d'arbustes, *Ricinus communis, Calligonum polygonoides* et *Zizyphus* spp. ont donné de bons résultats.

Le succès des plantations dépend 1) du choix des espèces ou essences, 2) de la robustesse des plants, 3) du moment opportun choisi pour la plantation, 4) de la plantation en profondeur. Des boutures de branches de *Tamarix articulata* et de *Calligonum polygonoides,* des souches pré-germées de *Prosopis juliflora* et *Dalbergia sissoo* et des plants en pot de *Prosopis juliflora, Prosopis spicigera, Tecoma undulata, Albizia lebbek, Eucalyptus rostrata* et *Dalbergia sissoo* qui ont fait leurs preuves sont plantés dans des fosses espacées de 5 m. sur 5 m.

La plantation "en briques" s'est révélée la meilleure dans les dunes de sable. Des briques composées, à parties égales, d'argile, de sable et de fumier, sont pressées dans des moules de bois et séchées au soleil. Des plantes sont cultivées dans ces briques, soit par semaille soit par plant de bouture. Les plants sont alors transportés sur le site à remettre en valeur et plantés avec leurs briques en profondeur, au début de la mousson. *Prosopis juliflora, Azadirachta indica, Dalbergia sissoo, Zizyphus jujuba, Albizia lebbek* et *Tamarix articulata* ont tous donné de bons résultats.

Le reboisement de ces dunes entraîne un clôturage à long terme ou même permanent de ces régions de manière à éviter complètement que le bétail n'y paisse. Ces dunes remises en valeur conviennent particulièrement à la production de combustible ou de fourrage de fauche, ce qui non seulement répondra aux besoins de la population, mais encore sera conforme aux principes acceptés de la Conservation du Sol.

Rehabilitación de las Dunas del Oeste de Rajasthan

En el oeste de Rajasthan abundan mucho las dunas, las cuales ocupan una superficie de 73.984 kilómetros cuadrados, o sea, un 22,1 por ciento del área total de la región.

El sistema seguido en el uso de la tierra en tiempos pasados ha causado perturbaciones del suelo, que ha sido removido por el viento y ha formado dunas en toda esta región. Sin embargo, hay dudas sobre si las dunas más grandes son un resultado directo de todo esto, o si representan un accidente topográfico creado durante un período anterior de aridez o si son simplemente costras gruesas sobre altillos rocosos.

La naturaleza desempeña un papel de importancia al cubrir estas dunas de vegetación. Las gramíneas más comunes son *Panicum turgidum, Elyonurus hirsutus, Eragrostis tremula,* y la mayoría de los arbustos son *Calligonum polygonoides, Indigofera argentea, Aerua pseudotomentosa, Rhynchosia* spp., *Citrullus colocynthis,* y *Tephrosia* spp.

El efecto del movimiento de estas dunas en la vida de los seres humanos es tremendo. La arena que invade los campos de cultivo ha causado un desnivel entre la población humana y animal de una parte y entre los recursos vegetales, hidrológicos y del suelo de la otra. Esto trae cambios, tanto en la hidrología como en el microclima de la región, que tienden a la creación de un ambiente más árido y menos productivo que el que originalmente tenía el lugar y, en consecuencia a la formación de nuevas áreas desérticas.

El método para la rehabilitación de las dunas incluye tres procedimientos distintos: (i) protección contra las influencias bióticas, (ii) la contención de las arenas movedizas mediante la erección de barreras que se extiendan desde el tope hasta la base de la duna, y (iii) la repoblación de las dunas que se encuentren temporalmente fijas, con el cultivo y plantación de árboles y gramíneas. El área que va a ser rehabilitada se escoge con un año de anticipación y se cerca. Después se cortan los matorrales del alrededor, como de *Crotolaria burhia, Calligonum polgonoides, Leptadenia spartium,* y de la especie *Zizyphus* y gramíneas como *Elyonurus hirsutus* enterrando la parte de la copa de 2 a 5 metros de distancia unas de otras, comenzando por el tope y acabando en la base.

La siembra directa de árboles y gramíneas se hace antes del comienzo de los monzones y es por hileras alternas entre las líneas de matorrales, a intervalos adecuados para que éstas sirvan de resguardo. Las especies de gramíneas que han demostrado adaptarse mejor en las primeras etapas de la sucesión introducida son *Elyonurus hirsutus, Saccharum munja, Panicum turgidum, Panicum antidotale,* y *Cenchrus ciliaris.* Entre las fanerógamas más adaptables figuran la *Rhynchosia minima* y *Citrullus colocynthis.* Las especies de árboles para semilla preferibles son *Prosopis juliflora, Prosopis spicigera, Acacia arabica, Tecoma undulata,* y *Acacia senegal.* Entre los arbustos, han dado buenos resultados *Ricinus communis, Calligonum polygonoides,* y *Zizyphus* spp.

El éxito de la siembra depende (i) de la selección de especies, (ii) resistencia de las plantas, (iii) la siembra en la época adecuada, y (iv) la profundidad a que se siembre. Los plantones de *Tamarix articulata* y *Calligonum polygonoides,* los tallos retoñados de *Prosopis juliflora* y *Dalbergia sissoo* y las plantas en tiestos de *Prosopis juliflora, Prosopis spicigera, Tecoma undulata, Albizia lebbek, Eucalyptus rostrata,* y *Dalbergia sissoo,* que han dado resultados, se plantan en fosas espaciadas de 5 por 5 metros.

La colocación de plantas en ladrillos en las dunas ha tenido el mejor éxito. Los ladrillos, secados al sol, se hacen de iguales proporciones de barro, arena y estiércol, en moldes de madera. Las plantas crecen en ellos, de semilla o plantón y después se llevan al lugar donde han de plantarse a cierta profundidad, juntas con los ladrillos al principio de los monzones. *Prosopis juliflora, Azadirachta indica, Dalbergia sissoo, Zizyphus jujuba, Albizia lebbek* y *Tamarix articulata* han dado buenos resultados en este caso.

La reforestación de estas dunas exige que se mantengan

cerradas estas áreas durante mucho tiempo para impedir que el ganado paste en ellas. Una vez rehabilitadas, para lo que sirven mejor es de suministro de combustible y reserva de forrajes con los cuales no sólo se satisfacen las demandas de la población de la comunidad, sino que también se mantienen los sólidos principios de conservación de suelos.

The Introduction of Forestry and Range Management To the Nomadic Stock-Rearing Community In Semi-Arid Somaliland

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The Country

In Somaliland Protectorate, where forestry and grazing management must be closely linked, the emphasis is on the maximum sustained yield of grazing and browse rather than on production of timber. With a population of 700,000, the country has an area of 68,000 square miles. Stock is also grazed over the Ethiopian frontier, so that the area over which the people live and move is nearer 90,000 square miles. There are 10 million sheep and goats, 1.2 million camels, and 500,000 cattle.

A range of mountains rising to 7,000 feet divides the country. North of this range is the coastal strip called Guban, meaning burnt, where rainfall fails completely some years; but good tree and shrub growth is found in wadis and on flood plains. On the mountains the annual rainfall rises to 25 inches. South of the mountains, on the vast upland plateau, the Ogo, rainfall varies from 6 to 18 inches.

There are four main vegetational regions:

1. The Guban carries vegetation of small trees and shrubs providing valuable browse. Near the sea are widely spaced *Acacia* and other shrubs. Along wadis and on flood plains there is denser growth including larger *Acacia, Balanites, Zizyphus* and fringing forest of *Conocarpus lancifolius,* with areas of *Indigofera, Aristida,* and *Panicum. Suaeda fruticosa* and other saltbushes form valuable salt grazing.
2. The low-rainfall plains towards the east of the plateau support a vegetation of low grasses (*Sporobolus* spp, *Dactylotenium scindicum,* and *Chrysopogon aucheri*) and shrubs (*Suaeda fruticosa* often predominating).
3. The Haud, or southern part of the plateau, contains many species of *Acacia* and *Commiphora* with *Indigofera ruspoli* and other shrubs, and *Aristida* spp, *Chrysopogon aucheri, Andropogon crytocladus,* and *Cenchrus ciliaris* as dominant grasses.
4. *Buxus hildebrandtii* and *Juniperus procera* forests occur in the mountains. The remainder of the country is *Acacia* open woodland with *Acacia bussei* dominant below and *Acacia etbaica* dominant above 13 inches rainfall, *Acacia tortilis* subsp. *spirocarpa* being dominant throughout. *Acacia etbaica* indicates the possibility of dryland farming of sorghum, provided there is good deep soil. Dominant grasses are *Sporobolus* spp. and *Dactylotenuim scindicum,* and, on open plains, *Chrysopogon aucheri.*

Nomadism

The livestock industry provides the only means of using the vast tracts of sparse vegetation. The goat, far from being an enemy, is a means of producing what wealth there is. The industry needs proper management to ensure its permanent maintenance and to improve the resources.

The people move with their flocks to keep them alive and to make best use of the grazing. Tribal movements vary considerably from year to year, depending upon the season and range condition and the friendliness or otherwise of neighbouring tribes. The main belt of wells lies some miles south of and parallel to the mountain range. Other permanent wells are on the Guban.

From the central wells, tribes move south into the Haud in spring, and stay until forced by water shortage to move north again. At the same time the tribes overwintering in the Guban move up to the plateau. In the autumn these moves are reversed so that the central well belt is continuously grazed. Within this general pattern are minor movements such as those to salt grazing or licks.

Present Conditions

A few generations ago tribal areas were maintained in a rough-and-ready way by inter-tribal warfare. With a reduction in fighting and an increase in health and numbers of the livestock and human populations, the pressure on the natural resources has become so great that they are no longer holding their own. All Somali have the right to graze their stock anywhere, though rough tribal areas with huge overlaps can be distinguished. There is no individual or tribal responsibility.

This has led to progressive deterioration of the vegetation and heavy loss of soil. Deterioration is evidenced by a thinning of the vegetation and an increase in the propor-

tion of unpalatable or harmful species. Sheet erosion is common. Areas of previously good grazing have become stretches of loose pebbles and bare ground. Gully erosion is frequent. Where the undergrowth has been even only partially destroyed, conditions are too dry and hot for the regeneration of *Juniperus procera,* and *Acacia bussei,* with its widespreading roots just below ground surface, is killed by insolation. Much water is lost as run-off.

Most destruction has taken place along the central belt of wells. Near permanent water points the terrain is often completely denuded. The Haud is still in good condition, owing to seasonal water pools only being available for a few months each year. The vegetation is so thin that fire is not a major hazard.

Four remedial measures have been tried by the graziers:

1. The construction of open pools for the collection and short-term storage of surface run-off,
2. the construction of sunken concrete tanks with brushwood roofs, each storing up to 100,000 gallons,
3. private appropriation of land by fencing against stock, and
4. carriage of water by motor transport.

Artificially dug pools may be any size, from shallow depressions holding a few thousand gallons to the large reservoirs dug by the government along the southern frontier, holding up to 14 million gallons each, of which 18 have so far been dug. Small shallow pools serve a useful purpose in enabling grazing to be used which would otherwise be inaccessible to the herds. The larger pools have distinct dangers to the vegetation if used without control, as deterioration may spread. These pools retain water for over three months after rain. Uncontrolled increase in watering facilities could, in enabling fuller use to be made of the range, also result in an increase in the number of livestock. Excessive grazing of the catchment areas of the pools also results in the destruction of the pools themselves through silting, or in excessive maintenance costs. Animals are at present allowed into the pools.

A recent development has been the construction of sunken concrete tanks. Very often these make use of a road as a catchment. In some places about twenty of these tanks are situated in a square mile, and villages are being built up around them. They serve a much larger grazing and browsing area. Water is stored until the need is great and then sold. Water from these tanks and pools has been known to fetch twenty-five shillings for a forty-gallon drum. Owners can usually obtain their capital back in two seasons. Tanks have a small capacity compared with pools, but their advantages are that water can be stored until it is most needed, and by controlled distribution of tanks better use of the range can be effected. At present, control is in the form of a 300-shilling permit fee before construction is allowed, but this has not been effective, and much unplanned and unwise development has resulted. In 5 years, probably 1,500 such tanks have been made.

One of the most controversial questions in the country concerns the private appropriation of land by individuals. This growing practice raises a great deal of opposition from graziers, who maintain that they have no objection to enclosures for growing food. Stock routes and access to watering places must remain open. Graziers do not yet look upon grass as a crop, and they vigorously oppose the use of enclosed land for private grazing. Most do not yet admit that it is the individual's way of rectifying the lack of public responsibility for grazing lands, a responsibility which, until very recently, has been completely neglected.

Recently, it has become common to carry water to grazing areas by mechanical transport. This is expensive, but haulage for 50 miles or more seems to be profitable, with water sold at 20 shillings for 40 gallons towards the end of the dry season.

Artificial pools, concrete tanks and haulage of water enable herds to be kept in remote areas of the Haud for longer periods. Some herds have over-wintered for two seasons or more, and a growing number of people are staying longer in the south. This is not an attempt at planned utilisation, but rather an attempt to make the same kind of destructive use of remote grazing areas as formerly on accessible areas near wells. Without some form of regulation the result is likely to be the same kind of degradation.

Lines of Approach

Technically, it is known what is required, though research into such matters as carrying capacities and production potentials would be useful. Social problems are more urgent, yet more difficult to solve. It is, however, difficult to separate these problems, as the technical approach is often determined by what is possible socially.

The simplest beginning is an elementary system of deferred grazing. Several attempts have been made with mixed results. Any control has appeared to the grazier as a government scheme and therefore suspect from the start. In 1951, grants of £25,000 a year were approved for grazing control. Grazing guards were to be assisted by tribal police to prevent access by stock for the growing season over closures covering nearly 10,000 square miles. The scheme was too grandiose and had to be abandoned because of Somali opposition. In retrospect, it is easy to see where the main fault lay. The graziers were not trusted enough to be expected to accept such a scheme. It all appeared as something imposed from above. The graziers had deep suspicions that all was not being done for their benefit.

A more sound approach is to carry out quiet but steady propaganda until the point is reached that the graziers demand that something be done. There must be no suggestion that compulsion would be used to bring about a scheme, though compulsion would, of course, be needed to prevent grazing once a scheme is accepted. At last a time comes, if the need is real, when the government is pressed into action. This is what happened at Arori in 1956 when 800 square miles were closed for seven months. Unfortunately, there was no follow-up in the following years on the same area.

A less spectacular but equally valuable form of development is to set up permanently controlled grazing reserves analogous to forest reserves. Grazing is on a rotational basis as laid down in a working plan.

Suitable areas within seasonal or permanent reserves should be used as experimental stations to determine

carrying capacities and to work out improved techniques of management.

Artificial pools or reservoirs should be as deep as possible to reduce the effect of evaporation. Animals should not be allowed into the pools, but devices for drawing water should be fitted. This would keep the water clean and reduce damage to the banks, and has been found practicable in Sudan.

Sunken concrete tanks should be encouraged, but their siting should be strictly controlled. As does happen, they should not be constructed within the catchment area of a newly dug pool. If the permit system were made effective these tanks could form a useful aid in better use of grazing resources, and by regulating their density, no more water need be provided than enough for the number of animals the range is capable of carrying.

It is proposed to encourage further development along the southern frontier to continue by private enterprise under government control. About 20 miles north of the frontier a line of pools will be made, each holding at least 8 million gallons and situated 20 miles apart. A similar line will be placed yet another 20 miles north. Beyond this is the belt of wells.

With the onset of the rains, animals will move south over the frontier to the distant Haud as before. They will then fall back northwards in stages to finish at the permanent wells a few weeks before the next rains are expected.

When some such system becomes effective and is combined with intensive marketing developments, it will be time to consider the optimum number of animals to be held in the country. Any discussion of a destocking programme now would lead to great opposition and halt all progress. But water developments should not increase the number of stock. The aim in the next few years should be so to improve conditions that the present stock population can be maintained. Later consideration can be given to raising or lowering the numbers of any class of livestock.

RESUMES

Introduction de la sylviculture et de l'aménagement des terrains de parcours chez les populations de pasteurs nomades des terres semi-arides de la Somalie

La Somalie britannique est un pays semi-aride qui se compose d'une bande côtière, d'une chaîne de montagnes s'élevant à plus de 2.000 m. et d'un haut plateau. La pluviosité varie en moyenne entre 50 et 75 mm par an sur la côte, à 625 mm sur les montagnes, et 120 à 360 mm sur le plateau.

La production de bois, même là où elle possible, cède la priorité au rendement des terres de pâturage et de brout. On évalue la population animale à 10 millions de d'ovins et de caprins, 1.200.000 chameaux et 500.000 bovins. Ces animaux paissent sur une superficie de 90.000 milles carrés, y compris 22.000 milles carrés au-delà de la frontière éthiopienne.

L'auteur décrit quatre types principaux de végétation, et décrit brièvement le déroulement des mouvements saisonniers de la population nomade. Comme il n'existe aucune responsabilité particulière ou collective en ce qui concerne les terres, la destruction de la végétation et les pertes de sols sont considérables et étendues.

Des mesures correctives sont à l'essai: bassins creusés pour recueillir le ruissellement de surface, réservoirs de béton encaissés servant au même usage mais permettant une accumulation de plus longue durée, attribution de terres à des particuliers, et transport de l'eau par automobiles. L'auteur souligne la nécessité d'exercer un contrôle sur l'exécution de ces mesures.

Au commencement, on prévoit un ajournement extensif du pâturage saisonnier, que l'on combine avec une série de petites réserves de forêts de parcours. On pourra progressivement introduire des méthodes d'aménagement plus avancées. L'utilisation de bassins saisonniers et de réservoirs de béton encaissés doit être contrôlé et s'intégrer comme il convient dans les déplacements saisonniers du bétail et en fonction de la capacité des pâturages. L'auteur esquisse les grandes lignes d'un système d'échelonnement saisonnier des points d'eau envisagé.

Introducción de la Administración de Selvas y Pastos en la Comunidad Ganadera Nómada de la Semiárida Somalia

El terreno del Protectorado de Somalia es semiárido y consiste en una faja costanera, una cadena de montañas que se eleva a 2,130 metros y una alta meseta. El índice pluvionístico varía en el país: un promedio de 2 a 3 pulgadas al año en la costa, 6 a 18 pulgadas en distintas partes de la meseta y un máximo de 25 pulgadas en las montañas.

La producción de madera, cuando es posible, ocupa el segundo lugar después de la constante de pasto y plantas forrajeras. Se calcula que hay 10,000,000 de ovejas y cabros, 1,200,000 camellos y 500,000 cabezas de ganado, que pastan en una superficie de 233,000 kilómetros cuadrados, entre los cuales figuran 57,000 de la frontera con Etiopía.

En el estudio se mencionan cuatro clases principales de vegetación y se describe brevemente el nomadismo de personas y animales durante las estaciones del año. Como no hay responsabilidad individual ni colectiva por el uso de la tierra, ha habido gran destrucción de la vegetación y de la capa vegetal.

Entre las medidas correctivas que emplean los ganaderos figuran la excavación de pozas para recoger el agua de la superficie, tanques hundidos de hormigón con el mismo objeto pero para conservar el agua más tiempo, la apropiación de tierras por particulares y el acarreo de agua en vehículos motorizados. En el estudio se recalca la necesidad de regular estas medidas.

Como principio, un sistema extensivo de pastoreo deferido por estaciones se está preparando combinado con el uso de varias pequeñas reservas forestales permanentes para ese objecto. Será posible implantar medidas progresivas más avanzadas de administración forestal. El uso de albercas y de depósitos hundidos de hormigón durante las estaciones de sequía debe regularse e integrarse de acuerdo con los traslados del ganado y con la capacidad de los pastizales. El estudio menciona también, a grandes rasgos, un propuesto sistema de aguaderos pará usar en forma escalonada durante las estaciones.

Irrigated Forest Plantations of West Pakistan

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Introduction

West Pakistan, lying diagonally from northeast to southwest between 24° to 37° N. and 61° to 67° E., has a total area of about 198,500,000 acres. Being situated in the region of subtropical anticyclones, subject to descending air currents and receiving less than 15″ of annual precipitation and with summer temperatures rising to 120° F. over most of the Indus basin, it is largely an arid to semi-arid region. The gross area of the Indus basin in West Pakistan is about 131,000,000 acres, and of this, about 57,000,000 acres is regarded as cultivable (Mahbub, 1960). According to the 1951 census, the population of West Pakistan was about 34,000,000, and at the yearly rate of increase of 1.6 per cent, it is expected to rise to about 40,000,000 by 1961.

About 23,000,000 acres are being irrigated at present by gravity flow irrigation from the canals in the Indus basin lying in West Pakistan. Some of the new irrigation projects which are now under construction will bring about another 10,000,000 acres under canal irrigation within the next 10 years or so. Ecologically, most of the 33,000,000 acres of this canal-irrigated area formed an important portion of the tropical thorn forest of West Pakistan. Earlier, this vast territory was largely used as grazing grounds by the local nomadic population and also yielded fuelwood at the rate of about 10 cu. ft. per acre per annum (Khan, 1955). However, in order to provide the food and other requirements of a steadily growing population, the scrub forests of West Pakistan have been cleared and converted into cultivated lands by irrigation from a number of irrigation projects. The first canal-irrigation project was the Upper Bari Doab Canal which was completed in 1860. In view of our rather meagre resources of fossilized fuels such as coal, mineral oil and natural gas, and because of the rapidly growing population and gradual shrinking of the area under the tropical thorn forest, the government wisely decided to start some irrigated forest plantations in the Indus basin to augment the dwindling essential fuelwood and small timber supplies of the country. The first fuelwood plantation, the well-known Changa Manga Irrigated Plantation, was started in 1866 on the Upper Bari Doab Canal. Since then, as the new irrigation projects come into existence, the government has, from time to time, set aside sizeable areas in the canal-irrigated tract for irrigated fuelwood plantations. But for these fuelwood plantations, West Pakistan would have suffered from fuelwood famines a long time ago.

The table given as Appendix I gives details of planted and unplanted areas, etc., of the various irrigated forest plantations which are being managed or which are proposed to be started by the West Pakistan Forest Department under the Second Five-year Plan in the near future. The gross area of various canal-irrigated forest plantations which have already been started or which are proposed to be started in the near future in West Pakistan is 538,848 acres. Up to date, about 116,880 acres have been stocked, chiefly with shisham (*Dalbergia sissoo* Roxb.), and at present they are yielding about 16,000,000 cu. ft. of fuelwood annually.

Management of Irrigated Forest Plantations

The virgin land is first cleared by removing the open-clump type of scrub vegetation, consisting mostly of *Prosopis spicigera* Linn., *Salvadora oleoides* Dcne., *Tamarix articulata* Vahl., *Acacia jacquemontii* Benth., and *Capparis aphylea* Roth. woody species. It is then levelled either by leasing it out on temporary cultivation for a few years, or by using heavy earth-moving machinery if it is not possible to cultivate it. An elaborate irrigation system is then laid out for spreading canal water by gravity flow. Shisham (*Dalbergia sissoo* Roxb.) is the major species that is raised by planting stumps (root-shoot cuttings) along about 1′ deep trenches, which are 10′ apart. Planting 6′ apart along the trenches gives a spacing of 10′ x 6′ to the young shisham plants. Other species, such as *Acacia arabica* Willd., *Melia azedarach* Linn., *Tamarix articulata* Vahl., *Albizia lebbek* Benth., and *Eucalyptus* spp. are also introduced on sites not quite suitable for raising shisham or mixed crops. Weedings and cleanings are also carried out in the young plantations as and when required in different localities.

The irrigated plantations have been established so far primarily for fuelwood production on a rotation of 20 years. Thinnings are carried out at intervals of five years, in the 6th, 11th and 16th years after planting. Underplanting with mulberry (*Morus alba* Linn.) stumps is done in the sixth year after the first thinning. As far as possible, evenly spaced shisham standards at the rate of about 16-20 trees per acre are left when the crop is felled at the age of 20 years. The shisham standards are allowed to grow for three consecutive rotations when, at the age of about 60 years, they yield shisham timber of suitable size. A good number of the shisham standards disappear before they are 60 years old, on account of wind damage or mortality from other causes. From some of the older plantations, small sized mulberry timber from about 20-year-old trees is also extracted. This is used in the manufacture of sports goods such as hockey sticks, badminton and tennis rackets, etc.

Irrigated plantations have also been raised recently in the form of narrow linear shelterbelts to protect the irriga-

tion channels and roads in wind-swept areas like the Thal. The width of the shelterbelts varies from 220′ to 1,000′. In the Thal, they have also been raised in the form of small scattered village woodlots of 50 to 200 acres to augment the fuelwood and small timber requirements of farmers in the treeless Thal. Shelterbelts and village woodlots occupy about 15,000 acres in the Thal at present.

The irrigation of forest plantations in the Indus basin has posed a number of serious problems. There is severe rival demand on the limited water resources of the Indus basin for farming, gardening and raising of irrigated forest plantations. The forest plantations are allowed canal water only for about six months during April to October when plenty of water is available in the rivers on account of larger run-off from the Himalayan catchments. A water allowance of 12 cusecs per 1,000 acres for six months is considered just adequate for raising irrigated forest plantations in the Indus basin and is being obtained with great difficulty. Irrigation in trenches in preference to flooding is being done on account of the scarcity of canal water.

The raising of pure shisham plantations has many disadvantages. During the shisham defoliator (*Plecoptera reflexa* Guen.) epidemics, pure shisham plantations are very badly damaged. Shisham also does not thrive as well on hard pans of "kankar" (calcium carbonate). Mixtures are, therefore, preferred in place of pure shisham plantations now. On account of different rates of growth, mixtures by blocks instead of lines are the rule. Even in areas which are suitable for raising shisham, other species, to the extent of 25 per cent, are being raised at present. Two independent Working Circles are now being provided in the new Working Plans to raise fuelwood and timber crops separately. Better areas will be put under suitable timber-producing species, and inferior areas will be devoted to the growing of fuelwood species. In the older plantations, it has been found that a crop of shisham raised from root suckers is superior to that raised either from coppice or fresh shisham stumps (Khan, 1960). It has, therefore, recently been decided that the older plantations which are already well stocked with shisham should be restocked with shisham root suckers after the final felling.

Statistics of Growth and Yield

The statistics of growth and yield are given in a number of Working Plans for the older irrigated forest plantations. The average actual outturn of timber and fuelwood per acre per annum of Changa Manga Plantation for the period 1896-97 to 1945-46 has been worked out and is briefly given in the following tables:

Period	Average age of felling (in years)	Yield per acre: Timber cu. ft. solid	Yield per acre: Fuelwood cu. ft. stacked
1896-97 to 1915-16	21.5	75	4,361
1916-17 to 1935-36	21.7	199	6,150
1936-37 to 1945-46	18.4	172	4,938
Total		446	15,449
Annual average		7.24	250.8

Thus, it will be seen that, on an average, the outturn of about 7 cu. ft. of timber and 250 cu. ft. of stacked fuelwood per acre per annum from Changa Manga Irrigated Plantation was obtained, which is far superior to that of 10 cu. ft. of stacked fuelwood obtained from the original tropical thorn forest (Khan, 1955) which it had replaced.

The provisional yield tables for shisham (Ram, 1941) were based on meagre and inadequate data and need an early revision.

Economics of Irrigated Forest Plantations Versus Irrigated Farming

According to the current Working Plans, the following table gives the gross income, total expenditure and net income per acre per annum of Chichawatni, Khanewal and Changa Manga Irrigated Forest Plantations:

Name of plantation	Gross income per acre per annum	Total expenditure per acre per annum	Net income per acre per annum
1. Chichawatni	Rs. 16/ 2/10	Rs. 11/13/3	Rs. 4/ 5/7
2. Khanewal	Rs. 48/ 5/ 5	Rs. 26/ 8/4	Rs. 21/13/1
3. Changa Manga	Rs. 56/ 2/11	Rs. 24/15/2	Rs. 31/ 3/9
Total	Rs. 120/11/ 2	Rs. 63/ 4/9	Rs. 57/ 6/5
Average	Rs. 40/ 3/ 9	Rs. 21/ 1/7	Rs. 19/ 2/2

For comparison with the above, gross income, total expenditure and net income derived from one square (about 25 acres) irrigated farms in three typical canal colonies of West Pakistan are given in the following table:

Name of canal colony	Gross income per acre per annum	Total expenditure per acre per annum	Net income per acre per annum
1. Lower Chanab Canal Colony	Rs. 44/10/7	Rs. 25/15/–	Rs. 18/11/ 7
2. Lower Bari Doab Canal Colony	Rs. 45/13/5	Rs. 26/ –/6	Rs. 19/12/11
3. Nili Bari Canal Colony	Rs. 38/ –/7	Rs. 16/ 9/1	Rs. 21/ 7/ 6
Total	Rs. 128/ 8/7	Rs. 68/ 8/7	Rs. 60/ –/ –
Average	Rs. 42/13/6	Rs. 22/13/6	Rs. 20/ –/ –

Thus it will be seen that gross income, total expenditure and net income per acre per annum in the case of irrigated forest plantations and irrigated farming are of about the same order. The financial return per acre per annum is comparable in the two cases except that raising of irrigated forest plantations is a long-term investment and cannot be undertaken by individuals and owners of small estates. However, the raising of irrigated fuelwood plantations by the state is considered essential to avoid the occurrence of fuelwood famines and for the maintenance of a healthy national economy.

Multiple-Use Aspect

The irrigated forest plantations not only yield fuelwood and timber but also are useful in many other ways.

Temporary cultivation of agricultural crops in the beginning not only levels the area of irrigated plantations but also yields a substantial amount of revenue. They produce considerable quantities of grass and also provide some grazing in grown-up crops and in unplanted, open areas.

Mulberry leaves produced in many plantations sustain the natural silk industry. Lac is also to some extent grown on *Acacia arabica* crops. The irrigated plantations also provide spots for relaxation and recreation as well as some hunting and shooting opportunities in the otherwise extensively farmed and thickly populated areas. In the form of shelterbelts, they protect the irrigation channels, agricultural crops and means of communication. The irrigated plantations also have a definite beneficial effect in moderating the local climate.

Problems and Research Needs

Some of the more serious problems of our irrigated forest plantations which require an early solution are briefly enumerated below.

Water Requirements of Irrigated Forest Crops

Irrigation is undoubtedly the most important factor for the successful raising of irrigated forest plantations in arid and semi-arid West Pakistan. It is not only the total quantity of water used that matters, but also its frequency and method of delivery in the field appear to have considerable impact on the growth of forest crops. A comprehensive factorial experiment involving five annual deltas, i.e., 1½′, 3′, 4½′, 6′ and 7½′, three frequencies of irrigation, i.e., weekly, fortnightly and three-weekly, and two methods of irrigation, i.e., flooding and trench irrigation, has recently been laid out in the Khanewal Irrigated Forest Plantation. The results derived from this experiment would be of great interest to us.

Mortality of Standards

The mortality of standards, particularly those of shisham, has recently become a common phenomenon in some of our irrigated plantations. Investigations carried out in the Khanewal Plantation (Khan, et al., 1956) indicate that the mortality of standards is probably due to a physiological condition resulting from the adverse soil-cum-irrigation and meteorological factors obtained in some of our irrigated plantations. This problem needs to be further investigated to find a suitable remedy.

Shisham Defoliator and Powder-Post Beetles

Epidemics of shisham defoliator (*Plecoptera reflexa* Guen.), occurring at intervals of a few years, cause serious setbacks to the growth of shisham crops. Mixed crops are not so badly affected. Chaudhry (1958) states that sprays with emulsions containing 0.5% Endrin have so far proved to be the best remedy for the control of *Plecoptera reflexa* larvae. One or two Dieldrin (0.5%) sprays against powder-post beetles (*Sinoxylon* spp.) attacking converted fuelwood in irrigated plantations have given very good results. The best remedial measures to control these two pests are still under investigation.

Growing of Timber in Irrigated Plantations

Hitherto, irrigated plantations have been managed primarily for the production of fuelwood. Some timber also used to be derived from the standards. In order to boost the production of timber which is also badly needed in West Pakistan, it has been decided to manage these forest plantations from now on partly for the production of timber. A number of fast-growing timber species have been suggested for growing in the irrigated plantations. It would be desirable to raise the new species experimentally first before undertaking their large-scale planting. Some of the fast-growing *Eucalyptus* spp. and hybrid poplars appear to be very promising.

Volume and Yield Tables

A set of provisional volume and yield tables for shisham grown in the irrigated plantations of the Punjab was compiled and issued in 1941. They were produced hurriedly, in view of an urgent demand, and were to be revised as soon as more detailed and authentic data were available. It is now time that more accurate and up-to-date volume and yield tables for irrigated forest plantations of West Pakistan are prepared.

APPENDIX I

Areas under irrigated forest plantations in West Pakistan

Name of plantation	Year started or proposed start	Gross area of plantation in acres	Area planted up to date	Balance of area
Changa Manga	1866	12,515	10,844	1,671
Chichawatni	1913	11,494	8,950	2,544
Khanewal	1917	19,455	15,826	3,629
Tehra	1917	837	133	704
Daphar	1919	7,126	6,634	492
Setlug Valley Project Plantations	1929	10,404	6,308	4,096
Burala	1946	10,864	2,950	7,914
Shorkot	1947	10,079	1,956	8,123
Thal Plantations	1948	62,000	26,600	35,400
Lloyd Barrage Plantations	1940	50,000	7,411	42,589
Bahawalpur Plantations	1945	57,174	12,762	44,412
Ghulam Muhammad Barrage Plantations	1958	60,000	16,413	43,587
Taunsa Barrage Plantations	1960	46,900	....	46,900
Guddu Barrage Plantations	1962	180,000	....	180,000
Total		538,848	116,787	422,061

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RESUMES

Les plantations forestières irriguées du Pakistan occidental

Au cours du siècle qui vient de s'écouler, environ 23 millions d'acres de la forêt tropicale d'arbustes épineux du Pakistan occidental ont été défrichés et convertis en cultures irriguées. Les nouveaux projets d'irrigation ajouteront bientôt environ 10 millions d'acres à la superficie déjà irriguée.

La Plantation Forestière Irriguée bien connue de Changa Manga, qui est la première de ce genre, a été entreprise en 1866. Depuis lors, en raison de la dégradation progressive de la forêt tropicale épineuse et des besoins croissants de bois de chauffage d'une population en expansion rapide, le Gouvernement a fort judicieusement mis en réserve de temps à autre des terres destinées à des plantations forestières irriguées. Jusqu'à présent, 538.848 acres ont été alloués pour ces plantations et 116.800 acres ont maintenant été boisés principalement à l'aide de "Shisham" (*Dalbergia sissoo* Roxb.). La production annuelle actuelle de bois de chauffage des plantations forestières irriguées du Pakistan occidental est d'environ 16 millions de pieds cubes (volume en tas).

Un système assez compliqué a été mis au point pour la délimitation, l'établissement et l'aménagement des plantations forestières irriguées. La quantité d'eau jugée suffisante pour leur croissance est d'environ 12 cusecs par 1000 acres pour six mois. La production est d'environ 250 pieds cubes de bois de chauffage (volume en tas) et de 7 pieds cubes de bois d'oeuvre par acre et par an par comparaison avec un rendement de 10 pieds cubes seulement de bois de chauffage obtenue de la forêt épineuse originale.

Le revenu net par acre et par année tiré des plantations irriguées soutient favorablement la comparaison avec celui tiré de l'agriculture irriguée. La culture de plantation irriguées par l'Etat pour la production de bois de chauffage est cependant considérée essentielle pour que toute pénurie de combustible soit évitée.

A l'heure actuelle, les plantations forestières irriguées posent encore de nombreux problèmes, et parmi les recherches qui s'imposent, les plus urgentes portent sur les questions suivantes: détermination des besoins optimums en eau des forêts irriguées, contrôle de la mortalité chez les baliveaux, lutte contre les insectes défoliateurs et les térébrants, sélection d'essences de haute futaie appropriées, et compilation de tables de volume et de rendement.

Plantaciones de Bosques Regados del Oeste de Pakistán

En el siglo pasado se talaron y convirtieron en terrenos de regadío unos 9.000.000 de hectáreas de bosques tropicales de espino del oeste de Pakistán. Las nuevas obras de riego agregarán otros 4.000.000 de hectáreas a esa cifra en un futuro próximo.

El primer trabajo de bosques regados fue el de la conocida Plantación Changa Manga, que se inició en 1866. Desde entonces y en vista del agotamiento gradual de los bosques tropicales de espino causado por la creciente necesidad de leña de una población que aumenta con rapidez, el Gobierno ha tenido la precaución de apartar terrenos de tiempo en tiempo para formar plantaciones de bosques regados. Hasta la fecha ha destinado para ese objeto 218.000 hectáreas y se han replantado ya 47.267, en su mayoría de "shisham" (*Dalbergia sissoo* Roxb.). La producción anual de leña de plantaciones de bosques regados del oeste de Pakistán es de alrededor de 16.000.000 de pies cúbicos hacinados.

Se ha preparado un sistema detallado para la disposición, establecimiento y administración de plantaciones de bosques regados. Un volumen de agua de 12 pies cúbicos por segundo durante seis meses para 400 hectáreas se considera adecuado para su cultivo. Estas plantaciones rinden al año como 625 pies cúbicos de leña hacinada y 17 de madera, mientras que de los antiguos bosques tropicales de espino se obtenían tan sólo 25 pies cúbicos de leña hacinada.

El ingreso neto anual por hectárea de plantaciones regadas de bosques es similar al de los terrenos agrícolas. Sin embargo, es indispensable que el estado establezca bosques regados de madera de leña para evitar la falta de ese producto.

La determinación del mejor abastecimiento de agua para los bosques regados, la represión de la mortalidad de árboles en pie, la lucha contra los escarabajos deshojadores del shisham y pulverizadores, la selección de las especies apropiadas de madera y la compilación de cuadros al día de volumen y producción son en la actualidad algunas de las necesidades más urgentes de la investigación que requiere la plantación de bosques regados.

Afforestation On Dry Hillsides

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Introduction

Mountains occupy more than 10% of the total land surface of the world. Of this, high mountains and rough area cover 3,000,000,000 acres. Dry mountains receiving less than 15% of average annual rainfall share nearly 15% of the total mountainous area of the world. In the Middle East, such mountains with low rainfall are mainly confined to West Pakistan, Afghanistan, Persia, Arabia and Turkey. This, of course, embraces a very vast and varied phytogeographic region between Palmir and Izmir and includes the well-known Mediterranean climate, the summer monsoonal belt, and bordering or intermediate enclaves between them. The present study is limited to drier parts receiving an average annual rainfall of 8" to 15". Despite the apparent diversity of climate and resultant vegetation, the broad basic principles and problems of this great region are, however, identical. The dominant physical and biological factors are:

1. Paucity of rainfall—its uncertain and uneven distribution;
2. Pastoral economy of the population, resulting in over-exploitation of vegetation; and
3. Poverty of the people and resources.

The Need for Development

The reasons why these dry rugged mountains should receive greater attention today are quite obvious. The threat of increasing population has stirred up an interglobal race across the space barriers, and it is just more practical that lands nearer home which are sparsely populated should also bear the optimum burden. This can be achieved only after developing the economic potential of these areas to their maximum. There is another important consideration. It would, perhaps, be pertinent to quote here a biblical citation, "I will lift up mine eyes unto the hills from whence cometh my help." This was true of olden days when man's interference with nature's balance was judicious. But now these mountains, through centuries of overexploitation and consequential depletion of plant and soil cover, have become a source of misery and calamity for the plain-dwellers down below. The denuded watershed can no longer bear the brunt of torrential rains. Accelerated erosion gives rise to flash floods which destroy agriculture, communications, habitations and irrigation canals in the plains. It is therefore essential to once again provide the soil with the protective shield of vegetation. Thus, the dual object of developing the hills for supporting and sustaining a larger population, including raising their standard of living and protecting the interests of plain-dwellers, is forcefully brought to the forefront. It is said that when President Roosevelt flew to Tehran to attend a historical conference, he was much struck by the denuded and desolate mountains of the Middle East and, on his return, advised that forestry should be included as a full subject under F.A.O. of the United Nations. This incident touches another important consideration. Very important persons, high dignitaries and even governments would continue to expect and demand from foresters that these hills be clothed with trees.

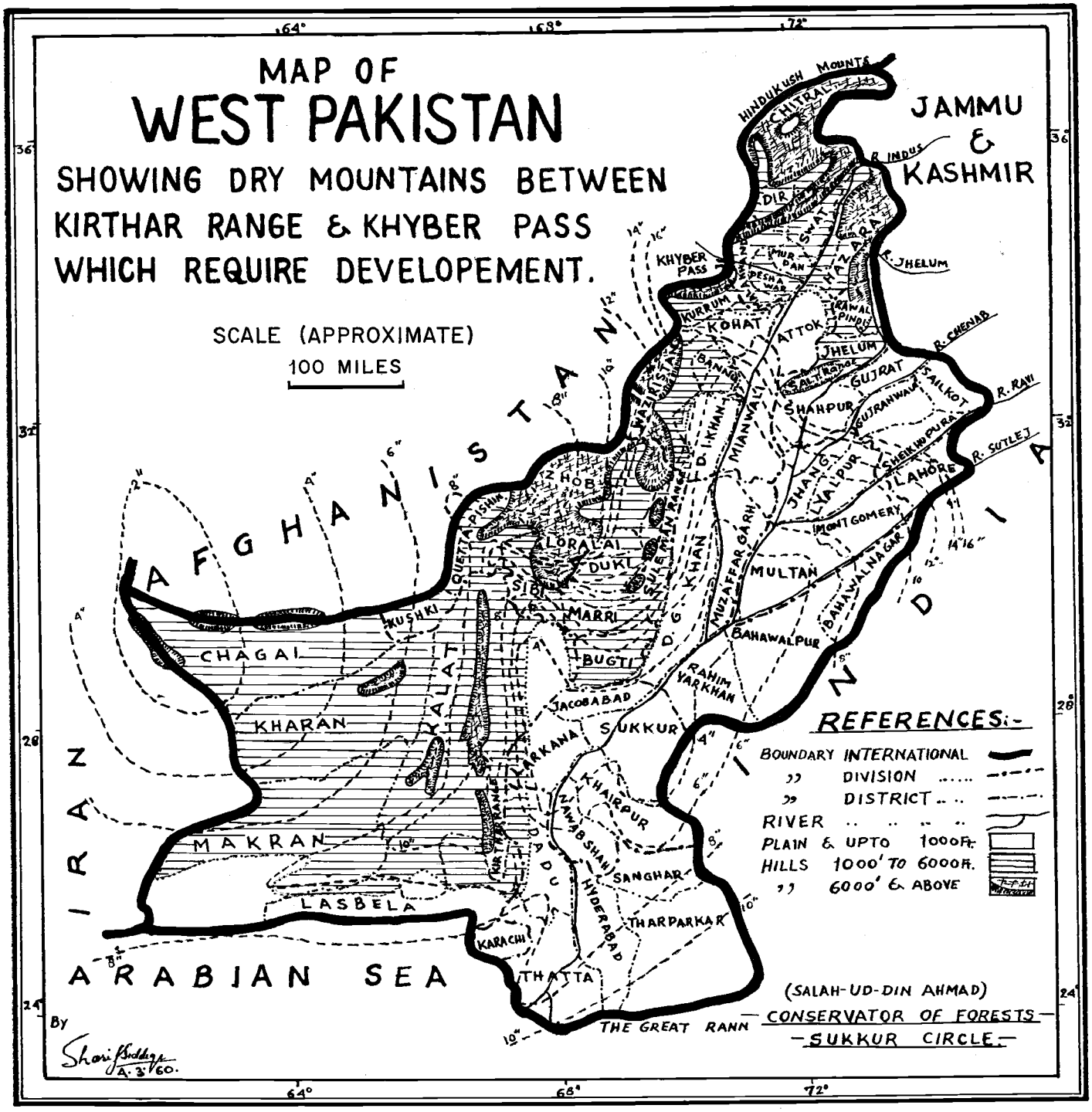
Is Afforestation the Answer?

It would be neither possible nor sound economics to prescribe or attempt large-scale afforestation. Afforestation on a large scale would come into sharp conflict with the immediate requirements of the people. The role of scattered dwarf-tree growth (for we cannot have lofty trees and close-canopied forests under such dry conditions) in checking accelerated erosion is also of doubtful value, especially when compared with grass-cover, which is definitely more beneficial. Under these complex biological forces, a comparatively new applied science of "range management" has become prominent. However, from a local standpoint, such as beautification of the landscape and provision of amenity spots, and also to meet the requirements of the people for fuel and small timber, afforestation still continues to occupy a place of importance. It may also be stated that trees play an important role even under range management. They provide shade and shelter, forage and fruit for livestock and human beings. The honey locust tree (*Gleditschia triacanthos*) can yield 1,000 lbs. of palatable beans per acre. When dry and mature grass is supplemented by the pods of trees during the dry season, cattle can maintain their weight. Olive and *Zizyphus* trees yield edible fruit which is relished and is of considerable value for the poor people during periods of famine. Trees also provide shelter and feed for wildlife, while their flowers are an important source of nectar for the honeybees. Trees and shrubs of grazing lands also have considerable value as windbreaks and in soil improvement.

As a result of soil improvement, the grasses produced under the shade of certain trees have a high protein and mineral content. It is, therefore, to be admitted that trees and their culture on the dry hills, though on a small scale and on selected sites only, are quite desirable and would continue to attract the attention not only of foresters but also of all others concerned.

Scope of Work

In West Pakistan, work along these lines is indicated, especially for the Excluded Area of the Dera Ghazi Khan tribal belt of Dera Ismail Khan (Waziristan), parts of the Salt Range and the Pabbi Hills and the Safed Koh. Outside Pakistan, it would be worth while to project this technique in conjunction with range management in other pockets susceptible of this type of development in the hilly areas of Afghanistan, Persia, Turkey and Arabia.



Mountainous Area of Dera Ghazi Khan

This tract is commonly known as the "Excluded Area of Dera Ghazi Khan," because it is governed under special laws applicable to tribal areas. It embraces a mountainous area 2,500,000 acres in extent, forming part of the Great Sulaiman Range. The average annual rainfall varies from 4" to 8". Most of the rainfall occurs during the summer months, July to September. A couple of showers are received during the winter months, i.e., December and January. There are prolonged periods of drought. The prevailing altitude is 3,000' to 4,500' above sea level. The gradients are gentle to steep. The hills are bare and sustain scanty vegetation which has largely disappeared as a result of excessive grazing by sheep, goats and camels. Although the population is small (46,000), its influence on vegetation is great, because of its pastoral and nomadic ways of life. Wind velocity is generally high. Accelerated erosion is rampant, so much so that bedrock has been exposed, and boulders and sand roll down along the hill torrents. These hills drain into the

plains below and irrigate agricultural fields enclosed by strong earthen bunds. The land is given deep and heavy irrigation. A quick-maturing crop like sorghum (bajra) is grown. When rainfall is heavy, the runoff losses are colossal. The floods carried by these hill torrents cause havoc in the plains; the agricultural fields are destroyed; the roads and canals are washed away. Due to development in the plains, the task of developing the hillsides has become all the more important, because unless erosion and floods are checked, the development in the plains is most likely to be overrun by the hill torrent action.

During 1953, more than one lac (100,000) acres were placed at the disposal of the Forest Department. The legal status of the area regarding ownership has not been clearly established. The entire territory is in a tribal area, and normal laws of the country are not applicable here. A Political Assistant administers these 2,500,000 acres under the Jirga Laws. Out of over one lac acres transferred to the Forest Department, work was started at three places, viz, Fort Munro, Leghari Tuman and Buzdar Tuman. The revegetation works in Buzdar Tuman were subsequently stopped because part of the area was returned to the owners, owing to some legal complication. The work described here pertains mainly to Fort Munro and Leghari Tuman. Sometimes protection from grazing and browsing poses a serious problem and has to be enforced at the point of guns.

Fort Munro—Past History

Fort Munro is the capital of the tribal territory of the District of Dera Ghazi Khan. It is a summer resort, and the highest point is 6,300′ above sea level. Fort Munro is a small group of houses which hum with activity during part of the summer season only. All the bungalows are sort of Rest Houses where touring officers come and stay. Tumandars (feudal lords) assemble during the summer season for about a week when Jirga Darbar is also held. How and why the place is called Fort Munro is not quite known. It is said that it has been named after one of the Political Assistants, Mr. Munro. The word "fort" is probably due to the fact that there was a fort here in olden days. Relics of the fort still exist at the top of the hill. The name "fort" may also be due to the fact that the hilltop is supported by rock structure resembling a great natural fort. Regarding geology, it may be said that the mountains include a considerable area of tertiary rocks which consist of sandstones and shales of the Eocene age. Limestone, clays and conglomerates are also found. The average annual rainfall is 8″, and the hilltop is a windswept locality. The original flora consisted of *Olea cuspidata* at elevations between 4,500′ and 6,000′ and phulai (*Acacia modesta*) at elevations between 2,500′ to 4,500′. The olive has almost completely disappeared except over only a couple of acres at Fort Munro. Among the bushes the following are common: *Mentha* spp., *Sophora griffithii, Stokesia brauhica, Nannorrhops ritchieana* (peesh or mazari), and *Daphne oleoides.*

These species are very hardy and are not readily browsed by livestock. Among the grasses, *Cymbopogon* spp. and *Eulalioposis binate* (baib grass) are quite common on higher elevations, while on lower, warmer places, *Chrysopogon* spp. come up if protection is enforced. *Saccharum ciliare* is also found here and there near ravines. Earlier work on afforestation must have started 40-50 years ago. Tree species attempted include deodar (*Cedrus deodara*), chir pine (*Pinus roxburghii*), cypress (*Cupressus sempervirens*), peach, plum and pear. There is no doubt that these species were quite heavily irrigated through manual labour at least during the first few years. Survivals among them are a couple of deodars, many chir pine and cypress trees. Although the area under them is not more than a few acres, yet these trees have lent considerable charm and beauty to the Hill Station. Later on, Quetta ash (*Fraxinus xanthoxyloides*), Persian pine (*Pinus halepensis*), *Eucalyptus rostrata* and mesquite were also introduced. These species have done well under the prevailing severe climatic condition. Both the height and girth are approximately one-third of their optimum size. Near lakes and ponds poplar, willow, *Robinia* and *Grewia* have done well. Mesquite (*Prosopis glandulosa*), which was introduced 25 years ago, has run wild and is still spreading. Donkeys relish its pods, while it is said that sheep suffer from stomach upset after eating the pods. An avenue of Persian pine planted during 1948 is thriving, though the rate of growth appears to be slower than that of chir pine.

Management Under the Forest Department—Phase 1 (1953-55)

During 1953, when the area was transferred to the Forest Department, the first step taken was the clamping of a complete closure on grazing and browsing. The area was divided into compartments af about 50 acres each. Soil and water conservation measures, such as interrupted-contour trenching and check-damming, were undertaken. Sowings of phulai (*Acacia modesta*) and snatha (*Dodonaea viscosa*) were done in both bed and berm of the trenches. The contour trenches (6′ x 1′ x 1′), with a spacing of 12′ x 10′, were dug over selected places having gentle gradients. *Pinus roxburghii* transplants were also planted in certain localities. As a result of closure during the first two years and other soil conservation measures, the improvement of the natural vegetation was phenomenal. Grasses completely covered the ground. Erosion was almost completely checked. Snatha grew will but phulai's growth was very slow. Until 1955, although the area was completely stabilized, yet the afforestation measures had not given very encouraging results except in places where plants were hand-watered and were protected from cold winter winds.

Phase 2 (1955-59)

During 1955 and 1956, a large number of chir pines were transplanted in pits, and quite a number of them survived and continued to grow. The work was concentrated near ponds from which hand-watering could be done. After 2 years, irrigation was discontinued. Similarly, Persian pine was also attempted, but the results have not been so encouraging. It does not show good growth during the first year when considerable mortality takes place. If it survives the first year, it grows fairly well subsequently. A number of *Eucalyptus* species were tried on a northerly aspect without the aid of irrigation. Their initial success was fair, and we become hopeful, but after two springs heavy mortality took place during the winter months. Some eucalyptus seedlings were transplanted inside the

Forest Rest House compound and were irrigated occasionally. These have done very well. *Acacia cyanophylla* did not flourish except at places where hand-watering could be done. Similarly, *Casuarina glauca* thrived well with additional irrigation. These efforts have clearly indicated that dry-afforestation in its strictest sense is not likely to prove successful. After a very careful choice of species, the plants should be planted on more favourable sites after carrying out preparatory soil and water conservation measures. Planting must be done at places where a couple of additional hand-waterings could be given between two showers of rain, if the interval was long enough. It was also decided to provide cover to the young plants during severe winter months. With these ideas, efforts were redoubled and another technique was evolved. It is described in the following paragraph.

The New Technique

The new technique may be known as "trough-shaped, interrupted-contour trenches with abutments, and scattered small ponds." Only favourable localities devoid of rock and boulders and with gentle gradients were selected. The distance between contour trenching varied from 50′ to 100′. The trough-trench is about 15′ to 25′ long, about 2′ to 4′ wide and 2′ deep and is supported by loose stone masonry from the downhill side. Dug-out earth is piled as a *continuous* ridge on the lower side of the trench. The expenditure on earth and stone work per acre amounted to Rs. 100/-. For every 8-10 acres, a pond having an average size of 20′ x 25′ x 4′ depth, at a total cost of Rs. 40/-, was also constructed. The selection of site for the pond can be easily made after some experience. While reconnoitering, a central place, where slopes from various sides gently drain and converge, is selected. It should not be located on the natural "nala," because here the gradients would be steep. Simultaneous with the construction of ponds and trough-trenches, pits 1′ x 1′ x 1′ are dug inside the trough-trenches, spacing them 10′ to 20′ apart. Transplants one to two years old are taken from the nursery with a ball of earth and embedded in the pits just after the first shower of the summer monsoons. The plants are hand-watered after 10-15 days from the previous shower. The total expenditure on trough-trenching, planting, irrigation, weeding, and construction of ponds does not exceed Rs. 150/- per acre for the first year. By this method, the effect of the rainfall is doubled or even trebled, and we are able to establish certain species which would not grow with only the basic 8″ of average annual rainfall. No irrigation may be given after the first two or three years, but it would be essential to: (1) maintain the trenches as good receptacles of rain water; (2) weed out the grass and weeds from the trough-trenches; and (3) keep the ponds in proper repair.

The first winter is likely to affect the plants adversely. It is desirable to protect them from biting, cold winds. For this purpose, the idea of a "peesh" hat was conceived. The leaves of dwarf palm (*Nannorrhops ritchieana*) of the locality were utilized. Subsequently, the peesh hat was modified into a peesh skirt which was fixed over the plants during severe winter months, i.e., December, January and February. This protection is essential because unprotected plants wither away during the winter months. The technique described above was evolved and developed during 1958 and 1959. The results have been quite encouraging. A large number of eucalyptus transplants, 1-2 years old, were planted during 1958 and 1959 on trough-trenches or pits and hand-watered. These plants have been growing vigorously. *Zizyphus mauritiana* also fared well at elevations between 3,500′ and 5,000′. A root and shoot cutting of Persian lilac (*Azadirachta indica* Juss.) planted accidentally during 1958 has done exceedingly well. Observations on various species have been tabulated below:

Species	Year of trial	Technique	Indications	Remarks
Eucalyptus gracilis	1956, 57, 59	Pits and trough-trenches with ponds	Promising	
E. rudis	"	"	Very promising	Fast growth.
E. camaldulensis	"	"	Promising	
E. erythronema	"	"	Promising	
E. woodwardii	"	Pits and ponds	Fair	
E. stricklandi	"	"	Fair	
E. oleosa	"	"	Good	
Acacia cyanophylla	1955	"	Good	Has been given copious irrigation.
A. modesta	1953 to 1958	Pits and trenches	Fair	Very slow growth except at lower elevations (3,000′ to 4,500′).
Casuarina glauca	1955	Pits and ponds	Fair	Was copiously irrigated.
Pinus roxburghii	1955, 56, 57, 58	Pits and ponds	Promising	
P. halepensis	1958	"	Uncertain	Older plants are doing well.
Olea cuspidata	1958, 59	Trough-trenches	Fair	Slow-growing.
Zizyphus mauritiana	1956, 57, 58, 59	Pits and trough-trenches with ponds	Good	Has done well at elevations between 3,500′ and 5,000′.
Robinia pseudoacacia	1959	Trough-trenches	Good	
Bauhinia racemosa	1958, 59	Pits and trough-trenches	Promising	
Azadirachta indica (Juss.)	1958	Trough-trenches and ponds	Very promising	Only one plant was grown accidentally.
Grewia spp.	1959	Pits and trough-trenches	Very promising	
Fraxinus xanthoxyloides	1959	Pits and ponds	Promising	Older trees are doing well.
Morus alba	1957, 58, 59	Pits	Promising	Grown in moist nala beds.

Future Outlook

The method described in this paper is just one aspect of the multifarious problems facing the people. It is in no way the last word on the subject. It is just a mention of limited experience spread over a couple of years. It may prove helpful in compelling further attention. However, much more is required. Above all, prolonged patience and perseverance are essential in order to achieve tangible results. We should be sure about the choice of species. It might be worth while to experiment with the following species also:

1. *Gleditschia triacanthos*
2. *Cupressus arizonica*
3. *Pinus radiata*
4. *P. pinea*
5. *P. brutia*
6. *Eucalyptus gomphocephala*
7. *Haloxylon persicum*
8. *Azadirachta indica* (Juss.)
9. *Pistacia atlantica*

Another point requiring attention is the physical and chemical methods which could be employed to reduce and minimize evaporation, percolation and leakage losses from the ponds.

Concluding Remarks

The exploding populations must explore and galvanize their own resources and potential. A stage may come when the competing nations across the Pacific Ocean may compromise, or aid and assistance may be replaced with trade and commerce. The Middle East countries must revive their ancient glory and should be ready to develop their resources to match the present and future requirements of their people and for export. Fortunately, science today offers opportunities, scope and hope for development unparalleled in history. The subject touched upon in this paper concerns more than 60% of the area of the Middle East. Any further delay and neglect in appreciating and grappling with the problems arising out of social, economic and political considerations would lead to regional suicide, and history would record this as an unpardonable crime.

Acknowledgement

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RESUMES

Boisement de versants de collines secs

Des zones montagneuses sèches constituent plus de 60% de la superficie totale du Moyen-Orient. Encore que cette région soit à la fois vaste et variée, les principes généraux fondamentaux qui la gouvernent et les problèmes qu'elle soulève sont identiques. Les éléments physiques et biologiques dominants sont:

1. Précipitations insuffisantes, incertaines et inégalement réparties;
2. Economie pastorale de la population entraînant une exploitation excessive de la végétation; et
3. Pauvreté de la population et de ses ressources.

Il a été fait état de la nécessité de développer cette région. A l'heure actuelle ces terres accidentées et montagneuses sont dans un état de négligence et d'abandon graves, dû à une mauvaise utilisation des terres. En raison de l'accroissement de la population, il est indispensable que ces terres soient remises en valeur pour soutenir à la fois la population humaine et le bétail dans les meilleures conditions. Il est indubitable que la plus grande partie de cette région peut être convertie en pâturages, mais il est également souhaitable qu'elle produise des arbres, non seulement parce que ceux-ci ont leur place dans un programme d'aménagement des terrains de parcours, mais également pour bien d'autres raisons d'intérêt local, telles que mise en valeur du paysage, création de sites agréables, etc.

Les conditions écologiques, sociales et géologiques qui existent dans la région montagneuse tribale de Dera Gazi Khan, que l'on appelle communément la région interdite du Dera Gazi Khan, ont été décrites. Les travaux de boisement n'ont affecté qu'une partie limitée de cette zone tribale, à savoir Fort Munro et Leghari Tuman. Les précipitations moyennes par an sont de 8 pouces. La plus grande partie de ces précipitations tombe sous forme de pluies torrentielles pendant les mois d'été, de juillet à septembre. Il y a de rares averses pendant les mois d'hiver, en décembre et janvier. La dénudation du terrain a hâté l'érosion qui est devenue générale. Les torrents montagneux descendent vers les plaines et des inondations "éclair" détruisent fréquemment les cultures, les habitations, les routes et les canalisations. L'altitude générale est de 3.500 à 4.500 pieds au-dessus du niveau de la mer Jusqu'à 1953, une série de spécialistes du gouvernement s'étaient efforcés depuis 40 ou 50 ans d'implanter des *Cedrus deodara, Pinus roxburghii, Cupressus sempervirens* et autres essences, telles que pêchers, poiriers et pruniers. Ces essences ont été irriguées à la main pendant les premières années. Peu de sujets ont survécu. En 1953, une partie de ce territoire a été placée sous l'autorité du Service des forêts. Jusqu'à 1955, il a été interdit au pâturage et au brout. On a construit en outre quelques barrages de retenue et fait quelques travaux de comblement de ravins. On a procédé à des ensemencements et plantations en potets et le long de petites tranchées en terrasses. Ces travaux ont contribué à stabiliser le sol et à retablir la végétation. Les semis et les plantations n'ont réussi que là où ils recevaient une irrigation supplémentaire. Ces échecs et les indications qu'ils ont fourni ont permis de mettre au point une nouvelle technique. L'auteur en fait la description. Elle consiste à creuser des tranchées continues en forme d'abreuvoirs, mais avec des coupures, et d'une longueur de 15 à 25 pieds. On construit en outre un étang de 20 pieds x 25 pieds x 4 pieds. Cette manière de procéder permet une utilisation maximum des précipitations non seulement pendant les chutes de pluie mais également pendant la période de sécheresse qui suit et durant laquelle on peut utiliser l'eau récoltée dans les étangs pour irriguer les plantes artificiellement. De cette manière, l'effet des pluies est doublé ou triplé et nous avons pu établir certaines essences qui ne pousseraient pas avec les précipitations annuelles moyennes de 8 pouces. Pendant les mois d'hiver, les plants ont été cinglés et détruits par des vents froids et violents. Nous avons inventé une sorte du jupon improvisé fait de "peesh" (palmier nain de la région) que nous avons fixé autour de ces plants pendants les mois de décembre, janvier et février. Ce dispositif a aidé les plants à survivre à cette période de froid.

L'auteur fournit sous forme de tableau une nomenclature des

diverses espèces qui ont été essayées. Les essences les plus intéressantes sont les suivantes:

1. *Eucalyptus gracilis*
2. *E. rudis*
3. *E. camaldulensis*
4. *E. oleosa*
5. *Acacia cyanophylla*
6. *A. modesta*
7. *Pinus roxburghii*
8. *Zizyphus mauritiana*
9. *Robinia pseudoacacia*
10. *Azadirachta indica* (Juss.)

L'auteur formule des recommandations concernant des essais ultérieurs.

Forestación de Laderas Aridas

Las regiones áridas y montañosas del Medio Oriente ocupan más del 60 por ciento de la superficie total de la zona. Aunque estas regiones áridas son vastas y variadas, los principios y problemas básicos en general son idénticos. Los factores físicos y biológicos dominantes son:

1. Exigüidad de las lluvias, su distribución incierta e irregular;
2. Economía pastoral de la población que es causa de la explotación excesiva de la vegetación; y
3. Pobreza de la gente y de recursos naturales.

El estudio trata de la necesidad de desarrollar la región. Estas extensiones de terreno bravío y montañoso se encuentran hoy en estado de abandono y de ruina debido al mal uso de la tierra. En vista del aumento de la población, se hace necesario desarrollarlas para mantener al mayor número posible de seres humanos y de ganado. No hay duda de que la mayor parte de la región puede convertirse en terrenos ganaderos; pero el cultivo de árboles es también conveniente no sólo porque es parte del plan de la Administración de Tierras Ganaderas sino debido a muchas otras consideraciones de carácter local, como el embellecimiento del paisaje, la formación de sitios amenos, etc.

En el trabajo se describen también las condiciones ecológicas, sociales y geológicas que prevalecen en la zona tribal montañosa de Dera Ghazi Khan. En esta zona tribal, la forestación se había circunscrito a una extensión reducida que se llama Fuerte Munro y Leghari Tuman, donde la precipitación media anual es de 8″. La mayor parte de la lluvia es en forma de aguaceros torrenciales durante los meses de verano, julio a septiembre. Unos pocos chaparrones caen en los meses de invierno, diciembre y enero. A causa de la desnudez de la tierra la erosión se ha extendido con rapidez. Los torrentes de las montañas se precipitan hacia las planicies y a menudo ocasionan inundaciones repentinas que destruyen sementeras, viviendas, caminos y sistemas de canales. La altitud general es de 3.500 a 4.500 pies sobre el nivel del mar. Antes de 1953, una serie de Auxiliares Políticos, que data de hace 40 ó 50 años, trató de plantar deodar (*Cedrus deodara*), pino de hoja grande (*Pinus roxburghii*), ciprés (*Cupressus sempervirens*) y otras especies como melocotones, perales y ciruelos, que fueron regados a mano durante los primeros años. Pocos de estos árboles han sobrevivido. En 1953 se traspasó parte de la región al Departamento de Silvicultura. Hasta 1955 estuvo en vigor la prohibición del pastoreo y ramoneo en ciertas regiones y, además, se efectuaban trabajos de represas protectoras y de cierre de cárcavas. También se practicaban la siembra y el trasplante en hoyos y en pequeñas zanjas en curvas de nivel. Estas operaciones contribuyeron a estabilizar el suelo y a que recuperara la vegetación. Pero la siembra y la plantación dieron resultado sólo en lugares que podían regarse en los intervalos de sequías. De estos fracasos y observaciones surgió y se desarrolló una técnica nueva, que se describe en el presente estudio. Consiste en zanjas continuas, pero interrumpidas, en forma de artesa de 15 a 25 pies de largo, hechas en curvas de nivel, y de una poza artificial de 20 pies de ancho por 25 de largo y 4 de profundidad. Con esta técnica se aprovecha al máximo el agua de lluvia, no sólo durante la propia temporada de lluvias sino en el período seco que la sigue, cuando se riega artificialmente a las plantas con el agua recogida en las pozas. Con este método se dobla o triplica el uso del agua de lluvia, y nos permite plantar ciertas especies de árboles que no medrarían con el término medio de 8″ básicas de precipitación anual. Los fuertes vientos fríos de los meses de invierno azotaron y mataron a las plantas. Como defensa se empleó una cubierta improvisada de "peesh" (palmera enana de la localidad) sobre las plantas durante los meses fríos de diciembre, enero y febrero. Esta estratagema ha permitido sobrevivir a las plantas durante esos meses fríos.

En este estudio aparece un cuadro en que figura una lista de especies ensayadas con distintos métodos. Las especies prometedoras de árboles son:

1. *Eucalyptus gracilis*
2. *E. rudis*
3. *E. camaldulensis*
4. *E. oleosa*
5. *Acacia cyanophylla*
6. *A. modesta*
7. *Pinus roxburghii*
8. *Zizyphus mauritiana*
9. *Robinia pseudoacacia*
10. *Azadirachta indica* (Juss.)

En este trabajo también se hacen recomendaciones para ensayos futuros.

La Forestación, Factor Significativo en la Recuperación de Zonas Aridas

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La inmensa superficie del globo terrestre, que por sus características climatológicas ha sido calificada como región árida o semiárida, debe merecer una especial preocupación, volcando sobre ella un amplio y decidido esfuerzo técnico que contribuya a su recuperación, a su rehabilitación y su utilización posterior en beneficio de los habitantes del orbe, en aumento constante y desproporcionado con la disponibilidad de recursos naturales y bienes de consumo.

Esta área, que en términos mundiales se ha estimado en una proporción superior al 30% de la superficie total, en la República Argentina podemos ubicarlas al oeste de la isoyeta de 500 mm. con un régimen pluviométrico irregular, caracterizado por prolongados períodos de se-

quía, que oscilan entre cuatro y seis meses, propios de las regiones áridas.

La original disponibilidad de tierras adecuadas para la actividad agrícola ganadera, así como una densidad de población reducida en el medio rural, determinó primeramente la explotación de áreas ubicadas en regiones húmedas y semi-húmedas, de mayores posibilidades económicas, pero paulatinamente se van cubriendo superficies marginales, destacándose la necesidad de realizar trabajos y estudios que permitan establecer las posibilidades potenciales de esas regiones, sometidas en algunos casos a procesos de destrucción más que de aprovechamiento.

La Inspección de Forestación en la Zona Central Pampeana, dependencia de la Administración Nacional de Bosques de la República Argentina, se ha venido abocando desde hace años, en una de sus diversas tareas a la consideración de este problema.

En una análisis general del panorama forestal que presenta la Provincia de San Luis, ubicada en posición central en el país y en cuya ciudad capital tiene asiento el servicio mencionado, se destaca que grandes superficies de su región Oeste han sido sometidas a una explotación irracional del bosque natural, constituído entre otras por especies arbóreas de valor comercial, tales como *Prosopis alba* Griseb. (algarrobo blanco), *Prosopis nigra* (Griseb.) Hieron. (algarrobo negro), *Prosopis caldenia* Burkart. (calden), *Aspidosperma quebracho-blanco* Schlecht. (quebracho blanco) y *Bulnesia retamo* (Gill. ex Hook.) Griseb. (retamo), determinando un retroceso en la sucesión vegetal, generando un proceso de avance hacia el desierto y restringiendo lenta pero constantemente las posibilidades económicas de la región.

La extracción de ejemplares de utilidad comercial realizada sin la previa ejecución de planes dasocráticos, así como la falta de contralor estatal apropiado, han provocado una creciente degradación de la masa forestal, a la que ha contribuido asimismo el ejercicio simultáneo o posterior con la explotación forestal, de prácticas ganaderas cuya actividad origina por parte de la hacienda el ramoneo de renovales que altera las formas futuras y una compactación excesiva del suelo determinada por el pisoteo, que reduce sensiblemente la penetrabilidad del agua de lluvia de por sí escasa y que comunmente ocurre en forma torrencial, con natural tendencia al escurrimiento más que a la infiltración.

Estos aspectos, a lo que se suma la mayor insolación que experimenta el suelo, al quedar al descubierto por desaparición de la cobertura vegetal, contribuyen a dificultar la regeneración natural del bosque.

El resultado de estas actividades, a traves de largos años, ha acarreado como consecuencia actual y en proporciones crecientes, un empobrecimiento del potencial económico, la desaparición de la masa arbórea, el consiguiente aumento de la vegetación arbustiva y la limitación de la actividad ganadera, por la unidad de superficie cada vez mayor que requiere un animal para su desarrollo normal.

No se pretende en este trabajo considerar todos los aspectos vinculados con las necesidades forestales de la zona considerada, sino destacar someramente algunas tareas que en este orden viene realizando el servicio mencionado, en un plan de activación económica de un sector de esa región semiárida.

Planteado el problema, el objeto del estudio—sin perjuicio de considerar la adopción de medidas complementarias que permitan el aprovechamiento del bosque natural sobre bases racionales—se orientó hacia la forma de modificar la economía de esas áreas, mediante la incorporación de plantaciones forestales, como un elemento incrementador de las posibilidades económicas futuras.

En la zona donde se realizan las tareas, la actividad ganadera es predominante y el plan consistió en considerar la utilización de porcentajes determinados en esas zonas con monte natural, degradado y con escasas posibilidades económicas, substituyéndolo con plantaciones forestales que hagan obtener productos derivados del bosque en un volúmen considerablemente mayor y en tiempo decididamente menor que el necesario para el aprovechamiento de las masas forestales naturales, de turnos de corte prolongados, estableciendo asimismo el grado de compatibilidad admisible entre el bosque y el pastoreo.

Se conceptúa posible en esa forma, mejorar la economía regional y las condiciones económico-sociales en que se desenvuelven su pobladores, condicionando con criterio realista el aprovechamiento de los subproductos del bosque, a las características locales edafo-climáticas y satisfaciendo el propósito con la obtención de leña para combustible y elaboración de carbón vegetal, varillas y postes de alambrado, y eventualmente postes para teléfono o telegrafo o entibado de minas, todos elementos necesarios en la región.

La finalidad básica del trabajo consiste en el establecimiento de prácticas adecuadas que posibiliten la forestación de estas tierras áridas y semiáridas y cuyos resultados que se consignan pueden servir de antecedente para labores similares en otras regiones.

Establecida la tarea en ese sentido se tomó primordialmente en cuenta la falta de conocimientos cabales en la región de los beneficios que puede proporcionar el bosque tratado silvícolamente en términos de cosecha anual de madera, y ello determinó una especial consideración al factor económico, es decir la inversión necesaria para llevar a feliz término la tarea.

Sobre esta premisa los primeros ensayos tendieron a su ejecución con el mínimo de gastos posible.

Si bien en las condiciones de trabajo experimental se disponía para las plantaciones de recursos fáciles de agua, para contribuír a la supervivencia de las esencias, la primera labor se orientó hacia la posibilidad de lograr el embosquecimiento con la exclusiva disponibilidad del agua de lluvia, teniendo en cuenta que aquel factor podría ser decididamente limitante, al llevar a la práctica planes de mayor envergadura, sobre la base de los ejecutados en pequeña escala.

Previa selección en pequeñas parcelas, de especies forestales nativas y exóticas, que mostraban aptitudes de arraigue y adaptabilidad y cuya utilización respondía a estos propósitos, se procedió a realizar plantaciones irregulares en parcelas del monte natural, en las cuales no se efectuaba ninguna operación previa, excepción hecha de su perfecto aislamiento del ganado.

Trabajos de ésta índole, realizados en diversas épocas del año, predominantemente otoño y primavera, destacaron la imposibilidad de obtener éxito mediante este sistema de labor.

Las características del régimen pluviométrico irregular,

lluvias de 500 mm. predominantes en primavera y verano, con lapsos de sequía acompañados de intensos calores, temperaturas de 36° a 39° C., otoños e inviernos secos, cuya precipitación representa de Mayo a Septiembre inclusive alrededor del 10% de las lluvias totales, así como la dificultad del control de las hormigas, abundantes en la región, fueron factores decisivos en el fracaso de éste ensayo.

Descartada la posibilidad de concretar esos propósitos en la manera mencionada, se consideró la forma de subsanar uno de estos inconvenientes, el agente predator, la hormiga, con un control adecuado, realizando ensayos en picadas, fajas de 100 a 150 cms. de ancho, previamente limpiadas de vegetación y con fácil acceso, mediante plantaciones lineales, y si bien aquel inconveniente fué salvado, la falta de humedad adecuada impidó llegar a resultados satisfactorios.

Otros intentos de naturaleza semejante, repetidos en años sucesivos, llevaron definitivamente a la conclusión que la implantación de macizos forestales de producción en esas condiciones locales, era solamente viable mediante el complemento de riegos adicionales, considerándose conveniente ejecutar en este caso, previa erradicación de la masa arbórea y arbustiva existente, trabajos de preparación del suelo semejantes a los realizados en las prácticas agrícolas, consistentes en aradas y rastreadas en épocas oportunas, en forma tal de almacenar la mayor cantidad posible de agua en el suelo y evitar al máximo el proceso de evaporación.

Las características fisiográficas del suelo, con ligeras pendientes, señalaron la evidente conveniencia de ejecutar tareas de nivelamiento, como factor de fundamental importancia para la tarea, pero la falta de equipos adecuados para esta finalidad, determinó la necesidad de descartarla en forma momentánea, sin perjuicio de haber realizado con topadoras algunos trabajos de emparejamiento, para evitar el encauce y escurrimiento torrencial de las aguas de lluvia.

Establecida esta forma de trabajo se estimó originalmente la necesidad de un régimen compensatorio de riegos, en número de cuatro, el de plantación y tres adicionales durante el primer período vegetativo e igual número durante el segundo. Cada riego proporcionado con camiones o carros aguateros, consistente en el suministro de 10-15 litros de agua por ejemplar.

Reiterando lo señaldo en el sentido que el factor riego compensatorio puede constituir un elemento limitante, en algunos casos difícil de salvar, en zonas de escasos recursos híbricos, los ensayos prosiguen con tendencia a suplantar el suministro de agua mediante la práctica de trabajos culturales adecuados, con lo que se ha logrado reducir aquellos a un número de tres, el de plantación y dos adicionales como total contribución, a realizarse en el primer período vegetativo.

De la misma manera corresponde señalar que la plantación otoñal, con trabajos de aradas y rastreadas en la época lluviosa inmediata anterior, es decididamente más exitosa.

Esta tarea se complementa con pasaje de rastras a continuación de las lluvias, evitando la evaporación mediante la ruptura de la costra superficial y facilitando la extracción de malezas, evitando así la competencia con los forestales.

Si bien para los primeros trabajos efectuados se tomó el criterio clásico del espaciamiento a 2 x 2 m., las dificultades que se fueron presentando para la ejecución de trabajos culturales entre filas, a medida que se verifica el crecimiento de los ejemplares y en especial a partir del segundo año de vida, determinó la conveniencia de ampliar estas distancias, en especial en un sentido, teniendo en cuenta que las labores culturales se realizan solamente en una dirección.

Condicionando la labor a la disponibilidad de equipos de trocha determinada, fueron ampliándose sucesivamente a 2 x 3 m. y 2 x 3,50 m., habiéndose establecido para los ensayos que se llevan a cabo actualmente las distancias de 2 x 4 m. que presentan los mejores resultados, posibilitando la implantación de 1.250 ejemplares por ha., ello no obstante, para el corriente año en el caso de *Eucalyptus* sp. esencia que destaca las mejores y más promisorias perspectivas de todas las ensayadas. Se usarán espaciamientos de 4 m. en todo sentido.

Una preáctica establecida en el curso del año ppdo. ha sido aprovechando la distancua entre filas de 4 m., la realización de cultivos intercalares, que se considera podrán llevarse a cabo en los dos primeros años de la plantación. Acorde con las características de la zona donde se ejecutan los trabajos, se han hecho siembras de maiz *(Zea Mays)* que permite mediante la utilización de variedades dulces, una cosecha de choclos que puede compensar parcialmente los trabajos preliminares del embosquecimiento.

Esta actividad complementaria que no exige el trabajo de siembra solamente, toda vez que el terreno se halla preparado con las labores adecuadas, para el trabajo forestal, a más de permitir un ingreso inmediato, evita operaciones de extracción de malezas, que en este caso no se hacen necesarias, observándose que la competencia que ejercita el cereal con el forestal es insignificante comparada con aquellas hileras donde no se ha hecho este cultivo.

Superado el período experimental y sin perjuicio de destacar la posibilidad de lograr resultados satisfactorios con nuevos ensayos, hasta el momento, de las 40 especies ensayadas, los resultados obtenidos han sido excelentes con *Eucalyptus camaldulensis, Eucalyptus viminalis, Eucalyptus tereticornis* entre las latifoliadas exóticas, y *Acacia visco* entre las nativas, aún cuando originalmente ésta última afecta forma fruticosa.

De las coníferas ensayadas, todas exóticas, *Pinus halepensis* y *Cupressus sempervirens* son las que han mostrado mejores características de adaptación y crecimiento. En este grupo sistemático los espaciamientos no han progresado a más de 2 x 3 m. con el objeto de procurar el desrame natural.

Para el caso de Eucalyptus se prevé la posibilidad de guiar mediante regímenes de podas, los fustes, en forma tal de procurar las mayores dimensiones que se relacionan con el orden de aprovechamiento económico.

Esta tarea experimental se viene realizando desde el año 1953, y las primeras plantaciones en base a las prácticas que se consideran adecuadas a las características locales, fueron efectuadas en el año 1955.

Como aspectos destacados que se observan en la actualidad, corresponde señalar las diferencias de crecimientos en los mismos ejemplares de una parcela, con mayores

diámetros y alturas en los lugares donde por diferencias de nivel existen acumulaciones de agua pluvial.

En término promedios, a los 5 años de edad se observa en *Eucalyptus camaldulensis* alturas de 4 m. y diámetro a 1,30 m., de 8 a 10 cms.

En apreciación objetiva, por cuanto recién en el corriente año se realizarán los primeros registros de datos volumétricos, se estima un incremento anual del orden de los 12-15 metros cúbicos por ha. que supera con amplitud los términos de la vegetación arbórea natural.

La supervivencia lograda promedia el 65-70% del stock original, porcentaje que de acuerdo a las características regionales se conceptúa muy aceptable.

En coníferas, *Cupressus sempervirens* a los 5 años alcanza una altura media de 2,50 m. con diámetros de 5 cm. a 1,30 m. del suelo, superando ligeramente los términos de *Pinus halepensis*.

Los resultados que se han obtenido en las tareas realizadas hasta la fecha pueden servir de base para la consideración de un programa nacional de recuperación de regiones áridas y semiáridas.

En éste habrá de tomarse muy en cuenta la situación de un número elevado de habitantes que viven en forma precaria en esta región, dedicados a la crianza de hacienda en pequeña escala, así como los que encuentran fuentes de trabajo en las explotaciones forestales, en sus múltiples facetas.

Se estima que el plan puede conciliar estos intereses, toda vez que el elemento que vive en esas zonas podrá constituir la obra de mano necesaria para los trabajos preliminares y posteriores de plantación y conservación, así como de aprovechamiento futuro del monte, conformando masas forestales de aprovechamiento económico, que con su mayor crecimiento volumétrico proporcionarán un recurso de trabajo que permitirá elevar su standard de vida.

RESUMES

Forestation, A Significant Factor In the Reclamation of Arid Areas

The idea is expressed that, in the work of reclaiming arid and semiarid areas, the forest plantation can play a dominant role by contributing to the reestablishment of suitable economic conditions in those areas which, in many cases, owing to improper use, have acquired the above-mentioned characteristics.

It is considered necessary, in addition to the adoption of measures making it possible to comply with existing laws on forest utilization, to promote the forestation of such areas with rapid-growing species to meet the growing demand for forest products and help improve the conditions of the region.

Mention is made of the experimental work done in San Luis, a province located in the middle of the Argentine Republic, to adapt forest species and test different forestation practices, adapted to the characteristics of the arid and semiarid areas.

An examination of the various methods used leads to the conclusion that, in view of the conditions of the environment in which the experiments are being made, it is essential to employ irrigation to supplement the 500 mm. of annual rainfall, which is distributed unevenly, most of it falling in the spring and summer, followed by four to six months of drought, during which only 10% of the total annual rainfall occurs.

The work is begun by eliminating the stands of timber and undergrowth in areas covered by degraded vegetation, thereby permitting the soil to be prepared by plowing and dragging, which increases the moisture-retaining capacity of the soil, followed by planting with varied spacing (now about 2 meters x 4 meters), which makes it easier to employ cultivation practices to conserve rainwater and eradicate the underbrush as well as to plant crops between the trees during the first two years.

A statement is made regarding the excellent results obtained with *Eucalyptus camaldulensis*, *E. viminalis*, and *E. tereticornis*, with an approximate annual increase in volume of 12 to 15 cubic meters per hectare a year, *Acacia visco*, *Cupressus sempervirens*, and *Pinus halepensis*.

Le boisement facteur significatif de la récupération des zones arides

La plantation forestière peut jouer un rôle prépondérant dans la tâche de récupération de zones arides et semi-arides, a contribuant au rétablissement de conditions économiques appropriées à ces régions qui, dans bien des cas, ont acquis les caractéristiques sus-mentionnées par suite d'un usage impropre.

L'auteur croit qu'en marge de l'adoption de mesures permettant l'application des dispositions légales en vigueur quant à l'utilisation forestière, il est nécessaire d'encourager le boisement de ces surfaces à l'aide d'essences à croissance rapide, afin de subvenir aux demandes sans cesse accrues de produits forestiers et en même temps contribuer à l'amélioration des conditions régionales.

Il signale les travaux expérimentaux réalisés à San Luis, province située au centre du territoire de la République argentine, en vue d'obtenir l'adaptabilité des espèces forestières, ainsi que la mise à l'essai de diverses pratiques de boisement qui puissent s'adapter aux caractéristiques particulières des régions arides et semi-arides.

L'examen des diverses méthodes appliquées conduit à la conclusion qu'il est indispensable, étant donné les conditions du milieu dans lequel on opère, de compenser, par un supplément d'irrigation, la distribution irrégulière des 500 mm de pluies annuelles, prépondérantes au printemps et en été, et suivies d'une période de quatre à six mois de sécheresse, pendant lesquels les précipitations ne représentent que 10% environ de la totalité des pluies annuelles.

La tâche commence par l'éradication, sur les surfaces couvertes de végétation dégradée, des masses arborescentes et frutescentes, ce qui permet de procéder à la préparation du sol par le labour et la herse, en vue d'augmenter la capacité de rétention hydrique, et de passer ensuite à la plantation avec espacements variés, qui actuellement sont de l'ordre de 2m x 4m; de ce fait se trouve facilitée la mise en oeuvre de travaux de culture destinés à conserver l'eau de pluie et à éliminer les broussailles, ainsi qu'à permettre d'effectuer, au cours des deux premières années, des cultures intercalaires.

On trouve également, consignés dans la présente communication, les meilleurs résultats obtenus avec l'*Eucalyptus camaldulensis*, *E. viminalis*, et *E. tereticornis*, indiquant un accroissement volumétrique annuel d'environ 12-15 m^3 par rectare et par an, et l'*Acacia visco*, le *Cupressus sempervirens* et le *Pinus halepensis*.

Recuperación Agroforestal de las Zonas Aridas y Semiáridas De la República Argentina

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La República Argentina se encuentra abocada a la solución del grave problema de la erosión y degradación de su suelo, a la pérdida de la fertilidad del mismo y a los bajos rendimientos de la explotación agropecuaria en todos sus aspectos.

Distintos organismos oficiales han encarado el estudio y solución del problema de la fertilidad de nuestro suelo dentro de la esfera de su respectiva especialidad, ya sea agrológica, agropecuaria o agroforestal. Si bien existen antecedentes de la materia de más de 15 años, prácticamente la acción es reciente.

Se estima que las causas de la aridez pueden clasificarse en dos grandes grupos: naturales, provenientes de los procesos de formación del suelo, y artificiales, por el mal uso o manejo del mismo. Una vez establecido el origen de la aridez, en un corto plazo se podrán atenuar los efectos o eliminarlos, según se trate del primero o segundo grupo.

Fácil es comprender la importancia que significa incrementar, restaurar o mejorar la fertilidad del suelo y la gravedad de no desarrollar la labor en ese sentido, si se tiene en cuenta que la Argentina posee más o menos el 75% de su superficie de zonas secas a semisecas y el 25% de húmedas a semihúmedas correspondiendo de éstas últimas el 10% a cultivos anuales y permanente y el 15% a lo que podría llamarse "bosque realmente productivo, sin pastoreo."

Dentro de las zonas secas existen montes de bajo valor económico, con pastoreo prácticamente esquilmante, y praderas permanentes no cultivadas y también sujetas a pastoreo.

De estos datos se desprende que el nudo vital agropecuario se apoya en el valor agrológico del 10% del total de la superficie del país.

Descuéntase el beneficio que significa para la vida y economía de los veinte millones de habitantes que tiene la Argentina el hecho de poder elevar este 10%, así como disminuir el 75% de zonas secas, aunque sea levemente, sin dejar de considerar la posíbilidad de un incremento de la población en relación directa al aumento y disminución, respectivamente, de esos porcentajes.

La Dirección de Investigaciones Forestales, dependiente de la Administración Nacional de Bosques, inició, en el año 1957, los estudios preliminares tendientes a establecer las posibilidades de recuperación de las zonas áridas y semiáridas del sur del país, tomando como punto de partida las provincias de Chubut, Río Negro y Neuquén.

Dichos estudios han permitido establecer que es factible esa recuperación, pero debido a la restricción de los medios económicos y técnicos se ha establecido una primera etapa que abarca únicamente la superficie de la provincia de Chubut por ocupar, prácticamente, la parte central de la Patagonia.

En el futuro dichas labores se extenderán hacia el norte, abarcando Río Negro, Neuquén y sud de Mendoza, y hacia el sur Santa Cruz y Tierra del Fuego.

A tal fin, se ha comenzado la concertación de Convenios de colaboración con los propietarios y arrendatarios más capaces de interpretar el alto valor de esas tareas, en las distintas zonas ecológicas de dicha provincia, con un máximo de garantias en cuanto a la práctica de las mismas.

Es de destacar que por Decreto N° 2431 del Poder Ejecutivo, de fecha 3 de Marzo de 1958, se aprobó el Convenio—Tipo de estudios de experimentación forestal.

De esta manera se soluciona el problema, por cuanto no existen posibilidades inmediatas de establecer Estaciones Forestales Experimentales.

Por estos Convenios los particulares facilitan el terreno, con superficies de hasta diez hectáreas con la obligación de cercarlo y tomar a su cargo la provisión de mano de obra e instrumental de trabajo necesarios, recolectar periódicamente semillas de plantas indígenas locales, de acuerdo a las instrucciones que reciban, y cuidar las siembras y plantaciones que se realicen, con directivas que expresamente se les hacen llegar en cada caso, así como también permitir a los técnicos de la Administración Nacional de Bosques realizar inspecciones de estudio y observación. Por su parte, el representante de la Administración Nacional de Bosques elige la fracción de terreno para destinar a estudios de Experimentación Forestal, se encarga de la dirección técnica del plan de trabajos, facilitando en forma gratuita su asesoramiento, y se obliga a proveer semillas de especies forestales exóticas a ensayar, las que son entregadas sin cargo.

Estos Convenios tienen una duración de cinco años, con opción a su renovación por acuerdo de ambas partes.

Hasta la fecha, los datos relativos a los convenios pueden resumirse así: 18 propietarios, 41 parcelas y 23 héctareas de superficie. Se calcula que al termino de dos a tres años se habrán duplicado, por lo menos, estas cifras.

Las superficies elegidas para la implantación de las parcelas se han analizado con respecto a sus características edáficas, topográficas y climáticas, clasificando las zonas en que se encuentran, en óptimas para el desarrollo de la vegetación, intermedias y adversas. Se han efectuado calicatas y extraído muestras de suelo de cada parcela para su posterior análisis.

Ya se han comenzado a recibir semillas de especies forrajeras xerófilas, halófilas, psamófilas, etc., que fueron

solicitadas a distintos países con condiciones ecológicas similares a las zonas argentinas en que se utilizarán.

La mayoría de los convenios han sido firmados con ganaderos, otros con agricultores de valles, y dos con propietarios de tierras francamente erosionadas (arenas movedizas).

Es de destacar la circunstancia de que el método adoptado permite, con gastos mínimos, realizar una tarea muy productiva sobre una gran extensión. La enseñanza derivada de este sistema sirve de mucho técnicamente. Cada uno de estos propietarios colaboradores, una vez compenetrado del trabajo de recuperación puede independizarse completamente, no necesitando más la orientación técnica proporcionada y, a su vez, será un propagador del sistema, ya entonces adoptado definitivamente, y dentro de la zona de influencia de cada uno transmitirá a sus vecinos todos esos conocimientos.

Asimismo, este sistema presenta la ventaja de acercar a los técnicos del Ministerio de Agricultura y Ganadería a los productores rurales, poniéndolos en contacto en una tarea de mutuo interés, de manera que esta enseñanza práctica redundará en un beneficio general, por cuanto el productor rural podrá apreciar cabalmente el provecho que para sí puede obtener en la práctica de la labor técnica del Ministerio.

Desde ya se ha establecido un plan general de trabajo, distinto según se trate de campos de pastoreo, valles de grandes ríos, terrenos erosionados o centros poblados con necesidad de urbanización.

En campos de pastoreo se contemplará, ante todo, la topografía del terreno (cañadones, lomas, mesetas, terrazas, etc.), altura sobre el nivel del mar, existencia de agua subterránea, ríos, arroyos, lagos, mallines, etc., así como también los factores climáticos preponderantes: cantidad de precipitaciones, caída de nieve e intensidad del viento. Se tendrá en cuenta el problema de la evaporación del agua por el viento, por loque se implantarán cortinas de protección con especies indígenas o exóticas, que atenuando la acción del viento disminuirán la evaporación pudiendo en consecuencia aprovechar mayor cantidad de agua la vegetación arbustiva y herbácea, por lo que se desarrollará más densamente y se creará un nuevo medio ambiente apto para la siembra de especies forrajeras de mayor productividad, se mejorarán los suelos en general y se recuperarán los degradados.

En los valles de los grandes ríos será necesaria, también, la implantación de cortinas de distintas especies arbórea de acuerdo a la índole del cultivo o plantación a proteger, es decir según se trate de fruticultura, forrajicultura, silvicultura industrial o protectora de costas de ríos, lagos, etc.

En terrenos erosionados es necesario, prima facie, establecer la etapa en que se halla el proceso y luego tomar las correspondientes medidas: preventivas cuando se encuentra en las etapas iniciales y en el caso de etapas graves, primero hay que paralizar el proceso, y luego recuperar el terreno con la lucha directa con métodos de forestación combinados con estacadas y otros artificios mecánicos.

En centros poblados donde avanza la erosión se presenta la necesidad de efectuar urbanizaciones con fines protectores, higiénicos y estéticos, por lo que se procederá a realizar plantaciones en forma de cortinas o de parques para establecer cordones verdes alrededor de esas localidades, resolviéndose asimismo, en muchos casos, el problema del combustible, por la leña que proporcionan.

Recientemente se creó, dentro de la Administración Nacional de Bosques, la Comisión Técnica de Recuperación de Zonas Aridas y Semiáridas, la que elaboró un Plan de Investigaciones a desarrollar en esas zonas, dividido en tres etapas: de corto, mediano y largo alcance.

El Plan de Mediano Alcance, que es el más concreto, establece en su parte substancial los sitios en que conviene instalar parcelas de ensayo, tratando de que esos sitios compongan una red que cubra los diferentes ambientes de la dilatada superficie del país.

Es importante señalar, que esta red de parcelas para estudiar las zonas áridas y semiáridas se la entiende como parte integrante de una red mayor, que incluye arboretums y parcelas permanentes ubicadas en ambientes considerados propicios para plantaciones de carácter industrial.

La Red de Parcelas de Ensayo abarca 30 localidades representativas de otras tantas zonas, siendo su nómina la siguiente: El Volcán (Jujuy), Ingeniero Juárez (Formosa) Los Frentones (Chaco), Pomán (Catamarca), Chilecito (La Rioja), Villa Dolores (Córdoba), localidades a determinar en Mendoza, La Pampa y San Luís, Fuerte General Roca (Río Negro), 19 localidades distribuidas uniformemente en la provincia de Chubut, Lago Viedma (Santa Cruz).

Desde julio de 1959 se encuentra en el país el Experto de F.A.O., Doctor A.Y. Goor, quien hasta el presente ha recorrido todas las zonas áridas y semiáridas del país, encontrándose en estos momentos abocado a la tarea de elaborar los informes pertinentes, de manera que próximamente podrán cotejarse los distintos planes y armonizar diferentes criterios para arribar, finalmente a un plan definitivo que deberá cumplir el personal técnico de la Administración Nacional de Bosques.

RESUMES

Recovery of Farm and Forest Lands In the Arid and Semi-Arid Zones of the Argentine Republic

Three-fourths of Argentina's area is covered by arid or semi-arid zones, for which reason a very special significance attaches to any measure intended to stop a rise in this percentage or to decrease it.

Consequently, the National Forestry Administration has drawn up a Research Plan for those zones, which has already been implemented in the province of Chubut in the southern part of the country.

The method used consists of signing agreements with private citizens to allow the introduction of experimental plots on their rural properties. The owners furnish the land and agree to fence it and to take care of the trees that may be sown or planted there. For its part, the National Forestry Administration provides the necessary seeds and plants and takes charge of the technical direction.

A general working pattern has already been devised with features applicable to either pasture lands, great river valleys, eroded lands, or populated centers needing erosion control measures.

Plans for the future have been made that would extend the network of test plots to a number of localities representing all the various zones of the country.

Récupération agro-forestière des zones arides et semi-arides de la République argentine

Les trois-quarts environ de la superficie totale de la République argentine représentent des zones arides ou semi-arides, c'est pourquoi tout ce qui est fait pour arrêter l'augmentation de ce pourcentage et en obtenir la réduction acquiert une signification toute spéciale.

Se fondant sur ce principe, l'Administration nationale des Fôrets a préparé, pour être mis en oeuvre dans ces zones, un Plan de Recherches qui a déjà été appliqué dans la province de Chubut, située dans la partie sud du pays.

La méthode dont on se sert consiste à conclure, avec des particuliers, des accords visant à la création de parcelles expérimentales dans leurs exploitations rurales. Ce sont les particuliers qui fournissent le terrain, avec obligation, pour eux, de le clôturer et de veiller aux semis et aux plantations qui y seront faits. De son côté, l'Administration nationale des Forêts fournit les semences et les plants nécessaires et se charge de la direction technique.

On a, depuis, établi un plan général de travail dont les détails varient selon qu'il s'agit de terrains destinés au pâturage, de vallées de grands fleuves, de terres atteintes d'érosion ou de centres peuplés ayant besoin d'urbanisation.

A l'avenir, on se propose d'étendre le réseau de parcelles d'essais à certaines localités représentant l'ensemble des diverses zones du pays.

Principios Básicos para la Elección de Especies En el Mejoramiento Agroforestal de la Patagonia Arida

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La cubierta vegetal de la meseta patagónica es típica de las zonas áridas y en parte de las zonas desérticas; en ella se distingue la flora (composición de especies), la vegetación (combinación de especies en asociaciones determinadas) y la distribución de la vegetación dentro del territorio.

La flora y la vegetación como consecuencia de su desarrollo evolutivo a través del tiempo y por fenómenos de interacción determinan la formación de tipos de vegetación.

La procedencia de estos tipos se ve en el pasado lejano* pero su existencia actual y la distribución en el territorio se mantiene mediante la concurrencia de todas las condiciones naturales como ser relieve, exposición de las pendientes (en serranias), distribución de las aguas superficiales y subterraneas, clima, composición de los suelos, relaciones mutuas entre las asociaciones y además por la acción del hombre.

Así la ausencia en varias regiones de la Patagonia de la especie *Schinus polygamus* y algunas otras se explica por su exterminio, consecuencia de las necesidades de los pobladores pués el pastoreo excesivo empobrece la cubierta vegetal y en algunos casos provoca hasta su desaparición total. Se observan casos de cambio de límites de la dispersión de asociaciones, las que se hallan en contacto entre sí; por ejemplo en los últimos años se observa en varios lugares de la Patagonia la invasión enérgica de la especie *Calliguaya integerrina* en asociaciones ajenas en zonas donde aparecen acumulaciones de arena traidas de lejos por el viento.

Examinando la vegetación de la Patagonia en conjunto pueden separarse de su composición varias formas biológicas como ser: plantas anuales y perennes, semi-arbustos y semi-arbustos enanos, arbustos, árboles, musgos y líquenes.

La forma y anatomía de las plantas son el reflejo de su adaptación a las condiciones exteriores. Las dos principales adaptaciones son: 1°) desarrollo efímero, de muy corto ciclo evolutivo y 2°) xerofitismo. Ambos tipos de adaptaciones relacionadas generalmente con el régimen hidrotérmico de la Patagonia.

Un tipo especial de adaptación se presenta en condiciones de alta salinidad en los suelos donde las plantas denominadas halófilas, adquieren formas especiales en la estructura anátomo-morfológica originaria y en el metabolismo especial, lo que permite a las plantas resistir la salinidad. Las particularidades características de las especies halófilas son: carnosidad de sus órganos, ritmo lento de su desarrollo y gasto extremadamente económico del agua por medio de la regulación de la transpiración.

Las plantas halófilas, dentro del tipo de plantas xerófilas, son las más resistentes a la sequedad y a las altas temperaturas.

Existen también en la Patagonia los arbustos y plantas herbáceas xerófilas con formas psamófilas de mucho valor para la fijación de las arenas movedizas.

La diferenciación exterior de la vegetación se forma por la dominancia en su composición de uno u otro grupo biológico o combinación de varios grupos biológicos de plantas. En ambos casos se cambia, no solo la estructura de la cubierta vegetal, sinó también el ambiente ecológico, en particular las condiciones edáficas e hídricas. Aún los mínimos cambios referentes a la humedad del suelo, composición química, tipo, relieve, etc., provocan de inmediato los correspondientes cambios de la cubierta vegetal.

La mayor parte de la vegetación patagónica es arbustiva y se compone de uno a tres estratos: el primero está constituído por arbustos, el segundo de arbustos y semi-arbustos y el tercero de semi-arbustos ananos y hierbas ralas. Estas cubiertas no forman estratos cerrados, pre-

* En varias zonas de la estepa patagónica, se observan árboles petrificados, impresiones de plantas sobre las piedras—en el borde del valle del río Chubut—, etc.

sentándose frecuentemente en ejemplares aislados o grupos pequeños. La densidad promedio de la cubierta vegetal oscila entre 10 y 40%, por lo que la mayor parte de la superficie queda desnuda. Los arbustos son bajos, de 40 a 200 cm de altura, con promedio de 130 cm; la mayoría de ellos sirven como forraje para los animales y también como combustible para los pobladores.

Casi toda la superficie de la Patagonia está sometida al pastoreo continuo, principalmente de ovinos y una reducida parte en los valles de los ríos se destina para cultivos de frutales, hortalizas, etc.

Por el uso irracional de los campos durante varios decenios, el pastoreo recargado, explotación excesiva de leña, etc., los suelos y su vegetación se encuentran en un estado general que puede clasificarse como poco satisfactorio y en algunos casos como malo, localmente como crítico y hasta desesperado. Así, por ejemplo, en varios lugares las plantas han sido ramoneadas en tal escala, que los arbustos presentan formaciones completamente degeneradas y raquíticas y los semi-arbustos formas de cepas muy bajas o con su parte aérea desaparecida totalmente hasta el ras del suelo. El papel protector de tal vegetación es muy ínfimo.

La fértilidad del suelo se ha reducido notablemente y continúa su empobrecimiento cada vez más; el nivel freático de los suelos bajó mucho provocando la desecación de los mismos; los ríos, no teniendo protección de árboles, se secan o se ensucian; la vegetación disminuye contínuamente. La erosión abarca ya, en distinto grado, una gran superficie de la Patagonia.

Concluyendo podemos decir que los suelos y la vegetación de la Patagonia se encuentran en situación mala y es imprescindible tomar medidas para su regeneración y mejoramiento.

El problema de recuperación de los suelos y de la vegetación, debe basarse, en primer término, en los esfuerzos orientados a la reducción del factor perjudicial de la sequía; esto puede resolverse hasta cierto límite, mediante los siguientes métodos técnicos:

A. Pasivos

Plantación con especies autóctonas elegidas entre las más resistentes a las sequías, para ampliar su área de dispersión hacia regiones más áridas.

B. Activos

1. Lucha contra los vientos mediante plantaciones especiales de protección—cortinas, macizos de bosques o de matorrales, etc., lo que permitirá mejorar sensiblemente el microclima.
2. Eliminación de plantas inservibles para los fines protectores o industriales.
3. Introducción de especies exóticas nuevas[1]
4. Selección y crianza de especies más resistentes a la sequía.
5. Labranza adecuada de la tierra cultivable, para acumular más agua en el suelo.
6. Acumulación de la nieve (en las provincias de Chubut (suroeste) y de Santa Cruz).
7. Manejo racional del pastoreo.
8. Irrigación artificial, usando las aguas superficiales y subterraneas.
9. Construcción de reservas hídricas.
10. Aplicación de medidas de hidrotécnia simple para la lucha contra la erosión, reforzando las pendientes, fondos de cañadones, zanjones, etc.

Citados todos los métodos de posible aplicación, se hace seguidamente el análisis de uno de ellos, motivo especial del presente trabajo: Principios básicos para la elección de las especies más adecuadas para las plantaciones protectoras, con las cuales se quiere llegar al éxito completo.

La tarea mencionada no es tan fácil de resolver, como parece a primera vista, y para su análisis puede descomponerse en las siguientes partes:

1. Elección de las mejores especies autóctonas.
2. Elección de las mejores especies exóticas, ya aclimatadas.
3. Elección de las nuevas especies exóticas de mayor posibilidad de adaptación.

1. La elección de las especies autóctonas ya aclimatadas no es difícil; para esto se necesita conocer bién sus propiedades biológicas y condiciones ecológicas óptimas y mínimas de su habitat natural.

Las especies autóctonas que poseen más alta resistencia fisiológica, tienen mayores perspectivas para asegurar el éxito en la lucha contra las sequías, los vientos, etc.; de entre éstas deben ser preferidas las menos exigentes a los suelos y de mayor, valor forrajero, etc.

2. Casi lo mismo se puede decir sobre las especies exóticas ya aclimatadas (*Tamarix* spp., *Elaeagnus angustifolia, Ulmus pumila, Cupressus* spp., etc.)

3. Otro aspecto ofrece el problema de la introducción de nuevas especies exóticas. Ante todo es necesario acumular los datos completos de estas especies, relacionados a su habitat óptimo, para poder ensayar su adaptación en las condiciones ecológicas más cercanas posibles.

La dedicación a la introducción de las especies exóticas a ensayar, no debe ser excesiva, siendo conveniente prestar más atención a la utilización de las especies autóctonas y exóticas ya aclimatadas. La introducción de plantas exóticas nuevas en unas u otras condiciones ecológicas determinadas, practicamente es muy limitada, pués exiten muy pocas cantidades de plantas que puedan prosperar bien, en éllas.

Muchas veces las dificultades de adaptación, que surgen de un análisis teórico, indican como no apropiada la elección de una especie determinada.

Para explicar mejor las dificultades que podrían suceder durante la aclimatación de especies exóticas, indicaremos algunos ejemplos de su reacción a las nuevas condiciones ambientales, como asi también el comportamiento de las especies mesofíticas y xerófilas respecto al mismo factor, el progresivo aumento de su intensidad a la sequía.

1. Si la especie se propaga en condiciones análogas a su habitat natural, crece y se desarrolla rápidamente.
2. Si la especie se propaga en regiones más frías de su habitat natural, crece rápidamente, pero desa-

[1] Las condiciones ecológicas precarias de las zonas áridas limitan las posibilidades de utilizar las especies nuevas, para su adaptación, en cantidad notable; además de esto en nuestro planeta se presenta para determinada región ecológica un número de especies que es relativamente muy limitado.

rrolla lentamente y varios ejemplares no cubren el ciclo completo de su desarrollo y no florecen.

3. Si la especie se propaga en condiciones climáticas óptimas de crecimiento, pero en suelos más pobres que los que exige, crece lentamente pero se desarrolla rápidamente y florece temprano.
4. Si la especie se propaga en condiciones climáticas y de suelo inferiores a las que exige comúnmente, su crecimiento y desarrollo serán lentos—podrán no florecer durante varios años.
5. Bajo un progresivo aumento de la intensidad de los factores de sequía, en las especies mesófilas, los procesos de transpiración podrán presentarse aproximadamente en la siguiente forma:

   Al principio la transpiración sumentara considerablemente, pero al cabo de poco tiempo con mayor cantidad de agua, compensará el gasto de la misma y los estomas acuíferos de sus hojas de cerrarán; como resultado, la transpiración disminuirá considerablemente y la asimilación se detendrá, pero como la transpiración por la cutícula será relativamente grande, el consumo de agua hará crecer rápido a la planta, lo que producirá su marchitamiento y si la sequía se prolonga, esta se secará totalmente.
6. Bajo un progresivo aumento de la intensidad de los factores originarios de la sequía, en las especies xerófilas, sus procesos de transpiración podrán presentarse aproximadamente en la siguiente forma:
   a. en un principio la transpiración hará crecer la planta y como sus estomas no se cierran por largo tiempo habrán de perder más agua que las especies mesófilas; pero esto no significará ningún peligro pués sus tejidos poseen características especiales, que le permitirán resistir las sequías más elevados y soportar sin perjuicios, una gran reducción del agua contenida;
   b. la asimilación será más larga que en las mesófilas; posteriormente también en las xerófilas los estomas de las hojas se cerraran y transpirarán sólo por la cutícula; como esta es mucho menos penetrable, especialmente en un estado de media sequedad, la pérdida de agua se reducirá al mínimo; la planta se encontrará en estado de marchitez, reteniendo además—durante un lapso largo—un mínimo de agua, la necesaria para la conservación de su actividad vital;
   c. después de llegado el período más húmedo, la planta se restablecerá y reanudará su actividad vital.
7. La sensibilidad de la planta a la sequía, en distintas etapas de su desarrollo, no es igual; así, por ejemplo, las plantitas de árboles de un año de edad, sufren de sequía generalmente al principio de su desarrollo, más tarde su resistencia aumenta a medida que se desarrolla el sistema radicular.
8. La especie xerófila resistente a la sequía, pero criada en condiciones de exceso de agua, tendrá menor resistencia a la misma.

Resumiendo, podemos concluir que para favorecer la tarea de elección de especies arbóreas arbustivas y herbáceas, con fines de regeneración y mejoramiento de suelos y de la cubierta vegetal de la Patagonia, se necesita:

   a. primeramente establecer una clasificación, dividiéndola en regiones fisico-geográficas según las diferencias topográficas, climáticas, edáficas, etc. Dentro de cada región conviene establecer subregiones en base a las particularidades menores, como ser: exposición, altura sobre el nivel del mar, zanjones, recursos hídricos, etc.;
   b. en segundo lugar, elegir para cada región o subregión las especies más convenientes, dando preferencia a las autóctonas, después a las exóticas, ya aclimatadas y conocidas y, por último, las exóticas nuevas a introducir.

RESUMES

Basic Principles in the Selection of Species in Forest Improvement of Arid Patagonia

One of the principal conditions for ensuring the success of forest-improvement work in Patagonia (to establish windbreaks and shelterbelts) is the proper selection of tree, shrub, and grass species. If this is not done, it is impossible to obtain biologically stable plantations that are productive and have a high protective capacity.

The correction of errors in plantations requires unproductive expenditures over a period of many years and frequently results in total failure. Therefore, the selection of suitable species must be made with great care. Before making the selection, it is necessary to classify Patagonia according to physicogeographical regions and subregions and then proceed with the selection of the most suitable species for each region, first choosing the native species, then the exotic species that are already acclimated and well known, and finally, new exotic species that are to be introduced.

The species selected must meet the following general requirements:

1. Make good growth under the ecological conditions of the site;
2. Have a long life span.

The desirable characteristics resulting from the first condition may be stated as follows:

1. Possession of a strong root system:
2. In windbreaks, development of deep, rather than shallow, broad root systems, so as not to damage crops;
3. Good height growth;
4. Good crown development;
5. Capability of forming with their crowns a continuous tree cover in a few years;
6. Provision of shade for the soil;
7. Easy regeneration through seeding and sprouting;
8. Good growth and development in mixed plantings;
9. Weed-resistance;
10. Ability to withstand snow, if in a snow belt;
11. Does not transmit disease;
12. Can be used preferably as forage for stock;
13. Preferably, its fruit is edible by the regional fauna;
14. The timber should have industrial value.

Principes fondamentaux régissant la sélection des espèces en vue de l'amélioration agro-forestière de la Patagonie aride

La sélection correcte d'espèces arborescentes, frutescentes et herbacées constitue l'une des conditions principales de succès des travaux d'amélioration forestière entrepris en Patagonie en vue d'établir des couverts et des massifs boisés de protection; à moins de remplir ces conditions, il est impossible d'obtenir des plantations forestières biologiquement stables, productives et douées d'une grande capacité protectrice.

La correction d'erreurs commises dans la plantation occasionne, pendant de nombreuses années, des dépenses improductives et bien souvent se traduit par un échec total. Voilà pourquoi il est nécessaire d'apporter le plus grand soin et la plus grande at-

tention à la sélection de l'espèce appropriée. Avant d'aborder la sélection des espèces, il est indispensable d'établir une classification des régions et sous-régions physico-géographiques de la Patagonie; il faut ensuite procéder à la sélection des espèces convenant le mieux à chacune d'elles, en commençant par les espèces autochtones, suivies des espèces exotiques déjà acclimatées et connues, et en terminant par les espèces exotiques qu'il s'agit d'introduire.

Voici quelles sont les exigences d'ordre général auxquelles devra satisfaire l'espèce sélectionnée:

1. Faire preuve d'une bonne croissance dans les conditions écologiques du lieu;
2. De préférence, être dotée de longévité.

Les caractéristiques qui découlent de la première condition peuvent être classifiées de la façon suivante:

1. Avoir un fort système radiculaire;
2. Dans le couvert forestier protecteur, ne pas développer de racines superficielles s'étendant sur une grande périphérie, afin de ne pas endommager les cultures;
3. Faire preuve d'un accroissement en hauteur;
4. Avoir une cime bien développée;
5. Avoir la faculté de former en peu d'années, en joignant les cimes, une couverture continue;
6. Bien ombrager le sol;
7. Se régénérer facilement au moyen de semis ou de pousses;
8. Bien croître et se développer dans des plantations mixtes;
9. Résister à l'envahissement par les broussailles;
10. Supporter la neige, quand il s'agit d'une zone neigeuse;
11. Ne pas être un agent transmetteur de maladies;
12. De préférence, servir de fourrage au bétail;
13. De préférence, porter des fruits qui soient comestibles pour la faune régionale;
14. Il est désirable que son bois ait une valeur industrielle.

Forest Remains of Interior Asia Minor

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The geographic term "Asia Minor" closely coincides with the Anatolian peninsula of Turkey, an area of 743,-634 km^2, which forms the major part of the country. Interior Asia Minor, also known as Central Anatolia, is a typical semi-arid region due to the fact that it is situated largely within the rain shadows of the coastal mountains.

Interior Anatolia is a plateau inclining from an elevation of 1,200 m. in the south toward an elevation of 800 m. in the north. It includes the province Kirsehir wholly and the provinces of Ankara, Çankiri, Çorum, Yozgat, Sivas, Kayseri, Nigde, Konya, Eskisehir largely, according to the geographic zonation made by the first Turkish Geographic Congress held in Ankara in 1941.

The continental climate of this area is characterized by the scarcity of precipitation accompanied by high temperature during summer and fall and very cold temperatures during the winter and early spring months. The most precipitation occurs during the latter-mentioned seasons. The lowest average annual precipitation is found in Cihanbeyli (275 mm.); it amounts to 336 mm. in Konya, 341 mm. in Ankara, 351 mm. in Çankiri, 362 mm. in Eskisehir, 363 mm. in Nigde and Kayseri, 377 mm. in Kirsehir, 419 mm. in Sivas and 528 mm. in Yozgat. The average minimum temperature drops below zero throughout the central plateau during the winter; the lowest absolute minimum temperature is reached in Sivas (—34.4° C.) and the highest in Ankara (—24.9° C.).

A steppe vegetation of xeromorphic small trees, shrubs, grasses, thorny or hairy stout perennial herbs, geophytes and ephemerals dominate interior Anatolia today. Opinions regarding the original nature of the vegetation here differ greatly among foresters and botanists. Some of the opinions are that the present steppe is man-made through destruction of forests which once existed extensively in the area, while others claim that central Anatolia has never been covered by forests, due to unsuitable environmental factors for the growth of trees. Our knowledge on the historical phytogeography of Asia Minor is inadequate to prove or disprove either opinion. However, the travel notes of Tournefort (1701), Fellows (1838), V. Vincke (1838), Philippson (1910-1915) and several others describe the presence of thick forests of oaks and conifers in various localities which are lacking any signs of woodland today. Furthermore, I recall the beautiful Tertiary fossils of leaves and fruits of maples, willows, hawthorns and chestnuts recovered by Turkish foresters at construction sites of roads, highways or building foundations and shown to me as articles of curiosity. The natural woodlands scattered as islets of various sizes throughout the central Anatolian steppe might be the relics of ancient forests which once dominated the area, but disappeared during glaciation and subsequent alternating drought periods. A paleobotanical survey comparing the elements of past and present vegetation of this region would be invaluable to understand the possible relation to the Tertiary flora.

The woodlands of the central Anatolian plateau are represented in three types today: (1) Riparian forests; (2) Montaine forests; and (3) Transitory forests.

1. *Riparian forests,* known as "Galeriewaelder" in the German literature, form gallery-like thickets along rivers and streams. They are composed of trees and shrubs such as *Elaeagnus angustifolia* L., *Hippophae rhamnoides* L., *Populus alba* L., *P. nigra* L. var. *italica* Du Roi, *Salix alba* L. var. *micans* And., *S. purpurea* L., *S. caprea* L., *Platanus orientalis* L., *Tamarix pentandra* Pall., *T. tetrandra* Pall., *Fraxinus oxycarpa* Willd., *F. syriaca* Boiss., *Rhamnus frangula* L., *Crataegus aronia* Boiss., *C. orientalis* Pall., *Acer opalus* Mill., *Cornus mas* L., etc. We notice that most of the species just mentioned are deciduous, mesomorphic or hydromorphic woody plants dependent on the presence of ground water and resistant to cold winters. The riparian forests in the central plateau are fortunately being increased from day to day, especially near settlements, due to a tradition of the Turkish peas-

ants which involves planting Lombardy poplars upon the birth of a child in the family to insure the wood supply of the future generations.

2. *Montaine forests,* so-called "Bergwaelder" in the German literature, cover the summits of mountains, especially near the marginal zones of the central plateau as shown on a map of Turkey. I attempted to produce a list of the scattered islets of montaine forests by combining my personal observations with those cited in the literature, but their exact localities, actual extents and detailed botanical inventories await further phytogeographic and floristic explorations.

At present, there is no reliable evidence to convince us that the numerous islets of forests were connected with each other, forming a continuous forest land, in the past. However, we do know that the individual islets occupied larger areas in the past than their present extents and that their sizes shrank due to forest fires, uncontrolled grazings, uprootings to gain agricultural land, and, above all, due to irregular cuttings to obtain timber and fuel. The forest destruction in the central plateau continues at an observable rate. That is why I designate the remnants of the present montaine forests as "forest remains," which struggle for survival under the pressure of human interference and subsequently changing environment. The lower limits of the remains of montaine forests are pushed constantly toward the higher elevations, and consequently, the forests face complete extermination. Today, the lower limits of the montaine forests lie between 1,200-1,400 m. in the northern and central parts of interior Analolia, between 1,400-1,600 m. in the eastern part, between 1,300-1,400 m. in the southern part and between 1,000-1,200 m. in the western part.

The conifers that occur most commonly in the montaine forests are: *Pinus nigra* Arn. var. *caramanica* Rehd., *P. sylvestris* L., *Juniperus excelsa* Bieb., *J. foetidissima* Willd., *J. communis* L. var. *saxatilis* Pall. and *J. oxycedrus* L. var. *rufescens* Asch. & Graebn. *Abies bornmuelleriana* Mattf. grows mixed with pines or broadleaved trees near the northern boundary of interior Anatolia, as I observed in Çamkoru, Kizilcahamam and in Karagöl, north of Çubuk. This species, however, is not a typical conifer of the area, and I consider it as an intruding element of the Colchian forests of the Black Sea coast of Turkey. Deciduous oaks such as *Quercus pubescens* Willd., *Q. haas* Ky., *Q. aegilops* L. and *Q. cerris* L. are associates of conifers. *Quercus pubescens* has a wider distribution than any other tree species in interior Anatolia. It forms pure coppice forests by itself, but they are highly denuded and mostly in creeping form under the pressure of overgrazing. However, they recover very well under protection, as I observed on the way to Kizilcahamam, about 60 km. north of Ankara. Other deciduous-broadleaved trees and shrubs that occur often in montaine forests are: *Acer hyrcanum* Fisch. & Mey. var. *tauricolum* Boiss., *A. campestre* L., *Amelanchier vulgaris* Moench, *Cotoneaster nummularia* Fisch. & Mey., *Cistus laurifolius* L., *Crataegus azarolus* L., *C. monogyna* (Willd.) Jacq. var. *typica* Beck., *Evonymus verrucosus* Scop., *Jasminum fruticans* L., *Ligustrum vulgare* L., *Pyrus elaeagrifolia* Pall., *Prunus domestica* L. var. *insititia* Poir., *P. spinosa* L., *Pyracantha coccinea* (L.) Roem. var. *kuntayi* Kasapligil, *Sorbus aria* Crantz, *S. torminalis* L. and *Viburnum lantana* L.

I should like to emphasize here that the species enumerated represent ecologically highly specialized races that can endure severe low winter temperatures and critically long summer droughts. Thus, the montaine forests of interior Anatolia should be considered as valuable sources of forest tree seeds for reforestation and establishment of shelterbelts, highway and park plantations in interior Anatolia as well as in the comparable regions of the adjacent countries.

3. *Transitory forests* represent the transition zones from montaine forests into true steppe. They are characterized by small, xeromorphic trees and shrubs scattered distantly in the steppe around the montaine forests. This type of forest, known as "Baumsteppe" or "Uebergangszone" in the German literature, is an association of forest trees and shrubs with the elements of the steppe vegetation. In addition to the species given above, several other woody plants are commonly found: *Amygdalus orientalis* Ait., *A. webbii* Spach, *Atraphaxis billardieri* Jaub. & Spach, *Berberis crataegina* DC., *Celtis tourneforti* Lam., *Colutea arborescens* L., *Crataegus tanacetifolia* Boiss., *Eurotia ceratoides* (L.) C. A. Mey., *Lycium barbarum* L., *L. ruthenicum Murr., Paliurus aculeatus* Lam., *Rhamnus petiolaris* Boiss., *R. tinctoria* W. K., *Rhus coriaria* L., *Rosa canina* L., *R. sulphurea* Ait. and *Ulmus campestris* L. var. *suberosa* Ehrh.

Transitory forests are accompanied by bunch grasses and cushion-forming plants such as *Astragalus* and *Acantholimon* in high altitudes and by many species of annual or perennial steppe plants in lower elevations. The ground is partly covered by the vegetation in either case. There is no doubt that the transitory forests have an environment more xeric than the montaine forests and that the trees and shrubs of these areas represent ecotypes extremely tolerant to cold temperatures and drought.

Some of the local species have been used for the establishment of shelterbelts by the Institute of Forestry Research of the Turkish Forestry Service in Bala, Ankara, since 1954. Native oaks raised by spot-sowing in the fall show remarkable survival rates: *Quercus haas,* 86%; *Q. pubescens,* 70%; *Q. aegilops,* 61%. Local pines, wild pears, Russian olives, elms and mulberries planted as seedlings are also very promising, with satisfactory growth and survival rates. On the other hand, all local junipers sown in the area did not germinate at all. A 5% germination rate was obtained within two years in the case of *Paliurus.* Studies to understand the nature of seed dormancies and germination habits of the local trees and shrubs are needed, along with the knowledge of their ecological requirements, in order to achieve successful planting practices.

Afforestation directly in the steppe would be costly, due to high irrigation and maintenance expenses, unless the plantations would be required to control soil erosion or act as windbreaks in agricultural land. Reforestations of the denuded montaine forests, however, can be carried out with reasonable expenditure since the environment is still suitable for tree growth. The population of the capital city of Ankara, as well as of other cities in interior Anatolia, is growing rapidly, and there is a crying need for recreational forests. Protection and restoration of the forest remains would be a solution to this problem also.

RESUMES

Vestiges de la forêt a l'intérieur de l'Asie Mineure

L'intérieur de l'Asie Mineure est un milieu semi-aride typique où croît surtout une végétation de steppe. On y trouve, sur toute l'étendue du plateau central anatolien, à l'exception du bassin extrêmement salin de Tuz Golu (Lac salé), des îlots épars de forêts. Il y a, dans cette région, trois types de surfaces boisées: (1) forêts riveraines, qui suivent les berges des cours d'eau ou leurs lits desséchés; (2) forêts montagneuses, circonscrites aux sommets des montagnes et à leurs vallées protégées; et (3) forêts de caractère transitoire, qui représentent des zones de transition entre les forêts des montagnes et la vraie steppe, que caractérisent des arbres et arbrisseaux disséminés parmi les plantes xéromorphiques de la steppe. On trouve, dans la présente communication, la nomenclature des principaux arbres et arbustes appartenant à chacun de ces trois types de forêts, et, sur la carte de cette région, l'indication de l'emplacement des 38 vestiges de forêt. Les espèces locales d'arbres et d'arbustes sont bien adaptées à la région du point de vue écologique et se prêtent fort bien au reboisement et au boisement des régions semi-arides, à condition que soient étudiées à fond les méthodes de leur propagation et leurs besoins d'ordre écologique. Les essais auxquels se livre actuellement l'Institut de Recherches forestières du Service forestier turc, en vue d'établir des rideaux protecteurs à l'aide d'espèces locales, s'annoncent fort bien. La régénération des vestiges de la forêt montagneuse offrirait des stations de loisirs à l'usage de la population croissante de l'Anatolie intérieure; cette forêt régénérée pourrait aussi, si le besoin se faisait pressant, devenir une source complémentaire d'approvisionnement en bois.

Existencias Forestales en el Interior de Asia Menor

El interior de Asia Menor presenta características clásicas de una región semiárida en la que predomina la vegetación de las estepas. En la meseta central de Anatolia, con excepción de la cuenca salina de Tuz Gölü (Lago Salado), se presentan superficies aisladas cubiertas de bosques. En esta región se encuentran tres clases de bosques: (1) Los ribereños que se extienden a lo largo de las márgenes de ríos o de lechos secos; (2) Los de montaña cuya presencia se limita a las cimas de las montañas o a los valles protegidos por las mismas; y (3) Los transitorios que constituyen una zona de transición entre los bosques de la montaña y la vegetación de la estepa que se caracteriza por árboles y arbustos aislados de la familia de plantas xeromórficas. En este trabajo se señalan las principales especies de árboles y arbustos de cada una de las clases de bosques y en un mapa de la región se indica la ubicación del remanente de 38 bosques. Las especies locales de árboles y bosques se han adaptado ecológicamente a la región y pueden ser utilizadas con éxito para la reforestación y el establecimiento de bosques nuevos en las zonas semiáridas, siempre que se estudien convenientemente de antemano sus métodos de propagación y sus necesidades ecológicas. Los experimentos llevados a cabo por el Instituto de Investigaciones Forestales del Servicio Forestal de Turquía para establecer fajas de protección con especies locales, han producido resultados prometedores. La restauración de los remanentes de los bosques de la montaña proporcionaría excelentes zonas de recreación para la población cada vez más numerosa del interior de Anatolia; asimismo, pueden llegar a transformarse en una adición para el abastecimiento de madera en épocas difíciles.

Comments

Alessandro De Philippis (Italy):

M. Goor a exprimé l'opinion qu'en pays aride ou semi-aride il s'agit aujourd'hui d'établir où planter plutôt que comment planter.

Je suis d'accord avec cette affirmation, mais je crois que M. Goor ait trop généralisé certains aspects du problème.

C'est bien vrai que les plantations d'arbres établies dans certains pays, tels que l'Afrique du Sud, l'Australie, la Nouvelle Zelande, l'Espagne du Nord, etc., bien faites et bien soignées, ont donné d'excellents resultats, mais il ne faut pas oublier que la plupart de ces plantations se trouvent dans des régions qui ne sont ni arides ni semiarides, et dans des stations, en général, plus ou moins favorables.

Des stations comparables dans les pays méditerranéens ne sont pas fréquentes; en tout cas les plaines et les bons sols sont occupés, par l'agriculture. Il y a, par contre, d'énormes surfaces en colline et en montagne où la végétation a été détruite par le pâturage, surtout des chèvres, et où le sol a disparu ou presque à cause de l'érosion.

Dans ces terrains le reboisement est absolument indispensable pour la reconstitution et la protection du sol. Il s'agit, sans doute, d'une oeuvre longue et difficile qui demande d'efforts financiers considérables et dont les resultats au point de vue de la production de bois peuvent être modestes ou même négligeables, mais tout forestier méditerranéen connait les raisons pour lesquelles on ne peut s'en passer.

Je crois pourtant qu'il faut bien distinguer entre la plantation d'arbres qui vise surtout à une production accélérée et élevée de bois, qu'on peut appeler arboriculture, forestiere e le reboisement à proprement dire qui, de plus, repond le mieux au concept des usages multiples de la forêt.

On peut bien faire de l'arboriculture forestière aussi dans les pays méditerranéens, là où les conditions sont favorables à la plantation et à l'élevage d'arbres à croissance rapide, tels que les peupliers, les eucalyptus, certains pins, mais *on ne peut pas et on ne doit pas* négliger le reboisement des sols denudés à vocation forestière et l'amélioration de la végétation naturelle, même s'il s'agit d'actions coûteuses et non rentables en termes de production de bois. Une conclusion différente serait, à mon avis, extremement dangéreuse pour la sylviculture des pays méditerranéens aussi bien que pour celle d'autres pays à climat plus ou moins aride.

Javier Prats-Llaurado (Honduras):

Señor Presidente, Señores: Agradezco esta oportunidad de comentar brevemente el tema de la relación entre el pastoreo y el bosque, que de manera tan competente han desarrollado, en esta sesión, los oradores precedentes. En este comentario me voy a referir especialmente a España, como miembro supernumerario de su Servicio Forestal.

En relación con el pastoreo en el bosque, las áreas forestales españolas pueden dividirse en 4 grupos principales:

1. *Areas forestales donde el pastoreo está prohibido:* que incluyen los bosques protectores y las áreas de alta productividad forestal;

2. *Areas forestales donde el pastoreo está tolerado:* que comprenden los bosques públicos bajo control de la Administración Forestal y la mayoría de los grandes bosques de propiedad privada, no comprendidos en el grupo 1.

3. *Areas forestales donde el pastoreo está equilibrado:* constituidas principalmente por las masas de encina (*Quercus ilex* L.) del Sur y Suroeste de España, donde existe una integración satisfactoria de una formación forestal estable, con una producción ganadera continua y altamente rentable.

4. *Areas forestales donde el pastoreo está irrestricto:* Que incluyen la mayor parte de los pequeños bosques privados y los bosques comunales. Este grupo presenta

muchas de las condiciones descritas por el Dr. Margaropoulos con referencia al área mediterránea en general.

La evolución de la importancia relativa de estos grupos de bosques, durante los ultimos años, permite deducir alguna indicación sobre las tendencias futuras de las relaciones entre el pastoreo y el bosque, en el área mediterránea.

Mientras los grupos 1 y 3 son relativamente estables, el grupo 4, es decir, las áreas forestales sometidas a pastoreo libre o irrestricto, se encuentran en España en franca disminución, no tanto por coerción administrativa, como por el juego espontáneo de los factores socio-económicos. En estas áreas, el pastoreo no es generalmente un buen negocio, sino una actividad marginal impuesta por factores sociales y demográficos.

Acompañando a la población humana, que emigra de las áreas de montaña hacia las nuevas áreas de regadio y hacia los centros industriales, la ganadería pesa cada vez menos sobre el bosque, y cada vez más sobre las áreas agrícolas, en particular sobre las áreas irrigadas.

En este contexto, que probablemente no es exclusivamente observable en España, la superposición de los usos forestal y pastoral de la tierra, problema clásico de la silvicultura eumediterránea, parece destinado a perder progresivamente su importancia, a medida que avanza la industrialización de los países mediterráneos.

En otro sentido, la evolución registrada en las áreas forestales donde el pastoreo está tolerado (grupo 2), también puede resultar significativa. En estas áreas, el pastoreo debe considerarse sólo "tolerado" ya que está regulado en forma más o menos estricta, a veces con normas técnicamente refinadas, pero casi siempre con la consideración implícita de su subordinación, más que de su integración, al aprovechamiento forestal.

Recientemente, dos factores de orden técnico han venido a facilitar, en España, el propósito de la Administración Forestal de modificar esta situación. Uno de estos factores ha sido la aplicación, cada vez más generalizada, del método de Braun-Blanquet para el estudio de las comunidades vegetales. El segundo ha sido el creciente contacto de los forestales españoles con los procedimientos desarrollados en los Estados Unidos de América para el estudio y la administración de los pastizales naturales. Hasta ahora, prescindiendo de los considerables progresos logrados en el campo de la observación sistemática, la experimentación y la enseñanza, un cierto número de mejoras han pasado ya al nivel de aplicación por la Administración Forestal de España. Entre ellos podemos citar: (a) dedicación de sumas importantes a la mejora de los pastizales en los montes públicos; (b) organización más cuidadosa del pastoreo tanto en relación al espacio como con relación al tiempo; (c) tendencia a evaluar la carga de ganado no por número de cabezas, sino por peso; (d) aplicación de varios planes-piloto de ordenación silvo-pastoral; y (e) tendencia a favorecer el cambio de ganado cabrío a lanar, y de lanar a vacuno.

Estos hechos parecen indicar que, en España, las posibilidades de lograr una verdadera integración entre los usos forestal y pastoral, en el sentido indicado por el profesor Raymond Price, se encuentran principalmente en las áreas que hemos clasificado como de pastoreo "tolerado," es decir, donde la productividad forestal no es la más alta, ni la productividad pastoral la más baja, ya sea actual o potencialmente.

Muchas gracias.

Christos Moulopoulos (Greece):

En ce qui concerne l'objection faite de la part de M. De Philippis au rapport présenté par M. Goor (Israël), selon lequel "le reboisement sur les terrains arides et semi-arides des pays méditerranéens n'est indiqué que sur des sols riches et même irrigués," nous croyons que M. Goor a raison dans le cas où il s'agit des régions arides.

Mais M. De Philippis a aussi raison, parce qu'il parle des reboisements dans les régions semi-arides, où la reforestation peut être économiquement indiquée.

En Grèce, les deux cas se présentent.

Jean Messines-Paviot du Sourbier (France):

Les travaux préconisés par M. Monjauze, nécessitent, on s'en doute, des dépenses élevées. Le sujet traité, comme l'a dit M. De Philippis est celui de l'arboriculture forestière ou de la culture d'arbres. Ce n'est plus de la sylviculture ou tout au moins la doctrine s'écarte largement de celle de la sylviculture traditionnelle. Nous pensons personnellement que l'application de ces méthodes en zones arides est le gage obligé du succès, et que l'on devrait entreprendre dans tous les pays considérés une expérimentation en grand des dites méthodes.

L'auteur n'a pas abordé dans son étude les problèmes d'ordre social et économique.

Je pense que de tels travaux sont justifiés dans les zones arides et semi-arides en raison tout d'abord du rôle important qu'ils jouent dans tous les pays pour la régularisation du régime des eaux et la lutte contre l'érosion sous toutes ses formes: érosion éolienne, érosion torrentielle linéaire ou érosion diffuse aréolaire par les eaux de ruissellement. Mais de plus, ils sont susceptibles, au point de vue économique, d'augmenter la production ligneuse en quantité et en qualité—de créer des ressources nouvelles en bois d'oeuvre et en bois de feu.

Dans les pays arides, la seule consommation de bois de feu est encore à l'heure actuelle, très importante et l'augmentation des ressources ligneuses de cette catégorie, non seulement améliore les conditions d'existence des populations, mais en outre, soulage les terrains de parcours, dont les dernières plantes vivaces sont arrachées et utilisées comme combustible.

Ces reboisements entrepris selon les méthodes coûteuses, ci-dessus exposées, sont donc particulièrement recommandés dans les pays surpeuplés, à forte pression démographique. Nous voici loin de la conception des terrains de parcours boisés et de l'utilisation mixte: forêt et pâturage.

Il faut cependant comprendre que ces méthodes de sylvicultures accélérée (ou intensive) doivent être combinées, ou intégrées, selon l'expression à la mode, dans des plans d'ensemble, avec d'autres travaux d'améliorations agricoles et d'améliorations pastorales.

C'est le problème de l'amélioration des terrains de parcours boisés et non boisés—nécessitant une action parallèle, et dont le but final est la transformation de l'élevage extensif, l'incorporation même des pratiques pasto-

rales et de l'élevage du bétail dans l'exploitation agricole sédentaire.

Mais ceci dépasse le cadre de l'étude de M. Monjauze.

Thadis W. Box (U.S.A.):

It appears to me that most of the problems we face are more sociological than biological. In fact, I have concluded that the problem of successful application of well-known biological principles to land use is one of the most challenging facing the forester or range manager today.

In his paper on the Mediterranean region, Mr. Margaropoulos stated that successional patterns in large areas had been changed by sheep-grazing to the extent that they were now more suitable for grazing by other classes of livestock. Indeed, this is true in all countries where grazing by a single class of livestock is practiced. In the sub-alpine regions of Utah the late Lincoln Ellison has described different successional patterns under sheep and cattle grazing. This animal-induced succession can be used as a tool for range improvement by the forester.

Work at the Sonora, Texas, experiment station and by workers at our own institution of Utah State University have shown that the total safe carrying capacity of the range can be increased by a combination of classes of livestock. Texas workers have shown that by combining cattle, sheep, and goats in the same pasture they can obtain a more uniform utilization of the plant species and control plant succession by using the different forage preferences of the animals to reduce the cover of undesirable plants while allowing the desirable ones to increase.

This concept of common use of rangelands, and forest ranges in particular, is biologically sound but is unpopular with many people. Admittedly, the use by several classes of livestock increases both the administrative and sociological problems of the range administrator. However, if we are to furnish our growing population with the livestock products it is sure to demand, then we must make the most efficient use of our range resources, regardless of the added management problems involved.

Foresters and range managers themselves must obtain more basic knowledge about the areas which they manage. It has been suggested this afternoon that the investment of outside energy may be necessary to obtain proper soil restoration. It is time that foresters and range managers alike start thinking of their forested areas as ecosystems from which they are constantly removing energy in the form of timber or livestock products. In many cases, there is no provision made for the restoration of that energy. Only two avenues are open to us. We can continue to remove stored energy indiscriminately and find ourselves faced with the costly process of restoring that energy through reforestation, reseeding, fertilization, etc., or we can manage our ecosystems so that the energy drain will be minimized. This will require management backed by scientific fact. Food chains and energy transfer mechanisms will have to be studied in detail. Systems of grazing and timber harvest will have to be designed that will allow the producer organisms, or plants, to capture the maximum amount of solar radiation and return it to the system as stored energy.

The problem of integration of forestry and grazing is not a simple one involving only livestock and trees. It is a problem so complex that it takes in all living organisms from viruses to man. First we must endeavor to understand the complex interrelationships of this system and then we must manipulate the controlling factors of the ecosystem in order to reach and maintain the maximum level of energy capture and use consistent with the standard of living that man will accept.

We do not know the biological facts concerning our forest ecosystems, but we are constantly gathering more information on them. Once we have these facts, then the sociological problem of getting them accepted faces us.

Sessions D and E

Modern Concepts and Advances in Silviculture and Management
Concepts modernes et progrès réalisés en sylviculture et dans l'aménagement des forêts
Conceptos y Adelantos Modernos en Silvicultura y Administraciòn

The Silviculture and Management of Exotic Conifer Plantations In South Africa

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Historical Review of the Development, Management, and Silvicultural Treatment Of Exotic Conifer Plantations

Due mainly to the fact that only eight percent of its total area enjoys a so-called temperate humid climate, the Union of South Africa is poorly endowed with natural timber resources. Its indigenous forests make up only about one-half percent of the total land area, and practically all these forests were heavily exploited during the early settlement and subsequent development of the country. Bearing in mind that these forests have, in any case, a very low wood increment per acre and that they are composed principally of hardwood species, it is clear that they cannot ever make any substantial contribution to the country's timber requirements.

It was already appreciated some 80 years ago that efforts should be made to supplement the country's meagre timber resources by means of afforestation but, as local species were not suitable for the purpose, recourse had to be taken to the introduction of suitable exotics. The intensive introduction and trial of hundreds of species from various parts of the world, with climatic conditions comparable with those prevailing in the Union, met with considerable success, and flourishing pine plantations, composed of various species and covering an area of some 770,000 acres, today grace those regions where conditions are favourable for afforestation.

Having succeeded in introducing into the Union conifer species that thrived locally, and it having soon become apparent that their rate of growth greatly surpassed that attained by conifers in the Northern Hemisphere, the next step was to determine how such artificially established forests should best be managed for timber production. Because conditions in South Africa were so entirely different from those obtaining in Europe, where forest management had been practised for a considerable time in forests which had been the gift of nature, South African foresters had practically no information to go by and had to feel their way by trying various methods of soil preparation, planting, sowing and silvicultural treatment and had to be guided by the response to such varying treatments.

Initially, a policy of intense soil preparation, close espacements and very light thinnings was followed. Slow-growing species, such as *Pinus pinaster,* were broadcast-sown at the rate of up to 30 lbs. per acre, while fast-growing species, such as *Pinus radiata,* in the winter rainfall areas of the Cape, and *P. patula,* in the summer rainfall areas of the Transvaal and Natal, were first planted at espacements of 4 feet by 4 feet and 5 feet by 5 feet. Because, however, of the comparatively fast growth which caused suppression to set in much earlier than was commonly experienced in European forests, the tendency developed gradually to increase initial planting espacements. By about 1915, the espacement for *P. radiata* had increased to 6 feet by 6 feet, and by the early twenties, *P. patula* was being planted at an espacement of seven feet. For *P. pinaster,* broadcast-sowing was partially

replaced by spot-sowing or planting at an espacement of 5 feet. The latter espacements remained in force until 1938.

Until about 1917, the degree of thinning generally was very light. No definite prescriptions based on stems per acre were laid down, and officers were allowed a considerable amount of discretion. The following prescriptions extracted from the Annual Plans of Operation for Tokai Plantation are probably typical of this period:

> 1909/10: *P. pinaster,* 18 years old, 30 ft. in height, about 10,000 per acre. Suppressed and dominated stems to be removed for droppers, the trees being left at an espacement of about 2½ feet.
>
> 1912/13: Pines which are exhibiting signs of requiring more growing space will be thinned.
>
> 1913/14: Pines: 100 acres will be thinned by removing dead, suppressed and badly shaped stems.

From about 1920 onwards, the degree of thinning gradually shows an upward trend, ranging from 25% to as high as 40%. From about this time also, annual plans of operations became more specific, detailed lists of compartments being shown, and the actual number of stems per acre to be removed in each compartment being prescribed. This policy has been followed in South African forestry ever since.

By the early thirties, standard thinning regimes for all the more important conifer species, based on the then accepted principle of thinning more heavily on the better quality sites and more lightly on the poorer quality sites, were in general use throughout the Department and were issued as general instructions for the guidance of the field staff.

Pruning for the purpose of producing as much knot-free timber as possible has been standard practice in South African forestry since the earliest days. The degree of pruning has varied, and until 1931 it was the general rule to prune up to 200 stems per acre up to at least a height of 15 or 18 feet in practically all stands, and higher in some stands. As the first pruning operation was undertaken between the 8th and 15th years, it almost invariably involved the removal of dead branches only.

In 1931 all pruning was stopped for economic reasons, it being felt that the cost would not be justified by the results. In 1936 a modified policy of pruning was again adopted, which aimed at securing a minimum radius of four inches of clear lumber, restricting the unpruned core to a diameter not exceeding six inches and prescribing a maximum pruning height of 22 feet.

Investigations by Craib (1934) into the silviculture of short rotation tan wattle (*Acacia mollissima,* Willd.) showed that the profitability of the industry could be greatly enhanced by allowing individual trees much more growing space than had been practised up till then, and the application of his recommendations did much to rehabilitate the wattle industry. Craib subsequently suggested that similar principles be applied to the production of softwood timber in the Union and in 1939 published a paper in which he dealt comprehensively with the implications of the silvicultural policy followed by the Department of Forestry up till then and, on the basis of research data then available, made far-reaching recommendations for the rationalization of the silviculture of conifer species in the Union.

Craib argued that "the financial result depends upon log-size at time of maturity" and, having based his assessment of financial expectation on a log-size of 18″ d.b.h. at maturity and a ratio of values of 1:2:4:8 for log-sizes of 3-5″, 5-8″, 8-12″ and over 12″ respectively, went on to show that about eighty percent of the total area of conifers controlled by the Department of Forestry would probably show a loss under the silvicultural policy then obtaining, due mainly to the small-size logs likely to be produced.

To achieve a log-size of 18″ d.b.h. and to increase the production of timber 12″ in diameter and over, he recommended the adjustment of thinning regimes to promote diameter growth. Furthermore, he advocated wider planting espacements (9 feet for fast-growing and 12 feet for slow-growing species) and also suggested that the technique of ground preparation in spots (as opposed to complete ground preparation) and the use of large transplants should be developed.

His thinning regimes left the treatment of first quality sites previously in force practically unchanged (apart from increasing the planting espacement), but he proposed thinning much more heavily at an early age on second and third quality sites. Under these regimes, yields would be slightly reduced, but the proportion of larger sized material would be greatly increased. Such comparatively heavy thinning for the poorer sites was contrary to the accepted silvicultural practice that thinning should not only be delayed but lighter on less favourable sites.

In regard to pruning, Craib proposed pruning in stages, depending on height of the predominant trees, up to a height of 22 feet for a specific number of stems per acre for all coniferous species on all site qualities. Pruning was to take place earlier than previously practised, which connoted the removal of live branches.

Craib's recommendations were, with minor exceptions, accepted by the Department of Forestry and introduced as general policy in 1938.

In 1948, following upon a critical review of the policy and as a result of additional research data that had become available, certain amendments were introduced, the most important of which was to adopt a 9-foot espacement for slow-growing conifers (instead of 12 feet) and amendment of thinning regimes for these species accordingly.

The 1948 prescriptions are still in force and are given in tables 1(a) and 1(b).

Table 1 (a). Pruning prescriptions.

1st Pruning:	All trees pruned to 8′ when mean predominant height is 20′.
2nd Pruning:	All trees remaining after 1st thinning pruned to 15′ when mean predominant height is 30′.
3rd Pruning:	150 best stems pruned to 22′ when mean predominant height is 40′.

Table 1 (b). Thinning prescriptions for sawtimber plantations.

Species	Site Quality I		Site Quality II		Site Quality III	
	Age	Stems per acre	Age	Stems per acre	Age	Stems per acre
Pinus radiata	0	530	0	530	0	530
	10	330	6	210	6	300
	15	220	18	150	14	150
	20	150	23	120	20	100
	25	120	40	0	50	0
	30	0				
P. patula	0	530	0	530	0	530
	8	300	6	300	6	300
	12	200	14	200	14	150
	18	130	20	130	20	100
	30	0	25	100	50	0
			40	0		
P. elliottii	0	530	0	530	0	530
P. taeda	9	300	7	300	7	300
P. pinaster	13	200	15	200	15	150
(Portuguese strain)	19	130	21	120	21	100
	30	0	40	0	50	0
P. roxburghii	0	530	0	530	0	530
P. palustris	9	260/280	8	260/280	7	260/280
P. canariensis	14	180/200	13	180/200	13	130/140
P. pinaster	20	100/110	18	100/110	20	70/80
(slow-growing strains)	40	0	50	0	60	0

Some Misconceptions Regarding South African Silviculture

Before any discussion of South African methods of silviculture can be attempted, it is essential that misconceptions regarding them should be removed. That such misconceptions do, in fact, exist is shown clearly by the italicised portions of such statements as the following in an American text book (Hawley and Smith, 1954):

"The *drastic* thinnings advocated by Craib are technically *spacing thinnings*. Since the stands are *never allowed to close* and, therefore, *do not differentiate into crown classes,* the trees to be removed *must be chosen on the basis of spacing and characteristics other than position in the crown canopy.*"

There is no doubt that thinning commences at a very early age by North American or European standards. This is due to the rapid early growth and the early age at which increments culminate in unthinned 6′ x 6′ stands in South Africa (e.g., d.b.h. increment at 4 years, height at 6½ years and volume at 18 years in a stand of *Pinus taeda*). Early thinnings are thus desirable to relieve early suppression and to take advantage of the period of vigorous growth.

Early thinnings tend to be unremunerative. Therefore, relatively wide espacements are a logical accompaniment of early thinning.

The idea that early thinning is synonymous with drastic thinning, which has given rise to the satirical term "orchard silviculture," is, however, entirely erroneous. The basal area per acre allowed to remain after each thinning is a common method of assessing thinning intensity. Ordinarily, the appropriate level is considered by Hawley and Smith (1954) to lie between 50 and 150 sq. ft. per acre, and Hawley has found that low thinnings of the C-grade leave a residual stand of 100 sq. ft. of basal area per acre in eastern white pine. In comparison, the figures for an average quality *Pinus patula* stand treated according to current prescriptions (Table II C) are:

1st thinning retains 55 sq. ft. B.A./acre.
2nd thinning retains 94 sq. ft. B.A./acre.
3rd thinning retains 95 sq. ft. B.A./acre.
4th thinning retains 108 sq. ft. B.A./acre.

The same authors class a C-grade low thinning as one in which 20% to 35% of the standing volume is removed at each thinning. In the above-mentioned prescription the percentages removed are:

1st thinning 28%; 2nd thinning 25%; 3rd thinning 26%; and 4th thinning 15%.

It will thus be seen that this thinning, which is applied to the greater portion of the most important species and is also representative of thinnings applied to other species, can unquestionably be classified as a C-grade thinning. Hawley and Smith (1954) describe a C-grade thinning as "the lightest which can possibly be undertaken in stands of light-demanding species." Yet these same authors repeatedly refer to the "drastic thinnings advocated by Craib."

The idea that spacing or mechanical thinnings are practised is equally far from the mark. Thinnings are certainly defined in terms of the number of stems per acre which are to remain, but the object in view is to control the intensity of the thinning rather than the spacing of the individual trees. No thinning is undertaken before crown closure is complete and the trees are clearly differ-

entiated into crown classes except on 3rd quality sites. The best trees are favoured wherever they may be found, and the trees which are removed are those which occupy an inferior position in the canopy or are inferior in form. Hiley (1959), after investigating South African silvicultural techniques on the spot, came to the conclusion that "numerical thinning has sometimes been grossly misrepresented in Europe and America" and that some of the thinning he saw being marked combined the quantitative and qualitative requirements of thinning better than any marking he had seen before.

Comparison of the Present Silvicultural Prescriptions With Possible Alternatives

A. From the Management and Economic Points of View

In considering the alternatives open to South African forestry, it must be borne in mind that the main demand is for softwood timber in constructional sizes and that the sites which have been or are being planted are almost exclusively virgin grasslands or scrub. The demand for the smaller logs is exceedingly limited, as the demand for boxes is dwindling and pulpwood is drawn mainly from certain favourably situated regions. There is also a demand for telephone, transmission, and building poles, but, as the species which produce the strongest poles are not those which produce the most suitable sawtimber, poles and fencing material are usually produced in stands specially planted for the purpose at espacements of 6′ x 6′ or 7′ x 7′.

Until South African plantations are due for regeneration on a large scale, there is no feasible alternative to establishing even-aged stands by planting. Extensive trials of exotic species have not indicated any conifers more suitable than pines for South African conditions, and, consequently, the species used are strongly light-demanding. Owing to the excessive demands in transplants and labour of close espacements, spacings of less than 6′ x 6′ cannot be contemplated, especially with a planting programme of some 20,000 acres per year and a policy which aims at growing forestry crops as a commercial undertaking.

Wide initial espacements have the disadvantage that they allow weed growth to persist for a few years longer than denser ones, particularly in the case of the slower-growing species. Moreover, the development of heavier side branches high up into the crowns tends to be encouraged, making it imperative to prune in strict accordance with prescriptions. Experience has, however, shown that labour shortages and other management problems often make it impossible to adhere to these prescriptions, with adverse effects on the quality of the final product. In addition, the percentage recovery from the unpruned portion of the bole is alarmingly low in heavily branched species such as *Pinus patula,* but this can naturally be overcome by high pruning, which can more readily be justified economically with the higher returns associated with wider espacements. It has also been found that, in species which are inclined to produce a large percentage of malformed stems, the selection is insufficient to ensure freedom from crooked and forked trees in the final crop and late thinnings.

In order to provide concrete examples to serve as a basis for discussion of the economic advantages of wide espacements, the yields from three treatments have been calculated from the data furnished by Marsh (1957) and converted to a monetary basis in Table II (a), (b), and (c). Treatment (c) is a close approximation of current prescriptions, treatment (b) represents a 6′ x 6′ espacement with heavy thinning, and treatment (a) a 6′ x 6′ espacement with light thinnings. In Table III, the costs of production for the respective treatments are compared.

It will be seen that treatment (a) gives a total yield of 9850 cu. ft. as against 8910 cu. ft. and 8190 cu. ft., respectively, for treatments (b) and (c). On the other hand, the value yield for treatment (c) is £491 as against £379 for (a) and £459 for (b). If the costs recorded in Table III are also taken into consideration, the superiority of wide initial espacements and early thinnings are even more striking and are as follows:

Treatment	Value Yield	Cost	Net Value Yield
a	£379	£145	£234
b	£459	£146	£313
c	£491	£ 79	£412

If it is assumed, as may well be the case, that a market for smallwood, i.e., 3″-5″ at the thin-end, is not available and that only 50% of the 5″-8″ material can be disposed of, the relative economic merits of the treatments will be as follows:

Treatment	Value Yield	Cost	Net Value Yield
a	£332	£145	£187
b	£426	£146	£280
c	£470	£ 79	£391

It is abundantly clear from the above that, provided the quality of the products produced under treatment (c) is in no way inferior to that produced under (a) or (b), the former is the economically superior method of cultivation.

If the economic results are disappointing in the case of initial espacements involving 1210 stems per acre, it may be imagined how marginal or even unprofitable they would become if the group plantings described by Anderson (1951) were adopted. In these plantings, groups consisting of 13 or more trees planted at an espacement of 2′ x 2′ were spaced with their centres at 15′ x 15′ or more and are thus equivalent to densities of up to 2500 stems per acre. The costs of production would, in such cases, be greatly increased, while returns would be so seriously reduced that it is doubtful whether a margin of profit would remain, especially when it is recalled that in Table III costs which are common to all treatments (e.g., fire protection, roads, overheads, etc.) have been omitted.

B. From the Utilisation Point of View

In deciding on the acceptability of wide espacements and the consequent acceleration of growth, the Union Department of Forestry was guided, as far as timber quality was concerned, mainly by the specific gravity of the timber. It has been established that specific gravity usually increases with the age of the tree, irrespective of the width of the annual rings, and culminates at the age of about 30 years. Specific gravity is not, however, the only consideration. As increasing quantities of South African pine timber have come on to the market, several defects in the timber have become apparent, such as excessive

TABLE II: COMPARATIVE YIELDS (CUBIC FEET) AND VALUES FOR DIFFERENT ESPACEMENTS AND THINNING REGIMES

Pinus patula

Treatment (a): Initial Espacement 6′ x 6′ With Light Thinnings

Thinning Regimes		No. of Trees Felled	Mean d.b.h. of Trees Felled	Mean Height	Total Volume Produced	Distribution in Size Classes (Cu. Ft.)				Value of Size Classes (In Pence) Standing				Total Value (Pence)	Value Compounded at 5% to Rotation Age
Age	Stems/ Acre					3″-5″	5″-8″	8″-12″	Over 12″	3″-5″ @ 2d	5″-8″ @ 4d	8″-12″ @ 12d	Over 12′ @ 18d		
0	1,210														
9	800	410	4.0	38	530	286	95	—	—	572	380	—	—	952	4,321
14	500	300	5.5	58	1,080	529	432	—	—	1,058	1,728	—	—	2,786	9,907
20	300	200	6.5	73	1,440	490	835	29	—	980	3,340	348	—	4,668	12,384
25	200	100	7.4	81	1,120	235	762	78	—	470	3,048	936	—	4,454	9,260
30	150	50	8.6	86	800	96	536	144	—	192	2,144	1,728	—	4,064	6,620
40	—	150	12.0	94	4,900	196	1,127	3,332	196	392	4,508	39,984	3,528	48,412	48,412
				TOTALS	9,850	1,832	3,787	3,583	196	3,664	15,148	42,996	3,528	65,336d = £272	90,904d = £379
					Treatment (b): Initial Espacement 6′ x 6′										
0	1,210														
8	600	610	4.4	35	800	464	160	—	—	928	640	—	—	1,568	7,472
12	300	300	6.2	52	1,200	456	636	12	—	912	2,544	144	—	3,600	14,112
16	200	100	7.2	65	740	178	496	37	—	356	1,984	444	—	2,784	8,978
20	150	50	8.2	73	570	86	399	74	—	172	1,596	888	—	2,656	7,046
25	100	50	9.7	80	850	68	459	306	—	136	1,836	3,672	—	5,644	11,734
40	—	100	14.8	94	4,750	48	475	2,755	1,425	96	1,900	33,060	25,650	60,706	60,706
				TOTALS	8,910	1,300	2,625	3,184	1,425	2,600	10,500	38,208	25,650	76,958d = £320	110,048d = £459
					Treatment (c): Initial Espacement 9′ x 9′										
0	530														
8	300	240	6.0	35	600	252	300	—	—	504	1,200	—	—	1,704	8,120
15	200	100	8.0	61	820	131	566	98	—	262	2,264	1,176	—	3,702	12,535
20	130	70	9.3	73	990	89	604	277	—	178	2,416	3,324	—	5,918	15,700
25	100	30	10.6	82	630	31	258	328	—	62	1,032	3,936	—	5,030	10,457
40	—	100	15.6	94	5,150	52	412	2,369	2,266	104	1,648	28,428	40,788	70,968	70,968
				TOTALS	8,190	555	2,140	3,072	2,266	1,110	8,560	36,864	40,788	87,322d = £364	117,780d = £491

longitudinal shrinkage, uneven texture, knottiness, compression wood and spiral grain, and the necessity has arisen of determining to what extent such defects may be related to silvicultural treatment.

Juvenile wood is brash and short-fibred and has a greater longitudinal shrinkage than normal wood. The first few rings of plantation-grown conifers invariably contain timber of this type. There is no doubt that the diameter of this core of juvenile wood is, in the first instance, proportional to the width of the initial espacement but within the range of espacements under consideration (6′ x 6′ to 9′ x 9′). The opportunity for restricting the size of this core is, unfortunately, very limited. For instance, the diameter of the first five rings would only be 1″ less with a 6′ x 6′ than with a 9′ x 9′ espacement.

Wide, irregular, and often eccentric rings are also a common feature of South African pine timber. This feature is not important in timber intended for structural purposes, where fairly large dimensions are involved and the timber is used in the rough. When, however, the timber is further processed, so that working and finishing properties come into consideration, for instance in joinery work, the width of the rings is of much greater significance. Timber with alternating wide bands of spring and summer wood has a very uneven texture and is very unsatisfactory for any type of joinery work. Here, again, the prospect of effecting much improvement within the range of silvicultural treatments being considered is not great.

Reduction of the initial espacement to, say, 6′ x 6′ and return to earlier thinning regimes will actually increase the variability in ring-width, which is, at present, approximately 2 rings per inch in the core of average quality *Pinus patula* and 6 rings per inch in the outer layers at breast height, and was previously approximately 2½ rings per inch in the core and 7½ rings per inch in the outer layers. It is thus evident that for even ring-width a

TABLE III: COMPARATIVE COSTS FOR DIFFERENT INITIAL ESPACEMENTS AND THINNING REGIMES

Pinus patula

Item No.	Description of Operation	Costs Per Acre in Shillings			Remarks
		Treatment (A) 6′ x 6′	Treatment (B) 6′ x 6′	Treatment (C) 9′ x 9′	
1.	Preparation of Pits.	94/–	94/–	42/–	
2.	Cost of Transplants.	97/–	97/–	43/–	
3.	Cost of Planting and Transport.	40/–	40/–	18/–	
4.	Blanking and Cost of Plants.	25/–	25/–	12/–	
5.	Weeding x 2 for A and B. x 3 for C.	50/–	50/–	30/–	Spot-Weeding Only.
6.	1st Pruning to 8′ at 5 Years.	35/–	35/–	20/–	
7.	2nd Pruning to 15′ at 7 Years. A = 500 STEMS/ACRE B = 400 STEMS/ACRE C = 300 STEMS/ACRE	30/–	25/–	20/–	
8.	3rd Pruning to 22′ at 9 Years. A = 300/ACRE B = 200/ACRE C = 150/ACRE	30/–	25/–	20/–	
9.	1st Thinning; A = 9 Years to 800; B = 8 Years to 600; C = 8 Years to 300.	25/–	30/–	20/–	
10.	2nd Thinning; A = 14 Years to 500; B = 12 Years to 300; C = 15 Years to 200.	20/–	25/–	20/–	
11.	3rd Thinning; A = 20 Years to 300; B = 16 Years to 200; C = 20 Years to 130.	20/–	15/–	20/–	
12.	4th Thinning; A = 25 Years to 200; B = 20 Years to 150; C = 25 Years to 100.	15/–	15/–	15/–	
13.	5th Thinning; A = 30 Years to 150; B = 25 Years to 100.	15/–	20/–	—	
14.	Clear Felling at 40 Years.	60/–	60/–	60/–	
15.	Interest Compounded at 5 %	2,345	2,364	1,240	
	TOTAL	2,901	2,920	1,580	
	=	£145/1	£146/–	£79/–	

regime with still closer initial espacement than 6′ x 6′ and frequent light thinnings in the later stages would have to be devised. However, such treatment would only be applicable to a limited number of stands specially devoted to the production of joinery timber.

The knottiness of South African pine timber also often leaves much to be desired. Observations on the effect of espacement on the average size reached by branches in the lower part of the stem have been made with the following results in *Pinus patula*.

Type of Stand	Average branch size at the undermentioned densities					
	1200 stems per acre	600 stems per acre	400 stems per acre	300 stems per acre	200 stems per acre	150 stems per acre
Pruned	0.70″	0.82″	0.88″	0.91″	0.92″	0.92″
Unpruned	0.74″	0.86″	0.98″	1.08″	1.15″	1.20″

It will be seen that both pruning and density within the range under discussion (540 to 1210 stems per acre) have a very minor effect in controlling branch size. Nevertheless, pruning cannot be dispensed with since the dead branches of the species under discussion are persistent and form loose knots.

It has also been investigated whether pruning the lower branches while some of them are still living tends to increase the size of the branches in the upper, unpruned portion of the crown. Over 600 branches from the 25′ to 40′ level in pruned and unpruned plots measured 1.52″ and 1.51″ respectively. It may thus be said that pruning of the branches below 22′ has not affected the mean size of the branches in the crown. Branches up to 6″ in size are, however, found in this portion of the stem and cause serious degrade in the timber. This again strengthens the case for pruning to higher levels.

Compression wood is very general in locally grown exotic pine timber. Although a relatively small number of boards are rejected on account of this defect when grading timber in the sizes originally sawn, its presence is often indicated by spring or bow when seasoned scantlings are planed or resawn. There are several possibilities which may account for this phenomenon, and these are being actively investigated. Spring and bow are also serious problems in the timber obtained from very conservatively thinned *Pinus radiata* stands in South Australia (Kloot and Page, 1959), and it thus appears that this defect may

occur in timber grown under a wide range of silvicultural treatments.

Spiral grain is prevalent in locally grown pine timber. Investigations carried out by the Research Division have shown that if the grain is very spiral to start with in *Pinus roxburghii*, rapid growth will make it worse, but if it is nearly straight, the rate of growth has little or no effect on it (Marsh and Rault, 1952). While spirality increases with age up to 20-30 years in *P. roxburghii*, it follows the opposite course in *P. patula*, the worst spirality being discernible in timber cut near the pith. Twist resulting from spirality gets worse as boards dry out, the twist at 10% moisture being on the average twice as much as at 15%. Quarter-sawn boards twist twice as much as flat-sawn boards. It is widely conceded, however, (e.g. Champion, 1930) that spirality is inheritable. The prospect of controlling it by seed selection rather than by silvicultural treatment thus appears to offer the greater promise.

Conclusion

It will be seen that there are marked economic advantages for the type of silviculture practised in South Africa, but that the Department of Forestry is far from satisfied with the quality of the wood now being harvested. It must, however, be kept in mind that by far the greater part of this timber is derived from thinnings or from premature clear-fellings undertaken for the sake of achieving eventual normality. It cannot be expected to be as satisfactory as the timber which will become available from selected stems allowed to reach maturity. While the possibility of a connection between current silvicultural treatment and the quality of the timber is not being overlooked, there is, on the other hand, no clear indication that this is actually the case.

In all the main coniferous species, the Department maintains several projects in which stands have been left to grow at densities varying from 50 to 1200 stems per acre. In addition, plots in which thinnings vary from very conservative to very extreme are maintained in each project. These projects are producing data from which the yields from any thinnings in which the remaining stand has between 50 and 1200 stems per acre are being deduced (Marsh, 1957). They are now mostly over 20 years of age and will thus soon be producing material which will give positive evidence regarding the effect on timber quality of silvicultural treatments which vary from one extreme to the other.

The Department of Forestry also maintains the D.R. de Wet Tree Breeding Station, at which active steps are being taken to establish seed orchards with grafting material from trees with outstanding form and timber qualities. Prospective elite trees have been selected for form and branching habits against criteria which have rejected all but one tree per 800 acres on the average. A wedge of wood is removed from each prospective elite tree and is examined at the Forest Research Institute with respect to specific gravity, fibre length, degree of spirality, amount of compression wood, and percentage of summerwood. As a rule, trees which fall in the upper (e.g., fibre length) or lower quartile (e.g., spirality), as the case may be, of the observed variation for that particular characteristic, are regarded as acceptable. It is believed, and Dadswell (1957) is of the same opinion, that the progeny of such trees can be grown at a reasonably rapid rate without detriment to their timber qualities. It is hoped, therefore, that within a reasonable period seed will become available which will produce trees with much superior form and timber qualities, thus eventually eliminating at least some of the defects at present encountered in South African pine timber.

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RESUMES

Le sylviculture et l'aménagement des plantations de conifères exotiques dans l'Union Sud-Africaine

L'Union Sud-africaine possède aujourd'hui 770.000 acres (346.500 ha.) environ de plantations d'essences résineuses exotiques. A l'origine, le système généralement adopté comportait la préparation intensive du sol, la plantation rapprochée et l'éclaircie reduit au minimum. Depuis 1920 environ, le taux d'éclaircissage a tendance à augmenter; il a passé de 25% au chiffre relativement élevé de 40%, et l'on a prescrit pour la première fois le nombre précis de plants à suprimer au cours de chaque éclaircie. En 1939, les propositions de Craig ont été adoptées sous une forme légèrement modifiée, à la suite de quoi des espacements de l'ordre de 9 pieds sur 9 (2,7 m. x 2,7 m.) ont été adoptés; des éclaircies de l'ordre de 30 à 40%, commençant dans certains cas à l'âge de 6 ans, répétés à des intervalles d'environ 5 ans et laissant un peuplement définitif de l'ordre de 100 plants par acre, ont été entrepris; des élagages de 22 pieds en trois stades pratiqués partiellement sur des branches vivantes, ont été prescrits; et un plan de rotation des cultures, allant de 30 ans, pour les espèces à croissance rapide dans des sites de premier choix, jusqu'à 50 ans, pour les essences à croissance modérée dans des sites de 2nd et 3ème chois, a été mis en oeuvre.

Les méthodes forestières de l'Afrique du Sud ont parfois été représentées en Europe et en Amérique d'une manière grossièrement déformée. En fait, les éclaircissages effectués correspondent aux éclaircissages par lebas de la catégorie C pratiqués en Amérique, du point de vue quantitatif comme du point de vue qualitatif.

Du point de vue de l'exploitation, les inconvénients que présentent le grand espacement initial et les éclaircies hatives sont: le retard apporté à l'élimination des mauvaises herbes; le développement de grosses branches si l'élagage est retardé et, en

tous cas, la croissance de telles branches dans la partie supérieure non-élaguée du tronc; la sélection insuffisante pour certaines essences. Ces inconvénients se trouvent compensés par des considérations économiques, du fait que la valeur nette à la récolte des nouvelles ordonnances est supérieure à l'ancienne dans la proportion de 412 Livres sterling contre 234 par acre.

De point de vue de l'usager, une proportion importante du bois actuellement produit dans les plantations de résineux en Afrique du Sud présente des défauts tels que la rétrécissement longitudinal exagéré, l'inégalité de la texture, la présence de nodosités, bois à fibres comprimées ou torses. Il ne semble toutefois pas qu'une modification du régime forestier dans les limites des densités considérées comme rentables du point de vue économique soit susceptible d'avoir un effet marqué sur la qualité du bois.

Les essais seront poursuivis sur les essences à croissance lente et à croissance rapide ainsi que sur les arbres brusquement libérés de leur étouffement. On pense toutefois que la solution réside dans la sélection d'espèces à fibres longues, d'une gravité spécifique moyenne, et d'une torsion réduite. La création de pépinières de semis comprenant des arbres de cette sorte a été entreprise.

La Silvicultura y la Administración de Plantaciones de Coníferas Exóticas en el Africa Del Sur

En la Unión del Africa del Sur hay actualmente 770.000 acres de plantaciones de coníferas exóticas. Al principio se procedió a una intensa preparación del suelo, pequeño espaciamiento y clareos muy ligeros; pero desde 1920 se aumentó el clareo, variando de un 25 a un 40% y se fijó el número de árboles a retirar por acre en los clareos. En 1939 se aprobaron, ligeramente modificadas, las proposiciones de Craib fijando el espaciamiento en 9 x 9 pies; el clareo de 30 á 40% comenzando, en ciertos casos, de la edad de 6 años, repetido a intervalos de poco más o menos 5 años y dejando un arbolado final como de 100 pinos por acre; podas hasta de 22 pies en tres etapas, en parte de ramas vivas, y rotaciones variando de 30 años para especies de crecimiento rápido en terrenos de primera calidad hasta de 50 años para especies de crecimiento medio en terrenos de segunda y tercera calidad.

Las técnicas de silvicultura del Africa del Sur han sido, a veces, muy mal comprendidas en Europa y en los Estados Unidos, y los clareos efectuados corresponden, en realidad, al clareo estadunidense, aclareo por lo bajo de grado C, tanto cuantitativa como cualitativamente.

Desde el punto de vista administrativo, las deficiencias provocadas por el gran espaciamiento inicial y los clareos tempranos fueron el sombreado tardío de maleza; el perpetuar gruesas ramas si las podas se retardan, lo mismo que en las partes sin podar del árbol, así como selección insuficiente de algunas especies. Estas desventajas se contrarrestan con las consideraciones económicas, pues el valor neto del rendimiento de los cortes actuales es mayor que el de los cortes anteriores, en la proporción de 412 libras esterlinas en comparación con 234 libras esterlinas por acre.

Desde el punto de vista de aprovechamiento gran parte de la madera que al presente se produce en el Africa del Sur de las plantaciones de coníferas tiene defectos como el de excesivo encogimiento longitudinal, textura desigual, abundancia de nudos, compresión o grano en espiral. Sin embargo, no hay pruebas de que cambios en los tratamientos silvícolas en el radio de densidades que se considera practicable por razones económicoas influyan considerablemente en la calidad de la madera.

Se harán pruebas con árboles de crecimiento lento y de crecimiento rápido y árboles súbitamente librados de represión, pero se cree que la solución del problema estribará en la cría de árboles de fibra larga, de gravedad específica media y de bajo espiral. Al presente se preparan semilleros con árboles de estas características.

"Orchard" Versus "Naturalistic" Silviculture in the Radiata Pine Forests of New Zealand

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Introduction

In this paper the author:

(1) Points the significance of radiata pine (*Pinus radiata*) as the major exotic tree species in New Zealand's production forest economy generally, and particularly in Rotorua Conservancy, North Island. This is considered adequate ground for limiting the theme to radiata pine in Rotorua Conservancy; (2) Defines the author's interpretation and use of the terms "orchard" and "naturalistic" silviculture; and (3) Discusses "orchard" versus "naturalistic" silviculture in the radiata pine forests of Rotorua Conservancy.

In addition, while not directly relevant to the theme, the author appends, as a supplement, an historical and descriptive summary of forests and forestry in New Zealand for the information of those unfamiliar with New Zealand.

Radiata Pine Forests

New Zealand's total production forest resource amounts to 3 million acres, comprising 2 million acres of indigenous species and 1 million acres of exotic species. In the latter, radiata pine is of major importance to the country's exotic forestry—for that matter, to its production forestry generally. Pure stands of radiata pine amount to some 570,000 acres, of which no less than 360,000 acres are concentrated in Rotorua Conservancy, within a radius of 60 miles of the town of Rotorua. Thus, 62 per cent of the total exotic forest resource is radiata pine, and some 40 per cent of the total exotic forest resource is radiata pine concentrated in large State and private company forests within a radius of 60 miles of the town of Rotorua. Because of the importance of this species in New Zealand's production forest economy, the author limits this paper to the radiata pine forests of Rotorua Conservancy. Radiata pine is virtually the only exotic species to have reached rotation age in forest formation and to have given New Zealand some experience in the regeneration of second rotation crops. Australia, Chile, and South Africa also rank radiata pine as a major exotic forest tree in their respective countries.

Interpretation

The terms "orchard" and "naturalistic" silviculture are susceptible of some breadth of interpretation. The terms could relate to even-aged stands originating from artificial regeneration and from natural regeneration, respectively, with subsequent tending extreme and intensive in the first case, and conservative and natural in the second case. Alternatively, they could relate to clearcutting with subsequent regeneration (artificial or natural), in contrast to even-aged stands managed under the uniform system, or to uneven-aged stands under the selection system. The author interprets "orchard" as indicative of cropping, artificial cultivation, with the tree, not the stand, as the unit of tending; "naturalistic", self-explanatory, as indicative of systems of silviculture and management closely following those in the natural forest with the stand, as part of the forest, the unit of tending. Hiley (4)*, in his comparison of European and South African forestry, describes European forestry as having an approach fundamentally ecological, emphasised in recent decades by the greater knowledge of ecology, and South African forestry as based on agriculture.

Köstler (10) refers to two opposing viewpoints typical of the history of forestry thought in the past 200 years, the mechanical outlook, understanding the forest to be a productive enterprise controlled by man and yielding timber, and the biological line of thought, regarding forests as members of a natural universe.

Toumey (16) considered that valid economic principles and basic silvical principles must be co-ordinated in a silvicultural practice both biologically and economically sound.

The Radiata Pine Forests of Rotorua Conservancy

Description and History

The large State and private company forests of radiata pine are situated in the northern part of the central volcanic plateau, or pumice country, as it is frequently called. These forests are all of artificial origin. A brief description of areas, ownership, and site factors follows:

Latitude and longitude:		38°S., 176°E.
Areas:	State	120,000 acres
	Private Company	240,000 acres
Total:		360,000 acres

N.B. Two large forests, one State and one private company, account for 280,000 acres of the above.

Age: Mostly planted between 1924 and 1937.

Altitude: 500 to 2,500 feet above sea level.

Rainfall: 50 to 60 inches falling on 150 days.

Mean temperature (coldest month): 41°F.
(hottest month): 59°F.

No. of ground frosts: 70 to 100, but up to 150. May occur in any month of the year. Up to 22°F. of frost have been recorded.

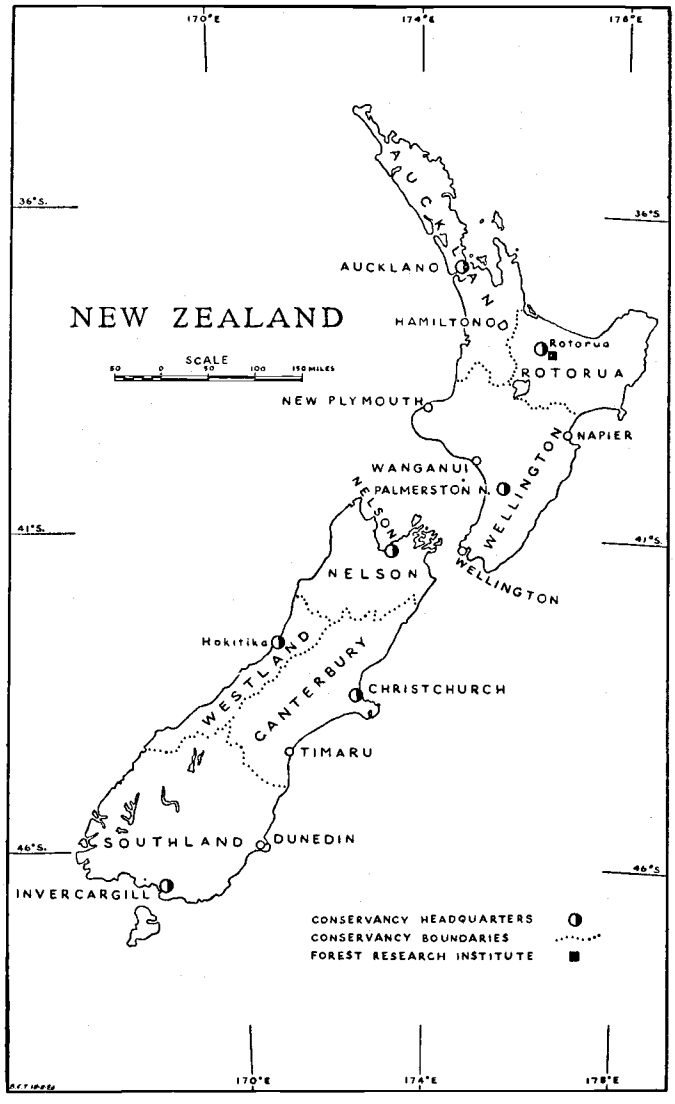
Snow: Rare.

Soil: Pumice loams, derived from frothy ash showers mainly of rhyolytic origin; coarse textured.

The fortuitous nature of the extent and concentration of exotic forests generally, and radiata pine forests in particular, in this area is often overlooked. Nowhere else in New Zealand could such extensive tracts of cheap, available land, so suited to forestry, have been obtained for the large-scale plantings of the twenties and thirties. It is certain that had the present agricultural knowledge developed earlier, few extensive tracts of land would have been available to exotic forestry in this locality.

Before planting, these areas were desolate wastelands, subject to sporadic firing, and occupied by indigenous vegetation of a heath-like or wild grassland character.

Up to 1923, the early, small-scale State plantings followed traditional European practice, and the results were well-stocked, well-planted stands. In the afforestation boom of the twenties and thirties, State and private afforestation companies alike increased spacing to a nominal 8′ x 8′, and even 9′ x 9′ in some private planting, and blanking



*Numbers in parentheses denote the references listed at the end of this paper.

(beating up) was neglected or unduly delayed. Emphasis was on maximum acreages and cheap planting. The greater part of the radiata pine stands under discussion were planted during this period. Seed was easily collected, seedlings were easy to raise and planted out readily, so that extension of plantings beyond the desirable site range of the species was inevitable. Furthermore, little or no tending was undertaken. By the later thirties, the shortcomings of resulting stands were becoming apparent. The State then reverted to orthodoxy by increasing initial stocking from a nominal 680 to an effective 1,210 trees per acre (reducing spacing from 8′ x 8′ to 6′ x 6′), by emphasising the need for timely blanking and release cutting, and initiated a programme of tending. World War II caused some delay to this programme.

The first rotation radiata pine forests are characterised by lack of tending and by an acute maldistribution of age classes, the effect of the latter being accentuated by the rapid growth of the species. This rapid growth has been advantageous in that earlier clearfelling necessary to help offset the maldistribution of age classes has been practicable.

The development of these radiata pine forests is naturalistic silviculture carried to extremes, but naturalistic silviculture, prejudiced from the outset by inadequate initial stocking generally, and, in particular cases, by faulty siting.

The 1913 Royal Commission on Forestry in New Zealand (12) should be mentioned. Then, total State exotic plantations amounted to just under 20,000 acres. World War I delayed the application of the Commission's findings, but there is no doubt that the latter played a significant part in State exotic forestry during the developments of the 1920's. The Commission Report recommended a large extension of exotic plantations on the volcanic plateau, and advocated the extensive planting of radiata pine and at wider spacing than 4′ x 4′.

The Commission recognised that thinning would be costly at that time and inclined to the view that, instead, the law of the survival of the fittest be allowed to operate. Experiments should however be initiated.

Pathological Hazard

Overseas foresters visiting these forests frequently comment on the susceptibility to disease of extensive monocultures, especially when the tree species is of exotic origin and still in process of acclimatisation and domestication. The relative isolation of New Zealand, and of the pumice country within it, and the fact that these forests have been established upon bare ground, have provided some temporary protection. Damage to young growth from unseasonable frosts has been followed by death or malformation caused by the fungi *Phomopsis strobi* and *Diplodia pinea.* The steel blue sawfly, *Sirex noctilio,* and its associated fungus, have been the cause of considerable mortality, but generally to weakened or defective trees. The bark beetle *Hylastes ater* girdles and kills trees up to 3 years old in recently felled areas. Numerous defoliators have been observed, but few have done serious damage; these include the indigenous looper caterpillar *Selidosema suavis* and *Hybernia indocilis.*

In 1953, the well-known pathologist, J. J. de Gryse (2), reported on the condition of New Zealand's forest at the request of the Government. He stated:

> "At this juncture, to ignore the notorious susceptibility of *P. radiata* to attack by insects and fungi, the extreme vulnerability of the extensive monocultures in which it occurs, or the astounding aggressiveness of *P. radiata* under New Zealand conditions, is tantamount to challenging all the laws of Nature governing the processes of growth and decay of the forest."

Condition of the Crop

Throughout the area radiata pine displays wide variability in tree form and vigour, a reflection of the parts played by heredity, site, and damage factors. This may be considered a desirable condition in the first rotation crop of an exuberant exotic species. Smith (15) considers two factors essential for success with a species of exotic origin, power of vegetative reproduction, or alternatively, abundance of regularly produced seed, easy to collect, store, and germinate, and great inherent plasticity.

Bannister (1) also refers to this variability and the use of the term "monoculture," explaining that this is a misleading expression when applied to radiata pine. Though individuals of these populations have much in common, he is equally certain that the radiata pine stands are not genetically homogeneous cultures. Bannister considers it a reasonable assumption that nearly every radiata pine tree grown from seed possesses a unique genotype. Further, that if the species has a wide genetic variation in the initial stages of acclimatisation, the environment may act so that the relative frequencies of some of the genes are altered, some being increased, while others are decreased. In this way, natural selection may occur, and, if it does, the species will make evolutionary progress. In Bannister's opinion, this concept of evolutionary change needs to be more fully grasped by the forester, especially when dealing with an exotic species.

Variation in tree form is a characteristic of radiata pine grown in the pumice region—at one extreme, heavy, acutely angled branches, rough boles prone to forking, often crooked and with pronounced taper; at the other, light-crowned, with almost right-angled branches and single, straight, cylindrical boles. Jones (8) recorded that in the early years the percentage of forked trees was not consistently high, averaging 20-25 per cent, rising to about 40 per cent at 15 or 16 years of age. Five or six years later, it tended to drop again to the 20-25 per cent level, due to the relatively higher mortality rate for forked trees.

Hutchinson and Henry (6) state that in unthinned stands with an initial stocking of 680 trees per acre, losses through various causes gave an effective establishment at age 6 to 9 years of 565 trees per acre. There was little further mortality until about age 12, when competition within the stand became intense. From this age a rapid decline in stocking occurred to less than 200 per acre at age 24, a loss of about 30 trees per acre annually for 12 years. From age 24 to 30 losses were much fewer.

Pollock (13) describes two unthinned stands, aged 32 and 34, planted to initial densities of 2,420 and 2,722 trees per acre, respectively, the former containing 280 living trees and 444 standing dead trees, the latter, 164 living trees and 456 standing dead trees.

Hinds (5) states that mortality in unthinned stands starts earlier and progresses faster on the better sites and denser stands, and that the age class 20 to 25 years has been the most susceptible. Mortality was heaviest in suppressed, sub-dominant, and co-dominant stems in that order; further, malformed stems have shown a higher mortality rate than normal stems.

Jackson (7) deals with stand mortality rate in an 18-year-old unthinned stand established at 1,210 trees per acre. He found a very steep drop in stocking between ages 6 and 11 years, during which over 50 per cent of the originally established trees were eliminated in the short space of 6 years. He considered competition between the trees themselves the most obvious factor of stand development likely to lead to mortality. Too much should not be drawn from the behaviour of one age-class, however.

Rawlings and Wilson (14) refer to the epidemic occurrence of *Sirex noctilio* in radiata pine stands in 1946:

> "Had it been possible to carry out light thinnings at frequent intervals and so maintain the stands in a healthy condition, free from too much competition, then there can be little doubt that no *Sirex* epidemic could have developed. Under the conditions which existed in 1946 all fully stocked stands, planted 6 x 6 ft or 8 x 8 ft, and over 15 years old, were in need of thinning. Over many thousands of acres mortality from *Sirex* attack has reduced the stocking by 30 per cent or more, and the trees killed were, in an overwhelming majority of cases, just those which would have been removed by thinning, that is, suppressed trees and those with double leaders or other malformations. . . . Sirex has conferred an inestimable benefit on the stands and in a few years the apparent loss of volume will be recouped by the dominant trees."

Jackson (loc. cit.) refers to the interaction between normal stand development and *Sirex* in 6 x 6 ft. spaced radiata pine at Rotoehu Forest. He indicates that *Sirex* gains entry as stand competition commences about the fifth year. *Sirex* populations increase rapidly as stand dominance and suppression increase, mortality reaching a peak between the sixth and ninth years. During this latter period, a proportion of healthy, dominant trees are attacked and succumb. Thereafter, *Sirex* populations decline to a residual population, and mortality within the stand decreases.

It is a matter of common observation that the more severe the climate the greater the proportion of stem malformation. Hinds (loc. cit.) found at Kaingaroa Forest that the incidence of malformation, expressed as a percentage of basal area, increased with decrease in site quality:

Site I (Index 90-110 ft.)	33 per cent
Site II (Index 73-89 ft.)	44 per cent
Site III (Index 56-72 ft.)	63 per cent

N.B. Site index is mean top height of the 100 trees of largest diameter at age 20.

He stated that the percentage of malforms was apparently not affected by planting or survival densities, but in the wider spacings a higher survival of malforms accounted for an appreciable percentage of the standing volume.

Some ecological changes following on the establishment of the radiata pine forests are recorded by Hutchinson and Henry (loc. cit.). When the pines passed their twentieth year, stocking density and canopy had decreased sufficiently to permit the entry and development of indigenous shrubs, ferns, and herbaceous plants (the latter including some of exotic origin). Significantly, this vegetation was more mesophytic in character than that occupying the area prior to planting. This would appear to be consequent on improvement in the soil, building up of the humus layer, and amelioration of the micro-climate.

In unthinned stands on average sites, current annual increment (C.A.I.) culminates at about age 20, with an increment of some 500 cubic feet to a 6-inch top. Mean annual increment (M.A.I.) culminates about ages 25 to 28, with 300 cubic feet per acre per annum. Volume per acre to a 6-inch top at age 30 ranges between 7,000 and 9,000 cubic feet, the stands containing 100 to 150 trees per acre, 18 inches in mean d.b.h., and 120 ft. in mean height (Hutchinson & Henry (loc. cit.)).

Conversion and Utilisation

Many problems in conversion and utilisation arose directly from the condition of the stands. Felling was hampered and made dangerous by the presence of many standing dead trees. Even the survival of heavily-branched malformed stems was a problem—felling was necessary in order to make way for the second crop—and costly. Branch development had, in many cases, been heavy, boles long, and the crowns high, with, in consequence, a long length of bole carrying dead laterals, leading to downgrading of the sawn timber. Entrican (3), discussing the influence of markets on silviculture, contrasted the intensive and, by comparison, stable demand for wood and small wood generally, in Europe, and in Australia, with the reverse in New Zealand. At the commencement of the afforestation boom in the mid-twenties, sawn production of radiata pine amounted to only 6 million board feet annually out of a total sawn production of some 350 million board feet (mainly of indigenous species). Today, radiata pine comprises 50 per cent of the total sawn production of 640 million board feet. This market for an exotic species has been developed in the presence of a forest resource of superior indigenous timbers, adequate for current and short-term requirements. It reflects the deliberate policy of conservation of the State's indigenous forest resource, and some general public appreciation of the need for conservation of the indigenous forest resource, but primarily the realisation by State and private owners alike that the market development of the fast-growing, short-lived radiata pine had to be tackled boldly or the investment would be lost. It is significant that the development of large wood-using industries in which sawmilling, pulp, paper, and board production are integrated has been in the large radiata pine forests of the Rotorua pumice country. There was no other way of correcting the maldistribution of age-classes in large, untended forests containing a high proportion of logs of indifferent quality. In retrospect, the development of these industries 10 years earlier would have conferred material silvicultural advantages on the radiata pine forests. Pulp production has risen (mechanical pulp, 6,000 tons in 1941 to 103,000 tons in 1959; chemical pulp, 7,000 tons in 1954 to 132,000 tons in 1959); paper, paperboard, and fibreboard production has risen; (newsprint, 9,000 tons in

1956 to 75,000 tons in 1959; other paper, 6,000 tons in 1941 to 44,000 tons in 1959; paperboard, 9,000 tons in 1941 to 32,000 tons in 1959; fibreboard, 9,000 tons in 1946 to 23,000 tons in 1959) (11). These figures relate to the whole of New Zealand. The bulk of the raw material originates from the Rotorua pumice country, where the greater part of it is processed, however.

Regeneration

Clearfelling, commencing in 1939 at the outbreak of World War II, has been the only method of felling practised so far because of the nature of the species and the even-aged condition of the stands. Kennedy (9) refers to the ease with which natural regeneration was obtained from the early clearfellings on most areas, to the profuse regeneration following fire, due to the fact that in normal years most of the seed is retained in the cones (stem cones, aged 15 years, have given a seed viability of over 50 per cent). Seedeating birds tend to congregate on the clearfelled areas and account for large quantities of seed; the European bark beetle (*Hylastes ater*), and the honey fungus (*Armillaria mellea*) take toll of the young seedlings; and weed species, particularly indigenous shrubs and ferns locally inhibit natural regeneration. Despite these adverse factors, stocking was generally adequate and even overabundant. Partially or completely failed areas were restocked by planting. Recently, instances of partial or complete failure of natural regeneration have been more frequent. Investigation has shown that agencies primarily responsible were seed-eating birds and climate. Weed growth and season of felling, inter-related with the foregoing, had some significance. Ways of overcoming failures are being studied and include seed-tree and shelterwood systems.

Tending of the Crop

Current practice in State forests in this area has shown both an adherence to "naturalistic" silviculture and also a move towards "orchard" silviculture. Influenced by the defects apparent in stands established at nominal densities of 500 to 700 trees per acre, standard prescriptions now are designed to secure an initial establishment of 1,000 to 1,200 trees per acre. Natural regeneration is thinned at 3 to 4 years of age and a top height of 5 feet to 1,000 trees per acre. At 7 to 10 years of age and a top height of 40 to 50 feet, stands are thinned to 240 trees per acre. A pulpwood yield of 1,000 cubic feet per acre may be obtained at this age. The final and principal utilisation thinning occurs at age 20 or top height of 90 feet, the stand being reduced to 80 to 120 trees per acre, with a yield of 2,500 cubic feet per acre. Rotations have been set at 40 years, top height 120 to 140 feet, and a yield of 8,000 to 10,000 cubic feet per acre. Concurrently with thinning, some 80 to 100 trees per acre are pruned to a height of 20 feet at 7 to 10 years of age (top height 40 to 50 feet), to develop clear timber in the butt log. Trials are in progress to test the practicability and economics of pruning to a height of 36 feet in order to develop two log lengths of clear timber.

Thus, while the silvicultural approach is "naturalistic" at the outset, with a full initial stocking, subsequent treatment is "orchard" in character, with a few heavy thinnings, improvement in the timber quality of the crop trees being obtained by careful selection, and by pruning one or two log lengths.

The bases are:

1. High initial stocking to permit selection of an adequate number of stems of apparently good type, form, and vigour.
2. A heavy, early reduction in stocking prior to the onset of stand competition, to reduce the subsequent susceptibility of the stand to *Sirex* attack, and to retain a deep crown and thus avoid dead lateral branches and timber degrade arising from dead encased knots.
3. Pruning to secure clear timber in at least the butt log.
4. Subsequent thinning to maintain a deep crown and vigorous diameter and volume increment on the crop trees, recognising the superior timber grade derived from logs containing green knots in contrast to those containing dry, bark-encased knots.

The above prescriptions apply to the State-owned radiata pine forests. There is little uniformity in private silvicultural practice, this varying from a continuation of the present lack of tending to tending at various levels of intensity. In explanation, it must be said that market development and plant capacity are still well below the sustained yield potential of these forests. Thus, where the forest owner has radiata pine only (and this is the situation almost without exception in the case of private ownership), with stands of a narrow age class distribution progressing rapidly towards rotation age, priority has of necessity been given to expansion of plant capacity, correction of maldistribution of age-classes by clearfelling, with tending of young second crops a bad third.

Conclusions

The problems facing the forest owners of the large radiata pine forests of the Rotorua pumice region are manifold. They relate to first crop stands, untended, age-classes maldistributed and approaching rotation age en masse at near half the likely physical rotation, to the regeneration and tending of the second crop, and to market development.

The lack of tending of the radiata pine stands has been "naturalism" carried to extremes. The advantages and disadvantages of this lack of action are stated briefly.

Advantages

1. Rapid creation of a large forest resource already significant in the country's economy. This has been developed at low cost.

2. Some improvement in soil fertility, primarily as a result of fire protection and the elimination of recurrent fires.

3. Natural selection has been allowed full play with the result that natural regeneration of the parent stand may prove better acclimatised to the locality and more resistant to damage by *Sirex*.

4. A greater area of land suited to production forestry is likely to remain permanently allotted to forestry, because of the development of large, permanent integrated wood industries. The importance of wood, a

primary product, in the diversification of this country's exports of primary produce is of high value.

5. Substantial conservation of the indigenous forest resource.

Disadvantages

1. Yields have been lower through loss of intermediate yields.
2. Quality of yield has been poorer.
3. Costs of harvesting final yield have been higher on account of presence of dead and malformed stems.
4. More land has been required than would have been the case under intensive tending.
5. Increased pathological hazard due to presence of numerous dead, damaged, and weakened stems, and the long-continued intensity of stand competition.

The tending prescriptions referred to in the previous section are designed to overcome these disadvantages. It may be that this trend towards "orchard" silviculture is too sudden and too severe. New Zealand has an insular climate in contrast to the climates under which radiata pine develops in Australia, Chile, and South Africa. The vagaries of this climate and the susceptibility of the Rotorua district to unseasonable frosts may dictate an adoption of more orthodox and conservative thinning regimes in order to maintain higher stocking densities. Progress in development of suitable silvicultural regimes has been greatly handicapped by failure to make tending experiments (as suggested by the 1913 Royal Commission).

As more experience is gained and the forests are converted to a normal condition, and as the associated wood industries attain full development, it will be necessary to integrate closely the capacity of the forests and the needs of these industries. Whereas at the time these forests were established the objective was, loosely, the production of timber in the future, today the sustained yield capability of these forests is linked with the needs of finite and permanent wood-using industries. Silvicultural objectives should be designed to meet the requirements of these industries with efficiency and economy, always within the concept of sustained yield.

The author considers the following principles can be derived from the New Zealand experience with radiata pine. They are not new but bear restating:

1. Intensity of tending varies directly with the market demand for smallwood.
2. Flexibility in the planning and timing of silvicultural operations is directly related to the rate of growth of the species, greater flexibility with slow- than with fast-growing species, i.e., flexibility at a minimum with radiata pine.
3. With its susceptibility to damage factors, initial stocking of radiata pine must be high rather than low.
4. To secure the optimum development and yield from radiata pine, tending should be naturalistic, with light, frequent thinnings.
5. Market development for smallwood must be initiated early and boldly in large-scale radiata pine forestry.

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APPENDIX I

New Zealand's Forest Resource—Historical

Forest history the world over has shown a tragic similarity of pattern in man's attitude towards his forest resources. New Zealand has conformed to this pattern to an unfortunate degree.

New Zealand's forest policy has evolved against an unusual background, and the evolutionary process cannot yet be regarded as complete. In little more than a century, the country has acquired a population of European stock of over two millions and has developed a prosperous agricultural economy based on the export of wool, meat, and dairy products. The development of New Zealand is predominantly a story of pasture establishment, and forests have played a highly diversified role in the overall picture.

In the North Island, once almost completely forest-clad, millions of acres have been converted from forest to grassland. There, the early European settlers had no option but to fell and burn the forest to make the soil available for agriculture, their only means of livelihood in a new, undeveloped land. Much the same procedure occurred simultaneously in the forested portions of the South Island, but large areas of this island, notably in the eastern districts, were naturally treeless. Here there was ample land, ready for the plough, and soils fertile enough to grow food and fodder crops in abundance. But these areas were almost uninhabitable because of frequent and devastating gales, and the complete absence of local timber supplies was a crippling bar to development. Thus, to settlers in one part of the country, survival involved the wholesale destruction of forests; in other parts, the establishment of forests to provide shelter and timber was no less urgent. It is fortunate for later generations that the early introductions to New Zealand included tree species from Australia, Europe, and North America. Experience with these

importations during the latter half of the nineteenth century laid foundations for the establishment of a considerable exotic forest estate which New Zealand was later to find so necessary (2).

Slow in gaining ground has been the recognition that the increased incidence of erosion and the resultant flooding of many rivers and streams are evils inevitably following the deforestation of steep slopes and river catchments. A policy of liquidation of the indigenous forest resource could be justified as a prelude to closer settlement and agricultural development, and even then only when not extended to steeper land subject to erosion. Too often this justification has been lacking. The result has been inevitable—a diminishing indigenous forest resource, the exhaustion of which under pressure from a rising population was early forecast by thinking men.

Recognizing that the major indigenous timber species were "difficult" silviculturally, slow-growing, and requiring rotations of 150 to 200 or 400 years, an alternative and/or supplementary forest resource was sought in the creation, by artificial establishment methods, of forests of fast-growing species of exotic origin.

While small-scale private and communal planting with exotic tree species commenced in the 1880's, planting by the State did not commence until the 1890's but thereafter continued steadily, though on a small scale until 1922. An afforestation boom of the twenties and thirties saw the establishment of the greater part of New Zealand's exotic forest resource, with private afforestation companies and the State playing equal parts in this development. Planting has continued, but at a reduced tempo, since 1934.

APPENDIX II

New Zealand's Forest Resource—Statistical

Statement of Forest Areas (3)

Tenure	Forest area in 1,000 acres and percentages		
	Indigenous (a)	Exotic (b)	Total (c)
State	11,140 (77%)	477 (52%)	11,617 (76%)
Communal	—	37 (4%)	37 (about 0.2%)
Private	3,330 (23%)	412 (44%)	3,742 (24%)
Totals	14,470 (100%)	926 (100%)	15,396 (100%)

N.B. (a) New Zealand's production forest area comprises about 2 million acres of indigenous forest and just under 1 million acres of exotic forest.

(b) 47% of softwood species belonging to the genera *Agathis, Dacrydium, Libocedrus, Phyllocladus,* and *Podocarpus;* 18% of hardwoods principally of the genera *Beilschmiedia* and *Nothofagus;* 35% of mixtures of the above softwoods and hardwoods.

(c) Mainly softwood species belonging to the genus *Pinus,* but also *Pseudotsuga, Larix,* and lesser quantities of *Cupressus, Cryptomeria, Picea, Thuya,* etc. Hardwoods, principally the genus *Eucalyptus,* amount to less than 1%.

The significance of New Zealand's developing exotic production forests is emphasised by the fact that for the year ended 31st March, 1959, the total production of rough sawn timber consisted of:

Indigenous species	319	million board feet
Exotic species	318	million board feet
Total	637	(about 106 million cubic feet)

It should be added that the entire wood requirements of the pulp and paper industries are from exotic forests.

An estimate of the total New Zealand demand for wood for the year 1957 was:

Sawn timber	106	million cubic feet	(77%)
Pulp products	26	million cubic feet	(19%)
Plywood & Veneer	2	million cubic feet	(1%)
Other roundwood	4	million cubic feet	(3%)
	138	million cubic feet	(100%)

APPENDIX III

New Zealand's Exotic Forests—Species Area Per Cent by Ownership Classes (1)

Species	Ownership class as per cent of area			
	State	Afforestation Company	Communal and other private	All ownerships
Corsican pine	14		1	7
Douglas-fir	11	0.4	2	6
Larch	2			1
Loblolly pine	0.7			0.4
Lodgepole pine	5.6			3
Patula pine	0.7			0.4
Ponderosa pine	18	6.2	1	12
Radiata pine	46	93.4	96	69
Slash pine	1.3			0.8
Strobus pine	0.7			0.4
Totals	100.0	100.0	100.0	100.0
Total ownership per cent	53	36	11	100

Exotic production forests, distributed throughout North and South Islands, amount to just over 920,000 acres, of which pure stands in State, communal, private afforestation company, and other private ownership comprise 96% of the whole, mixed stands in State ownership the remainder. These forests are generally less than 20,000 acres in area, with the State forests sited in relation to population centres to provide some measure of regional self-sufficiency. There are two exceptions to the above, both in Rotorua Conservancy, North Island, one a State forest of just over 250,000 acres, the other a private afforestation company forest of 175,000 acres. The two tables show by ownership classes and by age classes the percentage distribution of the ten major exotic species comprising over 90% of the total exotic forest area.

The table highlights the importance attached to radiata pine in all ownership classes. The greater diversification of species in State plantings is a reflection of the greater geographical range over which these plantings occur, poorer site quality, but also recognition by the State of the merit of diversification from a pathological point of view.

APPENDIX IV

New Zealand's Exotic Forests—Species Area Per Cent by Age Classes (1)

Species	Age class as per cent of area					Area Pure Stands (1000 acres)
	1-10	11-20	21-30	31-40	41-60	
Corsican pine	5	10	28	40	17	60
Douglas-fir	10	8	33	46	3	46
Larch	3	1	1	—	95	8
Loblolly pine	39	13	35	11	2	1
Lodgepole pine	—	7	65	28	—	20
Patula pine	16	54	29	1	—	3
Ponderosa pine	1	4	64	28	3	93
Radiata pine	11	19	22	57	1	572
Slash pine	7	44	49	—	—	3
Strobus pine	11	17	56	10	6	3
All species	8	10	29	50	3	809

The table highlights the maldistribution of age classes occasioned by the afforestation boom of the 1920's and 1930's, and that almost 80 per cent of the forest area is in the 21 to 40 age group. Again, the dominance of radiata pine as a major component of the exotic forests is given emphasis.

APPENDIX V

References Quoted in Supplement

(1) Hinds, H. V. and Reid, J. S. New Zealand Forest Service Bulletin No. 12. Forest trees and timbers of New Zealand. Government Printer, 1957.

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RESUMES

La sylviculture "jardinée" et la sylviculture "naturaliste" dans les forêts de Pinus radiata en Nouvelle Zélande

Les forêts productives de la Nouvelle-Zélande couvrent quelque 3 millions d'acres dont 2/3 sont plantés en essences indigènes et 1/3 environ d'essences d'origine exotique. La production actuelle de bois de sciage est de 640 millions de "board feet" (le "board foot" est une unité de mesure du bois représentant environ 30cm x 30cm x 2,5cm) répartis également entre les essences indigènes et les essences exotiques.

L'auteur indique l'importance de l'essence exotique *Pinus radiata* dans l'économie forestière néo-zélandaise, et son importance particulière dans l'arrondissement de Rotorua, dans l'île du Nord (dans les terres volcaniques du plateau central). En outre, cette essence est la seule qui ait donné lieu à une vaste expérience de régéneration et amélioration de la seconde récolte. Pour ces raisons, le document porte uniquement sur une essence, le *Pinus radiata* et se limite géographiquement aux grandes forêts appartenant à l'Etat ou à des compagnies de reboisement privées dans l'arrondissement de Rotorua.

Le *Pinus radiata* représente 62% de la totalité des ressources forestières en arbres exotiques, et 40% de l'ensemble de ces ressources se trouvent dans la région de Rotorua. Le document interprète les expressions "sylviculture jardinée" et "sylviculture naturaliste". L'auteur rend compte ensuite du développement du *Pinus radiata* dans la région de Rotorua. Avant la plantation, la terre était inculte et considérée pendant les années '20 comme ayant peu de valeur du point de vue agricole. Il est certain qu'avec les connaissances dont on dispose à l'heure actuelle on ne céderait plus ces terres à la sylviculture. Ces forêts ont été créées par voie de plantation, principalement entre 1920 et 1940 avec des ecartements de 8 pieds sur 8 pieds et de 9 pieds sur 9 pieds. Le document souligne le peu d'écart qui existe en consequence entre les différentes classes d'âge des arbres, état de choses qui a créé de nombreux problèmes quant à l'aménagement ultérieur et à l'utilisation des forêts. Pour n'avoir pas compris les besoins d'entretien de cette espèce à croissance rapide au cours des premiers stades de cette croissance, et faute de marchés pour le petit bois, on a été amene a remettre jusqu'à la fin de la Deuxième guerre mondiale les travaux d'entretien qui étaient arrivés à échéance à la fin des années '30. Immédiatement après la guerre on a examiné l'état de ces forêts et indiqué les mesures nécessaires à l'amélioration des peuplements de seconde récolte. L'état de ces forêts, virtuellement abandonnées à elles-même pendant la majeure partie de la rotation, offre un exemple frappant des dangers inhérents à une implatation de àgranas écartements soumise à des conditions climatiques extrêmes et aux dégâts qui en découlent. L'auteur indique certaines des conséquences du mal fait par les insectes (particulièrement le *Sirex noctilio*) et par les champignons (particulièrement les *Diplodia pinea* et *Phomopsis strobi*). L'absence de soins, a joutée aux fléaux indiqués, est responsable de la proportion considerable de tiges mal formées et d'arbres morts sur pied dans un peuplement d'unetrentaine d'années. Les rendements sont de l'ordre de 7 à 9.000 pieds cubes par acre, avec diametre superient de 6 pouces. L'acroissement annuel actuel atteint son maximum à 20 ans et 500 pieds cubes par acre, l'accroissement annuel moyen atteignant son maximum entre 25 et 28 ans à 300 pieds cubes par acre.

L'auteur est d'avis que le développement de ces peuplements represente le naturalisme poussé à l'extrême, compromis dès l'origine par une faible densité et par une très mauvaise répartition des catégories d'âges.

Il énonce les problèmes que posent la conversion et l'utilisation. Ces problèmes découlent du nombre d'arbres morts sur pied, des variations de formes des arbres, et de la mauvaise répartition des catégories d'âges. Leur solution demanda une action hardie en vue du développement du marché et de la création d'importantes industries utilisatrices de bois.

L'auteur conclut qu'avec le *Pinus radiata*, l'intensité des soins à donner dépend du marché du petit bois, qu'il ne doit pas y avoir de variation dans les calendriers de soins, que la prédisposition à la déterioration doit être combattue par une implantation dense, que les coupes doivent être modérées et fréquentes et qu'il est essentiel de créer aussi tôt que possible un marché du petit bois.

Horticultura en vez de silvicultura naturalista en los bosques de Pino radiata de Nueva Zelandia

Los bosques productivos de Nueva Zelandia abarcan una superficie de 3 millones de acres en los cuales las especies indígenas cubren 2 millones de acres y las exoticas poco menos de un millon de acres. La producción actual de madera aserrada es de 640 millones de pies tablares aproximadamente, en cantidades iguales do madera indígena y de madera exotica.

Se indica la importancia de la especie extranjera, *Pinus radiata*, en la producción maderera de Nueva Zelandia y, particularmente, en el Conservatorio de Rotorua en la Isla del Norte, o sea en las tierras de piedra pomez de la meseta Volcánica Central. Es más, ésta es la única especie con que se ha adquirido experiencia, en gran escala, para la regeneración y cuidado del segundo corte. En tal virtud, este trabajo se limita a una sola especie, el pino radiata, y geográficamente, a su diseminación en los grandes bosques del Estado y de la empresa forestadora en el Conservatorio de Rotorua.

El pino radiata representa el 62 por ciento de la riqueza forestal exótica, de cuya proporción el 40 por ciento se concentra en la zona de Rotorua. Se da la interpretación de silvcultura de "huerto" y de silvicultura "naturalista". Se presenta también una relación del modo en que se extendió el pino radiata en la zona de Rotorua, la que, antes de las plantaciones, se consideraba terreno inútil, considerado hasta 1920 como de muy escaso valor para la agricultura, pero con los conocimientos actuales en ella, es seguro que esas tierras no se hubieran destinado a la silvicultura. Los bosques se crearon plantándolos, entre 1920 y 1940, con espaciamientos de 8′x8′ y de 9′x9′. Se concedió atención especial a la resultante escasa variedad de edades, que suscitó muchos problemas en el cuidado y aprovechamiento posterior de los bosques. El hecho de no percatarse de la necesidad de cuidado inicial de esta especie de crecimiento tan rápido y la falta de mercados de madera pequeña, condujo a posponer el cuidado, casi desde 1940 hasta el fin de la sequnda guerra mundial. Después de la guerra se estudió la condición de los bosques y se consideraron las medidas necesarias para mejorar la del arbolado para segundo corte. La condición de estos bosques, prácticamente desatendidos durante la mayor parte del período de rotación, fue ejemplo patente de los males que acarrea la plantación escasa en lugares sujectos a cambios extremos de tiempo y a los daños del clima. Se presenta una relación de ciertos daños causados por los insectos, particularmente el *Sirex noctilio*, y por los hongos, particularmente el *Diplodia pinea* y el *Phomopsis strobi*. La falta de cuidado, además de los daños causados por insectos y hongos, condujo a una alta proporción de troncos deformados y de arboles muertos en pie como a edad de treinta años. El rendimiento se expresa entre 7.000 y 9.000 pies cúbicos por acre, hasta un punto de aprovechamiento de 6 pulgadas. El incremento anual del presente es máximo a la edad de 20 años y 500 pies cúbicos por acre, con el incremento anual máximo, por término medio, de 25 a 28 años de edad, aproximadamente, y 300 pies cúbicos por acre.

El autor afirma que el desarrollo de estos arbolados es el naturalismo llevado al extremo, con la mayor desventaja, desde el principio, de baja plantación inicial y muy mala distribución de clases por edad.

Se exponen los problemas de la conversión y del aprovechamiento suscitados por numerosos árboles muertos en pie, diversi-

dad de formas de los árboles y mala distribución de clases por edad. La solución requiere acción enérgica en la creación de mercados y en la fundación de industrias madereras en grande escala.

El autor llega a la conclusión de que, como la intensidad de cultivo del pino radiata depende del mercado de madera pequeña, no puede haber flexibilidad en determinar las épocas de cultivo; de que la susceptibilidad a daños requiere gran número de arboles en las plantaciones; de que los clareos deben ser ligeros y frecuentes y de que es necesario fomentar de inmediato el mercado de madera pequeña.

"Orchard" Versus "Naturalistic" Silviculture

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Introduction

The stormy development of technology and the resulting upheavals in our economic system have not remained without influence on our silviculture. For certain species the demand is climbing progressively, while other formerly important stocks are now hardly marketable. Hence, industrial and economically oriented foresters are increasingly attacking the foundations of classical silviculture. It is, therefore, to be welcomed that the leadership of the World Forestry Congress has placed this basic question in the center of debate, and we are thankful for the honor to contrast "orchard" forestry and naturalistic silviculture. In doing so, we shall try to illuminate a silvicultural teaching which has been undisputed in Switzerland for half a century, and which has been steadily developing since the time of Arnold Engler. It should be emphasized, nevertheless, that this teaching is in no way purely of Swiss origin; it belongs much more in the greater frame of a European silvicultural school, for which we must thank Boppe, Gayer, Cajander, Morosow and others, as well as such Swiss as Engler, Biolley and Schädelin.

If the teachings of the great European silviculturists have found fruitful ground in Switzerland, it is not only because of the nature of the country and its political and economic conditions, but also because of the good fortune that it has remained undisturbed, for many generations, from the ravages of war and extensive catastrophes. Through the long forest history of our country all the stages in the complex man-forest relationship can be clearly traced. These stages, standing side by side throughout the world today, are the origin of so widely differing viewpoints on basic silvicultural questions.

As one of the lowest stages, we see the primitive forest use, beginning with the collecting of wood, fruit, foliage and cow feed, and ending with the destruction of the forest through exploitation. Clearing for settlement and agriculture, fires and allied uses (grazing, etc.) which are today still in full swing over large parts of the world, reduced the forest area in Switzerland during the middle ages to barely one-fourth of the land area. Avalanches, floods, soil erosion, and other results of deforestation showed at an early time the protective role of the forest. As early as the 14th century, protection forests were established, and in 1488, the Zürcher Bürgermeister, Hans Waldmann, enacted a forest protection law, something which is still lacking in large parts of the world today.

The general Western and Middle European fear of a wood famine also gripped our country during the 18th and 19th centuries. From England, France, and especially Germany, a forestry movement began which led to large areas of pure stands on an agricultural pattern and which does not differ greatly from the "orchard" forestry practiced in some of the silviculturally less-developed lands today.

In the second half of the last century, damage of all kinds in areas using this old form of forest practice led increasingly to the knowledge that sustained yields would only be possible in biologically healthy forests suited to their environment. Mainly through Gayer, a movement began in Middle Europe toward a naturally managed forest. Like every revolutionary change, this movement also led to extremes. The picture of an unchanged natural forest was much too one-sided, and any alteration was regarded as disastrous. However, Engler, Schädelin, Dengler, and many other silviculturists developed the synthesis of biological and economic viewpoints. In our time, the postulates of a naturalistic school of silviculture were supplied by: basic yield studies, such as Wiedemann's; the strong development of soil science by Ramann, Wiegner, Pallmann, and their students; the progress in plant sociology by Braun-Blanquet, Tüxen, Pawlowski, Horvat, Szafer, and many others; and Lundegardh's and Hesselmann's outstanding work in ecology. It is this school which is taught by the majority of European silvicultural teachers. The existing differences in the Middle European schools arise from the fact that silviculture is characterized by the biological and economic nature of a region. A comparison of "orchard" forestry and naturalistic silviculture can, therefore, be made successfully only by considering such differences.

The Aims of Silviculture

In order to present the fundamental principles of the naturalistic silviculture of Middle Europe, and especially Switzerland, the essentials of the silvicultural objectives should first be considered. Silviculture is never an end in itself but rather a part of the national economy.

In our densely populated countries, the forest must provide the following requirements:

1. Protection from unfavorable climatic influences, such as soil erosion, floods, avalanches, and winds. The protective role of the forest is especially important in the Alps, Carpathians, and Pre-alps;

2. Social benefits, such as recreation and enhancement of the landscape. These are gaining in importance as the population increases; and

3. A natural resource, especially for wood. This is the only requirement which is not strongly regional, since it can be met partly or for a time by wood imports.

Since the largest portion of our Swiss forests are under public ownership, private and public interests seldom collide with each other. Further, we believe that the protective, recreational, and productive role of the forest is based in a large part on the same principle. Endurance, security, beauty, and good management do not exclude each other. We are, therefore, obliged to manage forests which comply not only with biological, but also with psychological and economic requirements. The continuous fulfillment of these requirements has long been the fundamental principle of European forestry. It is, therefore, self-evident that sustained yield has a much narrower meaning in mountainous countries like Switzerland than in the lowlands.

"Naturalistic" Silviculture

Naturalistic silviculture is based on the principle that in the long run a forest can satisfy economic and other requirements only when the interrelationship between stand, site, and entire plant and animal world exists in harmony. This interrelationship is harmonious if it can be maintained for a long time without human help, and if the site quality is continuously preserved. Thus, plant sociology is one of the most important foundations of naturalistic silviculture, while "orchard" forestry depends much more on the physiology and ecology of individual tree species.

Here we must clearly differentiate between "naturalistic" and "following nature." "Following nature" implies the natural forest, that is, a forest undisturbed by man in regard to species composition and stand structure. On the contrary, a "naturalistic" forest is one whose species, composition, and structure have been altered, but is nevertheless adapted to its site. From it we require an uninterrupted and constant or increasing yield in quantity and quality and the best possible fulfillment of all protective and social functions. Naturalistic silviculture differs from agriculture in that it adheres as closely as possible to natural conditions. The naturalistic forest *is* "forest" and not a plantation of trees. With natural conditions taken as a guide, a careful deliberation is made to see: (1) How far they depart from the economic requirements; and (2) How great a modification in mixture and structure of the forest can be allowed.

Thus, the naturally managed forest is attained through sound economic planning. The skill of a forest manager rests in continuously obtaining the highest possible yields without disturbing the natural environment.

When considering the choice of species, silvically and economically important tree species native to their site are chosen first. We know from experience that the species composition can be changed without appreciably disturbing the site. The same is true when species not native to the site are introduced, especially when these species are indigenous to the region. On the contrary, a danger exists when exotic species are introduced. Since these have not become adapted to the biocenotic conditions through a long natural selection, they are strongly susceptible to new pests and diseases. Impressive examples are the Weymouth Pine (*Pinus strobus*) and Douglas-fir (*Pseudotsuga taxifolia*). In contrast to pure plantation, the naturalistic forest has the advantage that under some conditions tree species foreign to the site may be introduced with outstanding results, while in pure plantations they are endangered, short-lived, or damaging to the soil. This is especially true for certain economically important conifers. The site adaptability of a species should not be estimated purely from soil and climatic factors; rather, its behavior within the entire environment must be scrutinized. I have coined the phrase "guest species" to mean two things. First, they constantly require special attention; secondly, they can be admitted in greater or lesser number (depending on the conditions) into the harmonious living community.

The more stable the biocenotic balance, and the greater the variety and number of organisms in the natural surroundings, the greater are the possibilities of altering the natural species mixture.

In the technique of reproduction, naturalistic silviculture strives for self-seeding. In comparison to a plantation, this may, under some conditions, demand more attention. However, it has the well-known silvicultural advantages of proper species distribution for the site, rich selective possibilities, small danger of root diseases, adaption to local light conditions, etc. The regeneration periods are prolongated as much as possible; first, to fully utilize the yield capacity of the best trees in the stand; and secondly, because many-storied, uneven-aged stands afford numerous advantages in regard to silvicultural operations and the reduction of various dangers.

In order to introduce and carry through natural reproduction, different cutting methods are used, depending on the site, stand, species to be reproduced, and the phase in the reproduction process. For this reason, Köstler coined the phrase "free felling".

In the Swiss naturally managed forests, only two cutting methods are differentiated, the "Femel-coupe" and the selection systems. Both management forms are used single-stem-wise, with reproduction in small areas, so that a stranger could easily speak only of "selection forests." Nevertheless, there are important differences.

The Swiss "Femel-coupe" is characterized by groups and clusters of reproduction, which are introduced over as long a period as possible. By the gradual widening and blending of the regeneration, the whole stand finally becomes regenerated. The entire procedure is carefully planned, with special attention being given to the felling and skidding. Reproduction is first carried out to the limit of transport. The greatest possible regard is paid to the site conditions, species, stand structure, and particularly to the local growth and timber quality.

The selection system, however, works toward a unified, continuous, and invariable stand structure. This is the selection form. Any spatial arrangement in the sense of regular fellings is missing; reproduction, harvesting, and tending are carried out continuously over the whole area. In Switzerland, typical selection forests are limited to the natural range of the white fir (*Abies alba*) and to the higher alpine forests.

In Central Europe, the doctrine of naturalistic silviculture also includes other cutting methods similar to the various shelterwood systems. These are always characterized, however, by a lack of schematic spatial organization, a regeneration period which is not strictly fixed, and cutting methods which are freely adapted to local conditions.

With naturalistic silviculture, the center of activity is not harvesting and reproduction, but rather the uninterrupted succession of tendings. These forests are conceived as complex living communities whose development, by continuous silvicultural intervention, is linked to the best fulfillment of the economic goals. Their yields are not primarily means of wood production, but rather means for forming the stands, improving their quality and growth, and regenerating them.

The advantages of naturally managed forests are the continuous production of wood, protection, and social benefits. The forest never ceases to be "forest." Long practical experience has demonstrated that a tended, naturally managed forest is far more resistant than a plantation to disease and damage. In Middle Europe, forest damage in large amounts appears almost exclusively in unnatural forests. The complicated biocenotic relationships of the naturally managed forests have shown themselves to be highly stable. The expense of their maintenance is extremely small, and forest protection plays a subordinate role. Trees not native to the site exhibit better growth, quality and health in naturally managed forests than in plantations, producing, in the long run, higher yields. The undisturbed nutrient cycle in the naturalistic forest assures the site an undiminished yield capacity. Such forests can make full use of the site productivity without artificial measures to maintain or improve soil fertility. The sustained yield of the naturally managed forests of Middle Europe in quantity, quality and value is relatively high. The capability to adapt to changes in the demand for different species and lots is a significant advantage. In general, overcuttings have proved less damaging to naturally managed forests than to "orchard" forests. A further advantage is the biological and economic possibility for natural reproduction. The increased costs for mixture regulation in young growth are compensated by the lack of costs to establish artificial reproduction. Also, higher logging costs are balanced by the better use of the site productivity. The sustained income from naturally managed forests is therefore strikingly high.

Finally, the lasting protection and social benefits of the naturally managed forests in mountainous and densely settled areas are not to be underestimated.

The disadvantages of naturally managed forests are, when compared with their advantages, small in Central Europe. Considerable silvicultural and business knowledge is required. Harvesting, tending and administration are more difficult. In countries where forest development, research and organization are high, these disadvantages appear small. Further, we don't believe the necessary road system to be a disadvantage. A good road network is the basis for *every* intensive forestry practice. Costs should never be the sole criteria by which an enterprise is judged. Its sustained success is much more decisive. As a disadvantage of the naturalistic method of management, we can only admit to the increased difficulty of all mechanized operations. Recently established, naturally managed forest enterprises demonstrate, however, that a correctly understood mechanization is possible. Today we possess equipment for tending, chain-saws, tractors and other transportation means which can also be used in mixed uneven-aged forests. It is our conception that machines and tools must be adapted to silviculture, and not conversely.

Of course the advantages and disadvantages of naturally managed forests have different significance in different regions. The state of technical development, the utilization possibilities of forest products, the general economic outlook, and natural conditions all alter the significance of the single advantages. Nevertheless, we cannot fail to recognize that in regions with an old forestry tradition the peak economic output is registered by intensively, naturally managed forests.

"Orchard" Forestry

"Orchard" forestry, unlike naturalistic silviculture, is based on the same principles as most branches of agriculture.

The choice of species, site permitting, is made exclusively on economic principles based on current market conditions. Stands are established artificially, and, whenever possible, by the use of machines. In the same way, they are harvested on an area basis by machinery. The yield capacity of the site is maintained and improved, when necessary, by artificial methods (cultivation and fertilization).

The advantages of "orchard" forestry are simplicity, opportunity for mechanization, the use of plant breeding, and the production of large amounts of readily marketable lots with relatively low costs. Although these arguments are convincing, there are also important objections. Through simplification, the ability to adapt species to small changes in site is lost. The one-sided performance of production makes adaptation to changing markets impossible. Regeneration requires planting on a clear-cut area, with all its well-known disadvantages and a high cost outlay. Area-wise, yields make it impossible to utilize the productivity of individual trees, so that a sinking of production costs is opposed by lower yields. The oft-stated advantage of high volume production holds, in most cases, only for short periods. However, the great biological disadvantages should certainly not be overlooked. These also become economically significant when considered over a long period. Sustained yields are doubtful. The expenses of maintaining soil fertility and pest control soon become appreciable. Large-scale damage from insects, fungi, drought, storms and fire can lead to considerable losses. Temporary high volume production also leads to losses in the yield capacity of the site. Further, the advantage of short rotations could also be found in naturalistic silviculture, for the length of rotation in both "orchard" forestry and naturalistic silviculture is a question of yields and business considerations.

Comparison of "Orchard" Forestry and "Naturalistic" Silviculture

"Orchard" forestry and "naturalistic" silviculture proceed from different basic assumptions. Each has advan-

tages and disadvantages which vary according to site conditions, economic provisions, and the tree species in question. Soils poor in nutrients and with physical characteristics which do not vary greatly require different consideration from rich soils which are largely dependent on the stand. For afforestation, other viewpoints than the management of existing, healthy, and high-yield forests may often be the deciding ones. Fast-growing, short-lived trees require different silvicultural treatment from the long-lived species of the managed forests. The demands placed on the protective function of forests in the high rainfall alpine areas are different from those placed by the dry lowlands. Finally, many types of required social benefits vary from region to region.

Therefore, we are not confronted by having to decide between "orchard" forestry and naturalistic silviculture. While timber production is the single function of the orchard, it is only one of the many functions of the naturalistic forest. But it would be highly disastrous to direct silviculture only and one-sidedly from the current economic conditions. Whenever biological and economic deliberations stand in opposition, we must not forget that silviculture will always remain a biologically bound technique. In the long run, whatever proves to be incorrect biologically will never be economically sound. In spite of technical developments the doctrine of sustained yield will remain the foundation for silviculture.

A century ago Pfeil demanded a regional silviculture based on site. Gayer gave this demand general recognition in Middle Europe. A series of outstanding practicing and research foresters have built, piece by piece, a scientifically grounded and practically tested naturalistic silviculture. This has clearly proved successful in countless model forest enterprises in Central Europe. Yet, we know that the possibilities of increased yields are far from being fully used. Many naturally managed forests can be enriched with especially valuable species. Wood quality can be improved still more through tending the forests. More careful silvicultural planning will increase the forest yields while preserving sustention, protection, and social benefits. Finally, it must not be underemphasized that research and teaching are everywhere the motor of progress. Naturalistic silviculture still poses countless unsolved questions—above all, questions which result from the mistakes of the earlier "wood farming." These have given us too many examples of how one should not proceed in the long run, and how immensely difficult it is in some cases to regain the lost yield capacity.

On suitable sites, with appropriate and fast-growing species, we give "orchard" forestry full regard. However, the ideal of silviculture has clearly proved to be the continuous production of the highest possible volume of valuable timber from biologically healthy, naturally managed forests.

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RESUMES

La sylviculture de pépinière et la sylviculture naturaliste

La sylviculture, elle aussi, a été influencée par la révolution qui s'effectue actuellement dans notre système économique tout entier. En particulier, les fondements de la sylviculture naturaliste, telle qu'elle s'est développée au centre de l'Europe, ont fait l'objet d'attaques répétées. Ce document décrit les différentes étapes du développement de la sylviculture, en se basant sur la situation en Suisse. Finalement, grâce à Gayer, un mouvement commença à se manifester vers l'aménagement naturel des forêts, qui existe aujourd'hui sous diverses formes suivant les conditions régionales. Les points de vue biologique et économique ont été réunis en une synthèse basée sur les résultats de la recherche scientifique.

En Europe centrale, le but de la sylviculture est de produire des forêts qui offrent les avantages permanents ci-après: (1) Protection; (2) avantages sociaux; et (3) matières premières. La sylviculture naturaliste est basée sur le principe qu'à longue échéance une forêt ne peut satisfaire les exigences économiques et autres que lorsqu'il existe des rapports harmonieux entre ses divers facteurs: peuplements, sol, climat, flore et faune. Le secret d'un bon aménagement forestier consiste à obtenir et à maintenir les plus hauts rendements possibles sans compromettre cet équilibre. Pour ce faire, les instruments dont le forestier dispose sont le choix des essences, les méthodes de reproduction et surtout les opérations d'aménagement.

Par contre, les méthodes plus simples de la sylviculture de pépinière reposent sur des principes plus proches de ceux de l'agriculture.

Procéder à une comparaison entre la sylviculture naturaliste et la sylviculture de pépinière n'implique pas que nous ayons nécessairement à choisir l'une ou l'autre. Dans des conditions convenables, nous reconnaissons donc pleinement les avantages de la sylviculture en pépinière portant sur les espèces à croissance rapide qui s'y prêtent. Toutefois, il a été clairement démontré que l'idéal de la sylviculture est d'assurer une production continue du plus grand volume possible de bois supérieurs, grâce à des forêts saines au point de vue biologique et faisant l'objet d'un aménagement naturel.

El "Huerto" y la "Silvicultura Naturalista"

La silvicultura también ha sido afectada por la actual revolución que se ha producido en la totalidad de nuestro sistema económico. Muy en particular, se han sometido a repetidos ataques las bases de la silvicultura naturalista, tal como fueran desarrolladas en Europa central. Partiendo de las condiciones que imperan en Suiza, se describen en este trabajo las distintas etapas de evolución de la silvicultura. Finalmente, Gayer fue el iniciador de un movimiento hacia la administratión natural de bosques, cuyas diversas formas, dependientes de las condiciones regionales, pueden apreciarse en la actualidad. Se han aunado aquí puntos de vista biológicos y económicos en una síntesis basada en los resultados obtenidos por medio de la investigación científica.

En Europa central, el objetivo perseguido por la silvicultura es la creación de bosques que en forma permanente ofrezcan: (1) Protección; (2) beneficios sociales; y (3) materias primas. La silvicultura naturalista se basa en el principio de que a la larga un bosque únicamente puede satisfacer exigencias económicas y de otra índole cuando las existencias, el suelo, el clima y toda su fauna y flora presentan una interrelación armoniosa. La competencia de un administrador forestal descansa en su habilidad de obtener y asegurar para el futuro el mayor rendi-

miento posible, sin causar un desequilibrio de esta armonía. Para lograrlo, tiene a su disposición elementos tales como la selección de especies, técnicas de reproducción y muy especialmente los métodos de atención y cuidado del bosque.

En contraste, la silvicultura de "huerto", que presenta características más sencillas, se basa en principios que se asemejan más a aquellos de la agricultura.

En nuestra comparación de la silvicultura "naturalista" con la de "huerto", en general no estamos confrontados con la disyuntiva de tener que decidirnos por una u otra. Por ello, en condiciones apropiadas, acordamos nuestro pleno reconocimiento a la silvicultura de "huerto" con especies adecuadas y de crecimiento rápido. Sin embargo, ha quedado claramente demostrado que el ideal de la silvicultura es la producción continua del mayor volumen posible de maderas valiosas, procedentes de bosques biológicamente sanos y administrados naturalmente.

Orchard Versus Naturalistic Silviculture

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This topic, that of orchard versus naturalistic silviculture, will most certainly be understood in many ways, and it is quite certain that in the various parts of the world different interpretations are accepted. In the following, I wish to put forward my opinions on the matter, first of all, as regards conditions in the Scandinavian countries, in general, and particularly in Finland.

Certain facts must, in this connection, be stressed concerning conditions in Northern Europe: (1) The northern location of the forests, which has its effect on the forestry practised in these areas; (2) The present state of the forests—there are still many unsatisfactory features dating from a less rational period of forest utilization; and (3) The great proportion of farm woodland, a question which has undertones which are both psychological and connected with private economy. Such factors mean that the practical treatment of the question under discussion differs somewhat from the theoretical deductions.

To get a clearer picture, it is worthwhile, first of all, to consider the advantages and disadvantages of naturalistic silviculture in comparison with management represented by orchard-like plantations, with specific reference to northern conditions.

Naturalistic silviculture has the following advantages: (1) Natural reproduction does not require any immediate expenditure on the part of the farmer, which is a great practical advantage; (2) The prerequisites for successful natural reproduction are generally good, with the exception of forests on polar and alpine timber line regions and success depends essentially on the treatment of the forests and is not so much a problem of natural seeding; (3) Racially, the trees are generally good, so that forest management does not require complicated methods necessitating great professional skill; (4) Natural reproduction, correctly performed, does not lead to degeneration of race—on the contrary, it leads to improvement.

The disadvantages are: (1) A rather long reproduction time, which, under intensive conditions, means a falling off in yield and an increase in the rotation period; (2) A more or less uneven new growth and an unsatisfactory use of the site; (3) Thinnings of the young stands which are unprofitable at an early stage, but are cost-consuming; and (4) A generally uneven development of the stands, even at a more advanced age.

The advantages of artificial reforestation include: (1) An even and efficient use of the site, the consequent strong development of the forest at an early stage, and high yield; (2) An immediate start of the forest generation without wasting time, which accordingly decreases the rotation; (3) The opportunity to make a particularly efficient selection of plants before planting, which accelerates the development of the forest; and (4) Thinnings in the young stands are not necessary, which means a consequent decrease in expenditure.

The drawbacks of artifical reforestation include: (1) A rather high direct expenditure, which makes its general acceptance difficult, especially among farmers; (2) The risk of failure due to weather conditions, insect pests and diseases, the quality of work, etc., and, consequently, a certain amount of uncertainty on the part of forest owners; (3) An insufficient seed supply in general and, in addition, the difficulties involved in moving provenances from one locality to another; and (4) The chances of rot.

When the question is examined against this background —the mutual relation between naturalistic silviculture and highly developed, orchard-like silviculture based on artificial reforestation—it is obvious that we are dealing with a dynamic phenomenon which has changed and will always change, primarily according to the intensity with which forestry work is carried out. Thus, in the North, it is not a matter of two conflicting silvicultural systems, but one of successive stages of development, which differ from one another periodically and locally with the intensity of forestry and the development of methods.

Thus, in early times, when the supply of timber was always adequate, or even exceeded the need, it was, to all intents and purposes, immaterial how the forests were treated and how quickly or slowly they were reforested. In those days, forests were not treated but used in a purely arbitrary fashion, to the point of downright plundering. Under such circumstances, there was naturally no question of artificial reforestation—any more than there was of other measures aimed at rational silviculture.

In the following, more developed stage, timber supplies were already more abundant and varied, but there was still not sufficient demand, and the yield could not support a heavy outlay. In this phase, attempts were made in the management of forests to consider their biological

needs together with the economic aspects, and, within this framework, to ensure that the development of the forests was put on a rational and permanent basis. In other words, within the limits of the facilities available, attempts were made, mainly for economic reasons, to use Nature's own methods and to develop them so that good results could be achieved. This was, and still is, the dominant period of natural reproduction and naturalistic silviculture in which the return from the forests has been relatively small and the reforestation period has not played a decisive part, any more than has the speed of forest growth. This phase, which has until now predominated in the North, has been supported by a considerable amount of research, experimentation and practical experience. It has been possible to develop it cheaply and, at the same time, efficiently and dependably.

But a new phase is again at hand. As the use of and the need for timber continue to increase, an intermediate stage appears in which all the remote forests and those not in use must be used economically; a phase in which the ratio between forest resources and ever increasing needs is approaching a critical limit, initially purely locally, but extending subsequently to increasingly great areas. Then, the orientation of forestry must be reconsidered (and, among other things, the importance of artificial reforestation will be considerably increased).

These aspects are emphasized by the rapid expansion of the pulp industry and the necessity, as foreseen by FAO, to increase its capacity in the near future. This implies not only the rational use of remote forests, but also a more systematic utilization of timber, an increase in the profitability of forestry and, thus, the opportunity of effectuating forest management and maintenance. The situation then approaches a point where present methods of forest management and reforestation can no longer produce sufficient timber, and the subsequent danger of overcutting looms threateningly near. This state of affairs is obviously not so distant in the Northern countries and is leading to the adoption of new and more effective methods, in which the importance of artificial reproduction, side by side with natural reproduction, will acquire greater significance, not solely for making effective the present understocked and poor forests (which will, of course, have to be done), but also as a normal method of reforestation. At the same time, the planting distance will clearly become somewhat greater, and the care of trees will be more individual. Only elite seedlings will be used, biochemical methods will be developed, and the tempo of swamp drainage will be stepped up. In other words, methods will increasingly come to resemble those used for orchard cultivation.

This kind of development will be stimulated by the changes in the structure of the woodworking industry. The once predominant role of the sawmilling industry has continued to decline, while the part played by the pulp industry has increased and will obviously go on doing so. At the same time, the importance of the technical quality of the timber has gradually decreased, while the importance of pulp has increased. This fact will accelerate the above development, especially in the creation of an extensive utilization of small-dimensioned timber, thereby increasing the intensity and profitability of forestry.

RESUMES

Le verger forestier et la sylviculture naturaliste

Jusqu'où peut aller l'intensification de la sylviculture, et avec quelle rapidité peut elle se faire, telle est la question qu'il convient encore d'étudier avec soin en ce que concerne les pays nordiques. Il est évident qu'un rythme accéléré s'impose, d'autant plus que le reboisement artificiel des forêts doit être considérablement développé si l'on veut être en mesure de faire face d'une manière satisfaisante à la demande croissante de bois. Le reboisement artificiel des forêts en tant que méthode courante n'a pas été adopté d'une manière générale, parce que les forêts peu boisées et pauvres qu'il faut reboiser le plus rapidement possible, sont encore si nombreuses que les semences et les plants dont on dispose, la main-d'oeuvre et les contremaîtres, doivent avant tout être utilisés pour l'amélioration de ces forêts. La méthode rapide et générale du reboisement artificiel des forêts a été considérablement gênés par l'approvisionnement limité des semences et plants mentionnées ci-dessus. Dans les pays nordiques, les bonnes années de semences surviennent en général à des intervalles moyens variant entre cinq et sept années pour le pin sylvestre, et dix et douze années pour l'épicéa. En conséquence, la construction de grands dépôts de semences s'avère difficile. Il faut également tenir compte de l'attitude des propriétaires de forêts qui s'opposent souvent au reboisement, ainsi que de la période relativement courte, au printemps et à l'automne, favorable au reboisement artificiel, qui a lieu au plus fort de la saison agricole. En général la mécanisation est difficile en raison de la nature rocailleuse et accidentée du sol.

Le développement efficace de la mécanisation et des méthodes de reboisement artificiel contribueront grandement à supprimer ces facteurs. Ils font, dans les pays nordiques, l'objet de nombreuses recherches et expériences. Les jardins de porte-graines jouent un rôle décisif dans la résolution du problème des semences, car ils permettent avant tout de constituer un stock suffisant de semences pour faire face à la forte demande une fois la saison venue. C'est pourquoi les évenements tendent vers une plus grande intensification de la sylviculture, bien que de grosses difficultés existent. En conséquence, la sylviculture naturaliste maintiendra également sa place dans les temps à venir.

A la lumière de ce qui précède, nous ne pouvons pas parler dans les pays nordiques du verger forestier par opposition à la sylviculture naturaliste. Si l'on tient compte des conditions qui y existent, il ne s'agit pas de deux système opposés. Ce sont tout simplement deux phases de développement successives, qui peuvent être toutes deux acceptées simultanément dans le même pays, suivant l'intensité avec laquelle le travail de sylviculture est accompli dans les différentes régions de ce pays.

Huerto Versus Silvicultura Naturalista

Hasta qué punto y con qué rapidez puede marchar la intensificación de la silvicultura es una cuestión que debe estudiarse con cuidado en lo que respecta a los países norteños. Es obvia la necesidad de incrementar las actividades, particularmente, las de reforestación artificial, porque así será posible satisfacer las crecientes demandas del mercado de la madera, cada vez más urgentes. Pero la reforestación artificial como método normal no se ha puesto todavía en práctica generalmente, porque son tantos los rodales pobres y subnormales que necesitan ser repoblados rápidamente, que la semilla y las plantas disponibles han de usarse primero para mejorar estos bosques. Las actividades rápidas y generales de reforestación artificial han sido retardadas considerablemente por la escasez de semillas y plantas. En el Norte, los años de buena semilla ocurren generalmente a intervalos promedios de cinco a siete años para el Pino Escocés y de diez a doce para el Pinabete Noruego. Por consiguiente es difícil crear grandes almacenes de semillas. La actitud de los propietarios de bosques, no siempre inclinados a la repoblación, ha de tenerse en cuenta también, así como la relativamente corta duración del período para la reforestación artificial en la primavera y el otoño, que coincide con la época más ocupada de la agricultura. En general, la mecanización es difícil también a causa de los terrenos pedregosos y montañosos.

El eficiente desarrollo de la mecanización y los métodos de reforestación artificial harán mucho para eliminar estos factores adversos y son actualmente objeto de considerable investigación

y experimentos en el Norte. Para resolver la cuestión de las semillas, los semilleros son factor decisivo, y el objeto es establecer suficientes de ellos para el abastecimiento más urgente de semillas. La tendencia es, por consiguiente, a una silvicultura más intensiva, pero quedan muchas dificultades por resolver. Por esto, la silvicultura naturalista mantendrá su posición en el futuro.

A la luz de todo esto, en el Norte no podemos hablar de la silvicultura de huerto en contraposición a la naturalista. Cuando se tienen en cuenta las circunstancias, no son sistemas en contraposición, sino fases sucesivas del desarrollo, aceptables simultáneamente en el mismo país, según la intensidad con que se lleve a cabo el trabajo forestal en las diferentes partes de éste.

Correlation Between Forest Production and Forest Stocks

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Introduction

Owing to the limited space available, this exposé cannot claim to be a comprehensive study serving to clarify the correlation between forest production and forest stocks; it is merely intended to be a small contribution to the solution of this problem.

Detailed statements on the subject are contained in separate exposés prepared by Dr. R. Frauendorfer (Forestry Research Institute, Marienbrunn, Vienna) and Dipl. Ing. N. Mair (Provincial Forest Inspection for Tyrol, Innsbruck).[1]

In the interest of better understanding, it should be mentioned that, according to Dr. Frauendorfer, "Forest Production" stands for the current annual increase in forest stocks resulting from their growth and expressed in terms of dense wood quantities of a certain forest class, and also for the increase in value resulting from the composition of species, from the quality and the market prices obtainable. By "timber reserves on stock" is understood the living, dense wood quantity of trees forming a forest stand or a given forest class.[2]

Brief, General Survey of Forest Conditions in Austria

Forestry is one of the most important factors of the Austrian national economy. The Federal Austrian territory comprises 8,385,000 hectares (1 acre = 0.40467 hectares); 3.3 million ha. are woodland, of which 2.7 million ha. are productive forests, while the balance is alpine forests, protection forests, etc.

The area is broken down into:

1. Land under agricultural usage 51.9%
2. Woodland 37.4%
3. Unproductive land 10.7%

Hence, about 38% of the Austrian territory is covered with forests, the wooded surface amounting to roughly 0.5 ha. per inhabitant. The quantity of timber which can be cut annually without risk of damage to the wood substance amounts to approximately 9 million festmeters. It should be noted that 44% of the Austrian woodland is divided into small woodlots of less than 100 ha., mainly farm forests; 11% are holdings covering 101 to 500 ha., while 45% are large forests. Austria's economy consumes 30% of the accruing volume of timber production, the major part of which is exported and accounts for approximately 25% of Austria's foreign exchange earnings. In wealth of timber, Austria takes third place among the European countries, directly after Finland and Sweden (not including the USSR, with 40.6%).

The share of softwood species in the variety of stocks amounts to 84.4%, of which 58% are spruce (*Picea abies*), the dominant species of our forests, representing the main source of income to Austrian forestry. Other industrial softwood species are: white pine (*Pinus silvestris* L.), with some 10%; European larch (*Larix decidua* D. C.), with 7%; and fir (*Abies pectinata*), with the same percentage. Then follow: black pine (*Pinus nigra* Arn.), stone pine (*P. ombra* L.), and mountain pine (*P. montana*). The latter two species are most important for soil conservation on the timber line.

The hardwood species represent 16% of overall stocks, 9.6% of which are red beech (*Fagus silvatica*). The oak varieties (*Quercus sessiliflora* Ehrh., *Q. rubor* L., etc.) cover 2% of the surface, followed by alders (*Alnus glutinosa, A. incana*), hornbeam (*Carpinus betulus* L.), poplars and willow trees (*Populus* et *Salix*), maple (*Acer*), lime trees (*Tilia*), elm (*Ulmus*), and birch (*Betula*).

The Austrian forests are divided into high forests (96%), medium forests (1%), and low forests (2.6%).

Forest production is influenced by genetic factors and environment. In Austria, we find within a small space a great variety of forest types, since its climate varies with the different altitudes from sea level to the glacial zone. The subsoil contains rock formations dating back to each geological era. Since, during the ice age, large parts of Austria were glaciated and later the most important wood species immigrated from the retreat areas of both Southeastern and Western Europe, and, meanwhile, the strongest species also remained as relicts throughout the glacial periods, the stocks are of great genetic variety. Mining operations (iron, salt), dating back to the year 800 B.C., have left their mark on specific areas which reflect millenniums of human exploitation. This explains the efforts made in Austria to study the influence exercised on timber production by genetic, environmental, and economic conditions.

[1] The summaries of these two exposés are attached as Annex A and Annex B.

[2] These quantities are expressed in "festmeters" (fm.): 1 fm. = 1 cubic meter of trunk timber.

Genetic Factors Influencing the Correlation Between Forest Production and Stocks

It was a wide-spread opinion that the various tree forms were attributable to nutritive modifications. However, investigations have revealed that timber production, i.e., the rate of growth on a specific area, is influenced by the variety of species. The species of our forests differ from one another in that they show various morphological marks and different physiological reactions. Due to the adaptive character of these peculiarities, we can speak of adaptation marks, denoting a population as "ecologic species" (or environment species).

As adaptive phenomena are interpreted, for instance, the various branch forms of spruce (pointed, rectinate, lamelliform spruce), the most important timber species in Austria.

Sylven, in the years 1909 and 1914, and Rubner, in 1943, examined individual trees with a view to ascertaining the growth rate of various branch types of spruce. They found the rectinate and brush spruce superior to the lamelliform spruce. Since the heredity of branch forms has been established, H. Schmidt investigated how this superiority shows in the stocks.

At first, the results obtained by Rubner's and Sylven's investigation of individual trees were attested. Basic increases developed as follows:

Table I. Current, periodic basic increases in cubic centimeters of lamelliform and rectinate spruce.

	Decades			
	2	3	4	5
Lamelliform spruce	3.8	6.4	6.7	7.7
Rectinate spruce	3.8	8.3	9.2	12.5
Difference	0.0	1.9	2.5	4.8
Rectinate spruce in percent of lamelliform spruce	100	130	137	160

The superiority of the rectinate type over the lamelliform type becomes apparent only in the third decade; this is attributable to the fact that the various branch types begin to differ in the 20th year. Since, up to that time, their growth rate is the same, the difference ascertained later on can be due only to crown conditions.

It was proved that the superiority in growth results from crown substance and needles (see the result of Burger's investigations in this paper).

The following is a comparison between the average indices of crown projection and the average trunk increase of the rectinate and lamelliform spruces during the last 5 years:

	Lamelliform spruce	Rectinate spruce	Rectinate spruce in % of lamelliform spruce
Crown projection in m^2	10.5	19.2	183
Trunk growth in Ltr.	9.0	17.6	195
Trunk growth per m^2 crown projection in Ltr.	0.86	0.92	107

Since a larger crown volume corresponds to a larger crown projection area, and since the rectinate spruce needs a larger trunk space than the lamelliform spruce, the trunkwood production per hectare of sheltered area shows hardly any difference; production was nearly the same, amounting to 9.2 fm. and 8.6 fm. per ha. While rectinate spruce has a smaller stocking rate but a larger crown expansion and, on the other hand, lamelliform spruce has a larger stocking rate but a smaller crown expansion, the stocking rate is likewise without noticeable influence.

It was not possible to increase the production volume per a given area by selecting and planting slender-crown varieties of rectinate spruce which need less space than the lamelliform spruce.

Investigations of the intensity of assimilation and needle sorts (sun-needles have a higher intensity of assimilation than shade-needles) showed that in the case of higher assimilation intensity the production of dry-wood substance was 100% larger (H. Schmidt, 1953). According to Schmidt (1952), a preferential utilization of rectinate spruce might be advisable, as the per-ha. volume of production within a given period is the same as that of lamelliform spruce, while rectinate spruce yields larger dimensions with a smaller number of trunks.

It will be necessary to clarify the characteristics of pointed spruce in comparison with rectinate and lamelliform spruce.

Tree stands of these types are known (stock recognition, Dr. Dirnberger, Dr. Gruell); they can be compared with those of other branch types according to trunk area, stocking rate and mass; this would also reveal information on the mass production of the respective stocks.

In case pointed spruce would show its superiority over rectinate and lamelliform spruce also in mass production of stocks, it should be preferred to all other branch types, not only for this reason, but also because of its higher stocking rate, particularly in Austria, where the major part of the mountain area is covered with spruce.

Similar environment species also exist among pine stocks; the swamp pine, e.g., in the high swamps of Waldviertel, represents a specific environment species and is not merely a result of nutritive modification. The Gutenstein pine, with a very small crown, and the small-limbed pine of eastern Styria are likewise specific environment species. Different species exist not only among conifers but also among hardwood trees.

In the black pine region of Lower Austria are factors indicating the existence of two environment species. Fukarek reported about black pine species in the southern area (Karst-Yugoslavia).

Environment Factors Influencing the Correlation Between Forest Production and Stocks

Forest production is chiefly dependent on the environment and its climate. The manifold variety of environment forms in Austria shows to what extent silviculture and the resulting forest production react to these basic conditions. In former times, the type and structure of stands were considered the most important factors of forest production. While their importance should not be denied at all, forestry has proved that environmental conditions come first.

Climate holds a special position among the factors determining the environment. Likewise essential is the altitude, which differs considerably in the individual areas.

The dependence of the entire biogeological Cenozoic is clearly perceptible from the large climatic area. We distinguish between the Central Alpine Region, the Northern Border of the Alps with its humid air, the Southern Border of the Alps with its Mediterranean and Illyric influences, and the eastern part of Austria with its warm summer weather, a result of the Pannonic climate.

Paterson recently has set up a CVP index (C=climate, V=vegetation, P=productivity). This index is to express in terms of figures the production possibilities of forest stocks, based on climatic conditions. The author shows how—in his opinion—the system of calculating the duration of a vegetation period should be modified, and he shows also how the yields produced on many experimental areas of France correspond with the yields which could have been predicted by means of the Paterson formula. Bosshard is of the opinion that the formula could be improved and ought to be improved before its practical application in forestry.

The tree societies and all the factors of production depend not only on climatic conditions, but also on the vast geological areas, such as the granite region of the "Bohemian Mass," the primitive rock of the Central Alps, the Flynch-zone of the Lower Alps, the loess region of the lowlands, the limestone Alps and the riverside areas.

Spruce prevails in large areas of the Central Alps, in their natural altitudes, and determines silvicultural practices, forest production and thereby all the marketing conditions in that region. Spruce, fir, and beechwoods are found mainly within the humid region of the Alpine Border, while oak and hornbeam forests prevail in the lowlands as well as on the Eastern Border of the Alps. The black pine dominates within the Pannonic-climate area.

Since forest production is substantially influenced by environmental conditions, many countries make environment studies in order to obtain a basis for forest-management plans.

The natural soil factors affect the potential tree societies which have become rather scarce and cannot be always easily identified as such. In many cases, we have to deal with secondary stocks in the process of advanced degradation, such as "huckleberry woods" or "secondary pine woods" with crude humus layers. There is a marked difference in production between the *potential* and the *actual* tree societies, the extent of which is not known as yet. At this time, Austria is not able to undertake large-scale investigations which would permit such a comparison. The soil research and soil mapping program of the Federal Forestal Testing Institute comprises experimental research on the yield of soil units, presently carried out in Eastern Styria and at Merkenstein. The analysis of environmental conditions, such as climate, type of terrain and subsoil, with its influence on the local ground formation, showed that the natural soil conditions were excellent, whereas human interference with nature had caused a considerable disturbance in the soil balance; such balance is only found where all biotical and abiotical factors, under consideration of their correlative effects, exercise their influence on the soil in equal manner and intensity. In other words, "Unit Area No. 7" (skeleton soil) of the aforementioned Styrian stand conversion area, with 200 reserve fm. per hectare, produces—fully utilizing its environmental factors—relatively as much as Unit No. 2 (slope base with deep-reaching brown earth layers) with 600 reserve fm. per hectare, but only to the extent which the lowest factor is able to produce. Nevertheless, one cannot say that Unit No. 7 is inferior to Unit No. 2. Seen from the viewpoint of environmental conditions, the production of both is optimum.

At the time when growth was exclusively due to natural reseeding, a temporarily disturbed balance was re-established within a comparatively short time. In the later periods of forest history, when man continuously interfered with nature, the forest was no longer able to recover and maintain its dynamic balance. Our efforts must be directed to the re-establishment of this natural dynamic balance in the forest without, however, disregarding the important economic factors.

Forest Management Factors Influencing the Correlation Between Forest Production and Stocks

Influence of Crown Volume, Leaf Surface, Leaf Quality on the Rate of Growth

Investigations in this respect have not been made in Austria, since the results of Burger's research in Switzerland can be applied here.

According to Burger, the crown volume of spruce of the same age-class in high forests goes up rapidly as the trunk diameter increases. At a trunk diameter of 10 cm., the crown will have reached nearly the same volume of 19 to 20 kg. in forests with fixed production rates, in partially bare-cut forests, and in selection forests. With the further development of the trunk, the rate of crown increase differs in the individual forest types. On the average, a tree crown with a diameter of 50 cm. has reached a weight of 300 kg. in forests with fixed production rates, 370 kg. in partially bare-cut forests and 470 kg. in selection forests. Investigations revealed that the crowns of sun varieties are lighter than those of shadow varieties such as fir and beech.

The all-round surface of one kg. of fresh needles of high-forest trees of the same age-class averages 5.5 m². The surface of needles of shadow varieties (7 m². per kg.) is twice as large as that of sun needles (3½ m². per kg.). The trunk increase of spruce of the same age-class is chiefly determined by environmental conditions, age, and location of the trees in the stands. The weight of fresh needles, which within a year can produce a trunk increase of one festmeter, amounts to 6,000 kg. and more, also in spruce stands of the same age-class, and is largest in sheltered underwood areas where light is dim and a comparatively large number of substances have to be absorbed for the renewal of the needle quantity.

The most rational growth increase is produced in co-dominating and less dominating spruce stands, whereas the needles of dominating spruce produce less intensively, because of the excessive crown volume. In detail, Burger said that 98-year-old beech stands in the Sihlwald, Tyrol, have a leaf surface of 122,700 m². per hectare. The 7,670 kg. of leaves with their surface of 12 ha. produce annually a rough-wood increase of 9.4 m². Hence, an average of about 810 kg. of fresh beech leaves are needed to produce one fm. of rough wood per year in these stands.

These cases show how the leaf surface and leaf quantity

influence the growth increase produced by the trees and stands, respectively.

Stocks and Stand Structure

It goes without saying that both these factors carry considerable weight in the development of forest production. Both stocks and stand structure are determined by many factors with complex effect. It is not silviculture alone that produces its effect in connection with stand planning and stand cultivation, but there are quite a number of other essential factors, such as the structure of holdings (large forest holdings, State forests and farm forests), the market situation, the prosperity or depression of the national economy, and also problems pertaining to wildlife and hunting, and the like.

As regards man's interference with forest life, which is decisive for the structure of stands, W. Ertfeld pointed out that harsh cutting practices cause normal growth increase to decline 10-15% (base closing and growth increase of pine, spruce and beech).

Bonneman arrived at the conclusion that the per-ha. mass production of pine and beech together, in the pole class, is higher than in monoculture; mixed stands are particularly suitable for production of large-diameter pinewood; the thinning rate of pine in mixed stands is determined by the desired ratio of hard wood; the more hard wood, the longer the rotation period.

The most important connections between growth increase and timber reserves on stock, or stands of one age-class, depending on type of stands and management practices, investigated by Frauendorfer in East Styria, have been plausibly explained by the author in his report.

Of particular importance are investigations of the wood production in "original forests" or "forests with natural structure." Again and again, the opinion has been voiced that biological safety is obtained at the cost of losses in growth and value. In Austria, this subject has been treated in exemplary manner by Pokberger, a pioneer of modern silviculture. He arrived at the important result that a selective-type stand structure with various age-classes warrants a more sustained and, above all, better secured production than stands of one age-class (age-class forests).

Annex A—Summary of Expose
By Dr. Rudolf Frauendorfer

An attempt has been made to reveal correlations between growth and stocks of a stand or a certain class, respectively, with consideration to the type of the stand and the economic measures applied. The subject of this discussion are monoculture stands of the same age-class, mixed stands of the same age-class, graduated stands, and stands of different age-classes.

A special case shows that the tending of crown and trunk is of essential importance for the growth in quantity and value of the individual trees and stands. The trunks of spruce with well-developed crowns were found to increase in diameter 60% more than those of spruce with less-developed crowns, and even 310% more than spruce with poor crowns. The same variation according to crown classes was observed with respect to the increase in height. The trunks of different quality likewise show remarkable differences in the increase in height, but, as yet, the causes have not been clearly established. The quality of trunks does not affect the growth in diameter. The importance of proper thinning is proved in this special case by the fact that the average increase in diameter of the eliminated trees amounts to only 50% of the growth of the remaining trees.

Another case shows a comparison between the production in a selection forest and a standard-type forest of the same age-class, both located in the same region. The selection forest with a trunk number of 105% and 118% of the timber stocks of the same age-class, produces a growth of 143%. The value-superiority, resulting from a more favorable distribution of growth over various grades of thickness, is substantially higher.

Annex B—Summary of Expose
By Dipl. Ing. Norbert Mair

The "representative random test inventory", introduced in forestry since 1956, has produced exact information on timber stocks and growth for the established forest enterprises in community forests (corporation forests), which cover 42% of the entire area. Since these enterprises are scattered over the entire province, it has been tried, according to height classes, to divide the individual tree classes of the community forests into growing stocks typical of the land in order to obtain a survey of the forest production in tree societies adapted to the environment, in connection with the timber on stock in the individual growth regions. The aim pursued is, in the course of time and increasing forest density, to obtain important standard data for future silvicultural measures and thereby to derive for mountain forests the aims of optimum natural development.

The following survey shows the correlation between timber stocks, growth and growth percentage according to the individual growth regions:

Growth area	Tree societies	Stocks Vfm./ha.	Growth Vfm./ha.	Growth, percent
Foothills	Spruce, fir, beech	170-300/222	3.2-4.4/3.7	1.7
Central Alps	Spruce, larch	140-240/193	2.4-3.4/3.2	1.7
Dry regions of limestone Alps	Pine	90-130	0.7-2.0/1.8	1.4
High altitudes, Central Alps	Spruce, larch, stone pine	140-280/187	2.0-3.1/2.4	1.3
Highest forest crown	Spruce, larch, stone pine	50-200/149	0.8-2.4/1.9	1.3

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RESUMES

Correlation entre la production forestière et les massifs forestiers

Etant donné la diversité de ses conditions édaphiques et climatiques, l'Autriche est particulièrement favorisée pour poursuivre l'étude de la production de différents types de peuplements. En ce qui concerne les influences génétiques, l'épicéa "rectinate" s'est révélé supérieur à l'épicéa lamelliforme. Les influences climatiques n'ont pas été élucidées en détail. Il a toutefois été prouvé que les peuplements adaptés à leur entourage ont donné des rendements quasioptimum. Quant aux pratiques de gestion, le système de coupe exerce une influence considérable sur la production. Les peuplements à essences mixtes et à structure sélective se sont révélés supérieurs aux autres types forestiers; en outre, ils sont biologiquement constants et sûrs, et garantissent un rendement soutenu et prolongé même sur de petites parcelles (futaies jardinées). Les multiples corrélations existant entre les différents facteurs influant la production forestière constituent un problème dont l'explication exigera des études approfondies pendant de nombreuses années. Les Instituts Autrichiens de Recherche Forestière déploient tous leurs efforts en vue de sa solution.

Correlación entre la Producción Forestal y las Cepas Forestales

Debido a la diversidad de sus condiciones de suelo y clima, Austria brinda grandes oportunidades para la investigación de la producción de distintos tipos de rodales. En lo que respecta a las influencias genéticas, el abeto rectinado demostró ser superior al lameliforme. No se ha aclarado todavía en detalle lo relacionado con las influencias climáticas. Sin embargo, sí ha podido determinarse que los rodales adaptados al ambiente dan comparativamente óptimos rendimientos. En lo referente a prácticas administrativas, el sistema de corta tiene considerable influencia sobre la producción. Los rodales mixtos con estructura selectiva probaron ser superiores a otros tipos forestales. Además, son biológicamente constantes y seguros y garantizan un rendimiento sostenido también en las parcelas pequeñas (granjas forestales). Las variadas correlaciones entre los factores que influyen en la producción forestal constituyen un problema cuya solución va a necesitar largos estudios durante muchos años. Los Institutos de Investigación Forestal de Austria están haciendo, en todo caso, grandes esfuerzos para solucionarlo.

Planning and Control of the Managed Forest Including New Inventory Control Procedure

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Efficient and organized forest economy is unthinkable without basic programs comprehending periodically elaborated technical projects including all the activities related to the organization of forest production and those directly or indirectly aiming at intensification of production.

All these activities are covered by the scope of forest management.

The analysis of natural and economic conditions of forest production, drawing of periodic inventories of forest resources, comparing changes occurring therein, control of yield in relation to social demand and needs harmonized with forest productive possibilities are basic objectives in this field of action. These objectives have to be based on natural productive regional division determining the maximum yield potentialities and providing for preservation of natural biological resistance of stands according to the economic regional division which accounts for release of distinct complexes of productive forces connected with the demographic development. In this way, regional objectives are outlined together with tasks for forest productivity, also for study of integrated processes of basic productional branches actually in existence or anticipated on the given geographic-economic territory. Results of such study should be indicative of lines along which the development of forest economy ought to advance and of objectives to be effected in immediate future embodied into the plan of forest management, which should be primarily a technical-economic project, including all tending and silvicultural practices to be performed at adequate time.

One of the main objectives of forest management is the control of yield and utilization, which becomes less and less connected with one particular forest area and a private affair of its owner. Control of production amount is more and more a problem of balancing timber supplies

and forest products with social demand on the scale of a whole country or even a vaster scale under a co-ordinated forest policy.

In planned economy, where the forest estate is integrated as a constituent part of the national economy, control of forest yield has to be harmonized with the long-range policy of development of the national economy as a whole. Harmonization of proportions with other sections of the national economy is secured by long-range planning of the forest economy. The long-term plans define and co-ordinate the quantity of forest production, i.e., the yield which may be utilized. Such a long-range plan has to be based on precise knowledge of forest resources and prevalent national economic conditions of forest production upon which the future growth of these resources depends. The long-range forestry plan helps to disclose the anticipated changes in forest resources implied by drain in respect to growth and forest area. The long-range plan of forest development should not be resultant from summing up of particular management plans drawn for individual forest areas; on the contrary, management plans should convey directories of the long-range plan to individual forest areas in order to implement recommendations of devised general forest policy.

Also in a non-nationalized economy, in which forest enterprises are individually conducted, the necessity to meet general social needs and demand for timber and forest products imposes the conduct of forest economy as an entity.

These developments are disclosed by enactment of forest laws by respective governments, consistent with such general forest policy.

Forest policy has to be based upon precise knowledge of economic and natural conditions of forest production, determining the future growth of forest resources.

Tasks of conceiving a basis for long-term development plans of the forest economy and forest policy extend the scope of forest management and provide them with special and new significance.

General surveys of forest resources carried out at fixed dates in Poland and many other European countries, among them the German Democratic Republic, Austria, Finland, Sweden, etc., testify to the underlying trends.

In Poland, two general surveys were carried out in the post-World War II period, covering the entire territory of State Forests which includes over 84% of the whole forested area of the country. The first survey of 1950 included measurements of the growing stock of over 40 years of age (age class III and older). Measurement of the growing stock of age class IV and older was performed by caliper on trees in 4 cm. thickness gradation. The inventory method used for growing stock of age class III, from 41 to 60 years of age, was that of sample plots, and the growing stock was calculated from yield tables. Stand growing stock according to age classes, tree species, and thickness grades was worked out as a result of the inventory procedure. Based on the accepted cutting age for different tree species, the yield to be utilized was computed for the whole country.

The inconvenience of this method consisted in that the growing stock in age classes was subdivided into different tree species according to their actual frequency in stands, whereas area age-class tables were constructed according to dominant tree species. Thus, a more universal application of the survey results was irrelevant, as, for instance, for appraisal of long-range variations of the growing stock, this appraisal being necessary for drawing the prospective plan of development of the forest economy.

When, in 1952, the first post-World War II stage of inventory work was accomplished for State Forests and results thereof made available for the whole country, tables were drawn of class age area and stand growing stock by species, as on January 1, 1953 for the whole territory of the State Forests. For this purpose, age-class tables which were originally arranged for the territory of individual chief forestries for various dates had to be all brought up to the date of January 1, 1953. Adjustments were brought about by subtraction of drain and addition of current increment for particular age classes. Current increment was calculated from corrected increment percentages as given in yield tables. Results obtained made possible the computation of variations in area and stand yield in subsequent years.

In the German Democratic Republic, independently of taxation estimates of growing stock carried out for management purposes, survey of growing stock has been performed since 1953 with the application of mathematical-statistic methods in order to get the picture of the growing stock for the whole country. The growing stock is measured on sample circles distributed uniformly over each compartment, one circle per half hectare (Richter's method—Netz System). Trees are recorded in 5 cm. thickness gradation. The growing stock is calculated with the application of tariffs which simplify computations. Survey results are listed in age-class tables by tree species, separately for each individual site area (Standortsbetriebsklasse).

In Austria, during the period of 1952-56, a forest survey was carried out in order to ascertain utilization possibilities. Forests with and without management plans were surveyed. The stand was taken as the basic survey unit. Photogrammetric technique was used, and modern statistical machines enabled taking of cards for all stands over the whole country and the numerical presentation of survey data, both for particular forest economic units and for the country as a whole. Stand growing stock was measured with Bitterlich's method. Most comprehensive survey results were presented in form of age-class tables (area, growing stock, average increment) with subdivision into ownership classes, management systems, and tree species.

In Sweden, the survey directory was amended. Former mathematical-statistic survey methods based on sample areas established on taxation lines provided for carrying out in one year of only a partial survey of the forest area. Since 1953, inventories are performed in such way as to cover at once the whole territory of the country with many times less density of taxation lines. Not only the growing stock and stand increment on sample areas are appraised, but also the amount of determined annual yield in order to define the effect of cutting upon the condition of the growing stock.

The preceding data show that all the general forest surveys are aimed at getting the picture of actual forest resources and at depicting variations that occurred since the last preceding inventory, in order to define basic

potentialities of utilization for the country as a whole. In European countries managed on intensive clear felling systems, the smallest working unit is the stand (and will presumably continue to be), i.e., tree stand including like taxation elements upon a forest extent of uniform site condition of production. In forests under the selective cutting management system, the silvicultural control unit is the basic working unit equivalent to the stand unit of the clear felling system.

Stand or silvicultural control units are those units which should also be accepted as survey units. All tabulations necessary for computing the annual cut or for other objectives will be the outcome of summing up appropriate data obtained from surveying of stands of like appraisal elements. Singling out stands according to their various elements is most labourious and impossible to perform without modern techniques.

At the time of the general forest survey in Poland in 1953, the results expressed in terms of area and growing stock could only be tabulated in age classes by tree species. Whereas in the German Democratic Republic survey results were listed in age classes with subdivision into sites, tree species, and soil fertility classes. In Austria, tabulation included ownership category, management system, and tree species. The presentation of survey results in Austria and the German Democratic Republic in age-class tables with subdivision into more elements than in Poland was made possible by the use in the former countries of modern machines for segregation and automatic tabulation of numerical data with a perforated card system. In Czechoslovakia, survey results carried out within management activities accounted for several features owing to sets of machines used for the inventory operation. Machines of Bull, IBM, IVT, and Remington-Rand are indispensable for computation of survey results and numerical presentation.

General forest surveys in Poland and the German Democratic Republic were confined to state forests. Smallholding forests were not included. The difficulty consisted in that these forests had insufficient underlying cartographic background.

In Czechoslovakia, aerial photography was used for cartographic surveys and for simplifying appraisals of small holdings. This up-to-date procedure applied to mountain territories is especially satisfactory for rapid mapping and may be utilized for periodical detection of variations occurring in the forest. Austria, where two-thirds of the forested area has been surveyed by aerial photography, seeks obviously to take full advantage therefrom.

For carrying out general surveys, up-to-date techniques are in use, enabling universal presentation of numerical results of inventories and also of mapping the forest area. At the same time, simplified methods for taking inventories of the growing stock and current increment are devised. In Austria, Bitterlich's method was used for determining the stand basal area. It saved work of delimiting sample area boundaries and of caliper tree measurements and in computation of the stand basal area.

Computation of stand growing stock is done by simplified methods based on volume series or height-form series (in Poland, Trampler's method; in Czechoslovakia, Kern's method; in the German Democratic Republic, Kreuter's method). Current increment may be ascertained on standing trees with increment borers. Computation of the current increment is highly simplified when advantage is taken of the increment percentage of Trampler's method (Poland) or Proddon's method (G.F.R.).

Modern survey procedure, on the one hand, simplifies field work in determining stand area and appraisal points (photogrammetry) and mensuration and computation of the growing stock and increment. On the other hand, owing to application of mathematical and statistical methods, not only is the area covered by mensuration reduced but also an estimate of precision and comparability results is made possible. Listing of the general survey results in the form of age-class tables is indicative of the underlying objective sought for, i.e., defining of correct yield to be cut or regulation of production on the whole national scale. The question may be raised whether, on the basis of age-class tables for individual silvicultural areas and methods of computing the annual yield for these areas used for management purposes, the yield to be utilized on the national scale is computable.

As is currently known, the application of the age-class method for intensively managed forests has been in universal use in Europe since the beginning of the twentieth century, whereby the annual yield is determined by two procedures, i.e., the inductive, which implies planning of cut for individual stands, and the deductive, implying computation of yield from summed survey results for particular areas according to given formulae. Planning of output for individual stands is based on the attempt to take full benefit of natural forces engaged in forest production, in accruing the growth of individual stands by maintaining the growing stock and its magnitude at an adequate level, or through regeneration of low-productive and mature stands.

Computation of yield from survey results for the whole of the forest estate according to formulae figured out from the concept of the normal forest is the outcome of adherence to the principle of sustained, continuous, and uniform yield as conceived at the beginning of the nineteenth century. According to this principle, the yield should be subject to such regulation as to correlate age-class area and the magnitude of the growing stock to a normal condition. Formulae deduced from this concept of the normal forest are usable only for computing the yield for forests under the clear cutting management system. Applicability of these formulae was always rather theoretical and recently lost still more importance because of the share of output of thinnings accounting for some 30% to 40% not covered by these formulae. Moreover, the forest area allotted to the clear felling system is on a steady decrease.

The endeavour to utilize more fully the natural forces in forest production implies the management of expanding areas with the application of combined clear cutting and selective systems or a pure selective cutting system. Thus a limiting factor is set up for the use of the formulae deduced from the normal forest concept for the purpose of yield determination. Moreover, in case the deduced yield is divergent from the amount of calculated cut in planned projects, the forest estate has to incur economic

losses on account of either unnecessary reserves of growing stock or premature cut.

The mentioned premises give support to the fact that regulation of the annual cut as devised by the classical concept of sustained yield is nowadays losing ground, whereas the principle of sustained production formulated by Judeich about the middle of the nineteenth century gains growing significance. However, with the exclusion of some untenable proposals ensuing from the latter concept in obsolete formulation, implying felling of low productivity and mature stands followed by immediate planting of cut areas, no one would suggest at present treating the indicative percent (Weiserprozent) as a relevant economic factor for qualifying the stand condition as being adequate or inadequate for subsequent production. Furthermore, as is currently known, in order to obtain the optimum possible production and its sustenance, planting in itself is not all that is necessary—it must comply to the following conditions:

1. Suitability of stand species composition and site factors for ensuring maximum production and preserving natural biologic resistance;
2. Maintenance of stand growing stock at an adequate level to ensure maximum growth of timber of the best service quality;
3. Maintenance of an adequate structure of growing stock under the accepted management system;
4. Taking measures to secure the stand from felling prior to reaching the condition of technical ripeness.

On the above grounds, regulation of utilization is entirely dependent on the concept of stand maturity, in terms of both time and physical development. Maturity in time will be reached when the obtainable assortment composition is satisfactory; physical maturity, when stand development has reached its marginal productivity. Thus, sustained production is based on sustained and periodically uniform yield, aimed always at enlarged reproduction.

This principle is not contradictory to other aims which the forest has to fulfill, such as control of water flows, influence on climate, etc. These latter functions may be fully accomplished under conditions of validity of the sustained-yield principle and especially when suitability of stand species composition and afforestation of the physiographic areas decisive for these functions are respectively observed and carried out.

In the light of such a principle of sustained yield, forest composition imitating a natural one is utterly unnecessary, and the species composition may be regulated from the standpoint of accruing optimum timber volume production of best quality together with sustained maintenance of site productive capability and of biological forest resistance by keeping in proper equilibrium the processes of forest biocoenosis.

The concept of such reproduction does not impose any predetermined management system. Practice for all sites of either a selective system or of a combined selective-clear felling system would be equally as stereotypical as an all-round practice of clear felling. The concept of enlarged reproduction provides for the practice of such a management system which ensures the maximum of volume production upon a unit of area and also is consistent with complementary functions which the forest has to fulfill.

The underlying principle of such reproduction is consistent with establishment of pure plantations and monocultures whenever increase of production per unit of area is implied, and in principle, neither causes site deterioration nor is contrary to the fulfillment of protective functions of the forest.

One of the conditions of the principle of sustained yield thus conceived is the attainment of felling maturity of the stand whereby its economic objective is fulfilled. Anteriorly, the economic objective of forest production was defined by rotation of felling, which was understood in terms of a production period of stands included in the same operational class (betriebsklasse), owing to similar economic and natural conditions. This production period used to be selected in such way as to bring the highest possible profit to the owner. At present, the economic objective of the forest estate is to supply the social demand for timber and other forest products and to bear unmeasurable indirect social benefits implied by the very existence of the forest; this holds good not only in respect to planned economy. Such an approach to the economic objective of forest production allows for consistent determination of the objectives related to the requirements of the forest management organization expressed in terms of condition of the felling stand maturity. Stand maturity may be determined either by technical maturity or by maturity of highest volume production. Technical maturity determines such stand conditions which may yield a specific composition of assortment. Investigations performed by Borzemski, Tiurin, Mitscherlich, and others disclosed that assortment composition to be derived from a stand may be determined by its mean d.b.h. Nowadays, technical maturity is generally determined indirectly by stand age which, according to the stand-height class, may also serve to determine the assortment composition of forest products.

Maturity of highest volume production defines the stand condition wherein the average volume production is at its maximum. The age of highest volume production may not coincide with the culmination of the average increment, this being dependent on economic conditions and intensity of the forest management. When the thinnest timber assortments may be utilized since the earliest tending practices, the culmination of average increment will coincide with the age culmination of highest volume production. In that case, when timber derived from thinnings is not being utilized owing to low stand age, the age of highest volume production will come after the age of culmination of the average increment.

For one stand being the basic management unit, only one felling age may be admitted. The same holds good for mixed stands, and in this case the age of technical maturity of felling is determined by the dominant species as conditioning the time of felling of the stand or initiation of its cutting for regeneration purposes.

As implied by the foregoing premises, in order to perform a correct computation of the yield, survey results have to be tabulated in such manner as to enable performance of calculations within stands of like economic and natural conditions, for forest production having the same productive objective.

In Poland, the accepted standard is survey results listed in age-class tables for operational classes connecting stands of like type (protective forests, productive forests, etc.) growing in the same site conditions. In the framework of thus created operational classes, survey results are tabulated by dominant species in respect to both area and growing stock. The growing stock confined within one age class, site, and dominant species may be subdivided in accordance with actual frequency of tree species or groups of tree species. Such procedure is the outcome of an attempt to ensure possibly the most accurate picture of the growing stock according to its true composition in order to compute correctly periodic variations of forest resources.

The yield is calculated in Poland from the area and the growing stock of the last or last two age classes, but the result is not considered as final. Results thus calculated are compared with the total yield derived from summed-up minute taxation projects. The purpose of this comparison is not to adjust planning to computation results. Yield calculation is not done in order to normalize either area or growing stock within an operational class or to insure uniformity of utilization over longer periods of time, but is implicative of actual possibilities of utilization of timber from mature and maturing stands. These calculations facilitate guidance in respect to the average quantity of timber removable in assortments determined by the productive objective in subsequent periods of management. The principle of sustained and periodically equalized utilization is thus made practically effective, and the anticipated increase of production at later periods is only ensured. Such an approach to the method of regulating the yield and to the mode of tabulating survey results in the form of site operational classes underlies the forest management system practiced in Poland, called the site-stand method, wherein the yield regulation is based on the age-class method.

Calculation of yield to be cut from summed-up values has more importance for forests managed on clear felling lines than for those managed on selective lines. These computations are valid only for yield regulation in the clear felling system and should not be used to regulate utilization of thinnings, although it may be indicative, to some extent, of the percentage of growing stock to be removed in the course of thinnings. Investigations carried out in Poland disclose that the growing stock percentage to be removed in the course of single thinning amounts to 5-15% and is dependent upon condition of the stand and intensity of thinning. Computation of the yield for larger areas may also be practiced provided that survey results are listed in age-class tables on the same basis as those for individual chief forestries, i.e., according to forest characteristics, site type, and dominant tree species. The maximum area to be covered by such tabulation is one uniform natural forest area situated on the territory of only one forest economic region. The area of this territory will vary from one European country to another according to the degree of differentiation of natural and economic conditions. Computation of the yield to be cut, based upon the existing growing stock of mature stands, may be indicative of possibilities of assortment supplies to meet social demands for various timbers. These computations may also be useful for tentative balancing of forest productive possibilities and demand. However, computations performed with the application of this method for larger areas should always be checked with results of yield calculations made for individual operational classes in chief forestries which are the basic productional units.

RESUMES

Organization et contrôle du régime forestier, nouvelles méthodes de contrôle des inventaires

L'organisation et le contrôle des ressources sont essentiels à une économie organisée de la forêt afin de permettre une utilisation efficace des forêts; elles impliquent l'application de méthodes artificielles adéquates et de techniques sylvicoles modernes. Dans le cadre d'une économie planifiée, les forêts constituent une partie intégrante de l'économie nationale au sein de laquelle les différents secteurs de l'activité économique répartis de façon appropriée sont coordonnés par des programmes à long terme.

Les programmes à long termes (en perspective) doivent s'appuyer sur la connaissance la plus détaillée des ressources forestières et des conditions économiques de la production forestière. Le contrôle de la production et du rendement perd constamment de son importance en tant que problème particulier limité à une entreprise forestière unique ou aux soucis de son propriétaire. Le contrôle de la production, ainsi que le contrôle forestier dépendent de plus en plus des besoins de la société en bois d'oeuvre et autres produits forestiers; ils ne se limitent pas nécessairement à un seul pays, mais peuvent s'étendre à un territoire plus vaste sur lequel l'uniformité des tendances économiques en vigueur et des directives sylvicoles appropriées créent les conditions souhaitées.

En outre, dans une économie non-nationalisée, l'obligation croissante de faire face aux besoins de la société en produits forestiers à l'echelle nationale exige une direction centralisée de l'économie forestière par l'Etat.

La nécessité implicite de connaître avec précision les ressources forestières et les conditions économiques naturelles de la production pour établir les bases d'un programme à long terme appliqué à l'économie forestière élargit le cadre des activités de gestion forestière et leur impartit une signification nouvelle. De ce point de vue, l'examen des ressources forestières est d'une importance primordiale et devrait servir à titre de comparaison au cours d'inventaires ultérieurs en même temps que servir à différents buts de l'économie forestière.

Un inventaire général et unique, ne tenant pas compte des traitements particuliers et de la distinction des différences naturelles et économiques des peuplements forestiers, serait insuffisant du point de vue de l'intensification de l'économie forestière. Au contraire, un contrôle périodique approprié, appliqué non seulement au stock de bois sur pied, mais également à l'efficacité des méthodes d'intensification, implique une concentration des efforts en ce qui concerne le choix d'essences convenables, le maintien d'un niveau optimum défini des stocks de bois sur pied dont la structure est adéquate et le développement maximum, et la protection du peuplement contre des coupes prématurées.

Il est possible de réaliser ces objectifs pour l'application du principe de rendement continu et périodiquement uniforme, dans le cadre duquel la réglementation de la coupe est uniquement fondée sur la condition du peuplement et sur la maturité technique pour l'abattage; celle-ci est déterminée par une analyse des rapports entre la superficie et les stocks de bois sur pied au cours des dernières phases de la croissance, ainsi que sur la structure des couches.

Du point de vue de l'organisation comme de celui de l'utilisation, la réglementation de la production et de la diversification des ressources forestières exige qu'il soit tenu compte des fonctions sociales de la forêt et des éléments indirects et impondérables qui font sa valeur. A cet égard, et selon sa situation physiographique, la forêt a de nombreuses tâches à remplir. Le fait d'être située à proximité des sources des cours d'eau, dans des bassins principaux ou dans des régions à forte concentration industrielle limite les fonctions productives de la forêt et souligne l'importance de ses fonctions générales dans la société ou vice versa. Dans le dernier cas, l'établissement d'une monoculture et l'implantation d'arbres permettant une production maximum par rapport à une étendue donnée est d'autant plus impérative que les techniques

modernes protègent contre la détérioration du site et que les fonctions sociales protectrices et générales de la forêt ne sont pas entravées.

Le principe de la production continue et périodiquement uniforme et l'organisation de la continuité de la production exigent beaucoup de souplesse dans l'utilisation de systèmes de gestion qui devraient assurer à la fois une production maximum pour une superficie donnée et le développement des fonctions complémentaires de la forêt.

La maturité du peuplement se mesure à son utilité technique, calculée, en principe, d'après une certaine proportion dans la composition des assortiments utilisables qui sont evalués sur la base du peuplement "d.b.h." moyen. La maturité de la production optima en volume de bois d'oeuvre, quels que soient les assortiments, exige que l'on procède à des mesures et que l'on utilise le bois le plus mince, pour égaliser le maximum de l'accroissement moyen et le maximum de la production supérieur.

Le peuplement demeure l'élement de base et l'on poursuit un objectif unique dans le cadre des divisions économiques et naturelles. L'uniformité des objectifs de production exige la création de plus vastes catégories d'exploitation permettant un calcul correct du rendement et l'organisation des pratiques sylvicoles. Pour ces raisons, une étude éventuellement plus approfondie de la forêt et de ses ressources est une condition préalable; elle incluerait une ventilation de toutes les composantes nécessaires à l'analyse et à la tabulation.

Des machines statistiques (à cartes perforées) et tabulatrices, ainsi que les techniques mathématiques et statistiques appropriées, offrent une manière plus universelle d'aborder le problème en question et permettent une analyse périodique de l'évolution du stock de bois sur pied et de sa croissance grâce auxquels il est possible d'évaluer l'efficacité des mesures économiques adoptées.

Planes y Dirección de Bosques Administrados, Inclusive Nuevos Métodos de Regulación de Inventarios

La preparacion de planes así como la regulación de los recursos son medidas esenciales a toda economía forestal bien organizada puesto que con ello se facilita la utilización eficiente de las fuerzas naturales de producción y presupone el empleo de prácticas artificales y la aplicación de los procedimientos modernos de la silvicultura. En una bien dispuesta economía el patrimonio forestal es parte integral de la economía nacional, dentro de la cual se coordinan, mediante planes a largo plazo, las diferentes ramas de la actividad económica.

El plan a largo plazo (de perspectiva) se ha de basar en el más preciso conocimiento de los recursos forestales y de las condiciones naturales y económicas de la producción forestal. La regulación de la productividad y rendimiento no es ya un problema de interés particular limitado a una sola empresa forestal o de la sola incumbencia de su dueño. La regulación de la productividad, así como los planes de silvicultura, dependen cada vez más de la demanda general que hay de madera y otros productos forestales y esta regulación no tiene que limitarse, necesariamente, a un solo país, sino que puede extenderse a un territorio más vasto en el cual se hayan creado condiciones adecuadas, debidas a la uniformidad de tendencias económicas reinantes y a la factibilidad de las normas forestales.

De la misma manera, en una economía no nacionalizada la necesidad, siempre en aumento, de satisfacer en escala nacional la demanda general de productos forestales llega a imponer un sistema de dirección estatal centralizada de la economía forestal.

La supuesta necesidad de datos precisos de los recursos forestales y de las condiciones económicas naturales de la producción para llevar adelante el plan a largo plazo de economía forestal, se extiende el campo de las actividades administrativas y les da un nuevo significado. En este particular, el estudio de los recursos forestales es de primera importancia y deberá servir de medio comparativo para otros estudios subsiguientes y ser útil para varios fines de la economía forestal.

Una vez realizado un estudio general no resultaria adecuado sin un estu del tratamiento y la distinción individuales de las diferencias naturales y economicas de los bosques en lo que a la intensificación de la economía forestal se refiere. En cambio, la realización periódica correspondiente, no solo de los árboles en crecimiento, sino también de la eficacia de las prácticas de intensificación requiere concentrar la atención en la selección de la composición de especies apropriadas, el mantenimiento de un óptimo determinado de árboles en crecimiento de estructura adecuada y máximo incremento y la seguridad de que los árboles no sean cortados prematuramente.

Estos objetivos pueden alcanzarse por completo mediante el efecto del principio de rendimiento sostenido y periódicamente uniforme, conforme al cual la regulación del rendimiento de corte está gobernada solamente por la condición del bosque y por la madurez técnica de su corte, basada esta última en un análisis de la relación del área y de los árboles en crecimiento en términos de edad y tamaño agrupado por clases.

La regulación de la producción y variación de los recursos forestales requieren planeamiento y previsión para aprovechar los bosques en su función social así como en todos sus aspectos indirectos y valiosos. En este respecto, según sea su situación fisiográfica, los bosques tienen una variedad de servicios que rendir. Su situación dentro de la zona de recursos fluviales, en cuencas principales o en distritos industriales agrupados son los factores limitantes de la funcion productiva de un bosque y determina favorablemente, o viceversa, su importancia social, en general. En situación desfavorable es absolutamente necesario, económicamente, el establecimiento de monoculturas y plantaciones de árboles con las cuales se obtenga el maximo de rendimiento para el área, especialmente ahora que la técnica moderna previene cualquier deterioración del sitio. Además, de esta manera, no se obstruyen las funciones protectoras y sociales de los bosques, en general.

El principio de rendimiento sostenido y periódicamente uniforme así como el plan de continuidad de la producción requieren cierta elasticidad en cuanto a los sistemas administrativos, los cuales deben asegurar un máximo do producción por unidad de área y el dumplimiento de todas las funciones complementarias de los bosques.

En principio, la madurez de un bosque se juzga por su utilidad técnica, de acuerdo con cierta y determinada proporción de composicion de variedades aprovechables que se calculan a base del promedio diametro al altura del pecho para el rodal. La madurez de la producción óptima de volumen maderero, no importa cual sea la variedad de árboles, requiere la aplicación de cálculos y medidas y también la utilización de los troncos menos robustos para así igualar el incremento promedio de culminación y el máximo de producción.

El rodal continúa siendo la unidad básica, con su objetivo asignado dentro del cuadro de la división natural y económica. La uniformidad del objetivo de producción requiere la creación de clases operativas más amplias con el propósito de rectificar los cálculos sobre rendimiento y planear las prácticas silviculturas. Para ello el requisito es un estudio, lo más detallado posible, del bosque 4 sus recursos subdividido hasta incluir en él todos los elementos constituyentes necesarios para el analisis y la tabulación.

Las máquinas perforadoras para dichas estadísticas y las tabuladoras, auxiliadas por los métodos matematicos y estadísticos, contribuyen para obtener una solución universal de los problemas aquí tratados y permiten un análisis periódico de las variaciones del crecimiento o incremento de los árboles para avaluar mejor la eficacia de la actividad económica emprendida.

Developments In Planning and Control On Managed Forests In the United States and Canada

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My purpose is to inform you about status and trends in planning and control on managed forests in the United States and Canada. These are large countries; management conditions and problems are diverse in each. Time prevents more than a sketch of developments that seem of general significance and interest. I have more knowledge concerning the United States, having worked in it for over 30 years. If there is any seeming bias toward the U.S. in presentation, it is only because my information basis is strongest there.

The term "managed forest" in my title is rather vague. In discussion here, a managed forest is any area on which planned and organized procedures are applied to obtain continued forest production. Practice may be extensive or intensive. Primary attention will be given to the larger ownerships, public and private, because this is where technical developments center.

In presenting this subject, I will first discuss briefly some general items that affect the total management situation, and then separately consider four areas of management that seem significant in gauging progress. These are: (1) forest organization and subdivision; (2) methods of inventory control; (3) methods of determining the cut; and (4) management planning and plans.

General Factors Affecting Forest Management

There are both strong similarities and dissimilarities between U.S. and Canadian forestry that are important to realize in understanding management developments. First, I shall discuss the similarities, since they are basically the most important. Utilization in both countries is dominated by a large and well-organized private industry operating in a highly competitive economic system. Industrial forestry is strongly business-minded, and this viewpoint permeates woodland as well as mill operations. A profit must be made in order to survive. In both countries, the technical pace in woodland management tends to be set by the fiber industry. With large fixed investments in mills, they have the strongest of economic reasons to ensure a stable wood supply and to increase production on company-owned or controlled lands.

As is well known, both countries are deeply concerned with applying protection and management to very large areas of forest lands. Differences are largely in the stage of development; the U.S. is farther along. In this country, lands that have never been cut over occupy a small proportion of the total area (less than 10 percent) and are nearly all in the western part. Major accessibility needs remain in the West, but for the country as a whole, accessibility is less critical than in Canada, where forests stretch away into a vast hinterland from a relatively thin fringe of settlements. Accessibility is often extremely difficult. Forest development has tended to concentrate around areas of settlement and in a ribbon-like pattern along major transportation routes. A major characteristic of Canadian forestry is its very sharp contrasts; intensive and very extensive industrial practice can be found almost side by side. The same situation exists in many parts of the United States.

While large-scale industrial utilization is of long standing in both countries, permanently organized planned management to *grow* timber as a crop on large areas is fairly recent. Both industry and public management people will consistently tell you that they have really got down to the ground in growing timber only within the last ten years or so.

Second, there are the differences, which center mostly in land ownership and public policy. Considering the United States first, forest lands are dominantly in private ownership. Of the 489 million acres of commercial forest lands in the continental United States, 73 percent is in private ownership, including 13 percent in industrial holdings. Twenty-one percent of the total area is in federal ownership (85 million acres in the National Forests) and six percent is in state, county, and municipal ownership.

Private industry is consequently based primarily on privately owned lands except in areas of large public ownership, principally in the West, where there is considerable dependence on public timber. Federal and State agencies directly administer the lands they own and sell stumpage to private bidders who are responsible only for cutting the timber under stipulated conditions. Large industrial owners not only grow stumpage but are also timber processors, almost without exception. Very few own enough timber lands to supply their needs, but most wish to obtain a substantial portion of their raw material from their own lands; somewhat over 50 percent is a common objective. The trend, consequently, is for the larger owners to acquire more forest land and to intensify management of what they have. Despite enabling legislation and much consideration, management mergers between Federal and private agencies with intermingling ownerships have not developed. Only one cooperative management unit, that at Shelton, Washington, has been established.

The situation is very different in Canada. The Federal Government owns little forest land. About 93 percent of the total productive forest area is owned by the prov-

inces who are largely autonomous in their administrations. This predominance of public ownership is not likely to change. Because of difficult accessibility and heavy capital requirements, large-scale industrial units are a practical necessity. To a major degree, this private industry is built on semi-permanent leases of public lands. On these lands the lessee not only pays for stumpage cut but assumes much of the total land management job. There is a long history behind the present licensing system.

On public lands not in large industrial leases, the provinces assume the land management job and sell stumpage much as on the National Forests in the U.S., but in general are less strongly financed. The general trend is to favor development of public management. The provinces face a difficult problem of encouraging and keeping large-scale private industry permanently operating on public lands without monopoly domination, also giving fair opportunity for small independent operators. The operation of private industry based primarily on public lands is distinctly a Canadian situation with no parallel in the United States.

Forest Organization

The kind of forest organization employed gives a good index to the degree and character of management applied. Commitment to timber growing is clearly indicated by the organization established to carry it out. It is assumed that the organization of the National Forests of the U.S. Forest Service is generally understood. Emphasis here is on private industrial organization. The development of woodland departments strongly organized for continued timber growing is relatively recent. Most of them date since World War II and in their present form few are over ten years old.

It will be instructive to review the structure of a woodland department for a large southern U.S. pulp and paper corporation illustrative of a thoroughly organized timber business. The corporation owns about a million acres of forest lands, much of it presently understocked and in need of rehabilitation. Much of this land is in small units interspersed with many other ownerships. The mill currently uses a little over a million cords of wood a year, of which about a quarter is presently obtained from company lands. The rest is bought from private owners, mostly small, in active competition with other mills buying wood in the same area. State and Federal timber is not a factor in this situation.

All forestry work is consolidated in a woodland department with a woodland manager in charge reporting directly to top executive management. His principal jobs are procurement of wood for the mill (from both company and non-company lands), management (and acquisition) of company lands, and cooperation with local forest owners and other people. For administration, company lands are grouped into three large districts of around 350,000 acres each. These districts are divided into three to four forests averaging about 100,000 acres. Each forest is divided into management units of 25,000 to 30,000 acres. It is planned, though not yet fully accomplished, to have a graduate forester in charge of each management unit. These units are further subdivided into cutting compartments of around 1,000 acres. The total woodlands staff includes about 70 professionally trained foresters.

This company is organized for intensive management and control. Administrative units of 25 to 30 thousand acres in charge of a technically trained man are not unusual in the South, however. Management of company-owned lands is functionally separated in the Woodland Department from procurement of wood from non-company lands. This is the more common practice, though in some organizations procurement and land management are combined. In either case, there is close liaison between management of company-owned lands and purchase of other timber. In the South, as is general in the U.S., little cutting is done by company employees. A contractor-jobber system is almost universal, and the same jobbers often cut wood on company and non-company lands.

While there is much variation in specific industrial organization, the trend is to combine all forest-land activity into one strong department. Its head usually has rank coordinate with mill managers and other major department heads who report directly to top management.

On both public and private ownerships in the U.S., there is a strong tendency to merge the working circle concept with administrative units. That is, administrative districts or forests, regardless of size, are usually managed for continuous production whether for literal sustained yield or not. The original idea of a working circle meant not only a sustained-yield management but also that the area was tributory to some community or other unit of economic dependency. Changes in transportation and technology make economic dependency a changeable thing.

In Canada, due principally to differences in land ownership, sustained yield is organized differently. The general pattern is as follows:

1. Large areas of public (Crown) lands are leased to big operators. They are variously called forest management licenses, Tree Farm licenses (in British Columbia), lease or "limit" lands. Both privately owned and public lands are managed in conjunction with a specific sustained-yield objective. These licenses, though written with termination dates, are intended to be continuing, provided their provisions are followed. The recipient accordingly has reasonable assurance of tenure and is expected to manage these public lands on a permanent basis as if they were his own. The large pulp and paper industry of Canada is built on this basic plan. Leases of hundreds of square miles are common; some include several thousand square miles.

2. In several provinces, British Columbia and Ontario especially, sustained-yield units of public lands are established that, in a general sense, are counterparts of the National Forests in the United States. The units are managed for sustained yield by the respective province with stumpage sold to individuals who, as on the national forests, have distinctly limited land management responsibilities. Organization of such areas as permanent public operating units is comparatively recent. Only within about the last decade have the provincial forestry departments developed the staffs to undertake direct and effective management of large public areas.

3. *Farm Woodlot Licenses.* In British Columbia small tracts not exceeding 640 acres or 10,000 cubic feet in

annual yield may be permanently leased to a farmer for farm use and supplemental income. This is a sustained-yield unit in miniature.

The objective is to get all commercially valuable Crown lands under sustained-yield organization, be it through long-term leases to large operators, public working circles, or small individual leases.

Inventory Control

It is axiomatic that any kind of continuing management also requires a continuing flow of information from the forest. As management practice develops in the United States and Canada—as it rapidly is—there is a consequent change from the older stock-type inventory emphasizing *how much* timber there is and where, to a production or flow-type inventory needed to guide continuing and increasingly intensive management, area by area.

Notable advances have been made in procedures to obtain this continuing information and in its application. Technique development is an area of particular interest in the U.S. and Canada. In discussing this matter, I wish to distinguish between these management-centered inventories and periodic regional, state, or national forest surveys that are discussed elsewhere in the Congress. There is much in common in mensurational techniques, and it is also true that general survey data are used in management of particular properties. There are, however, sharp differences in objectives, specific methods, and often in the kinds of data needed. Here, I am concerned with inventory control to serve the needs of management on individual properties, whether National Forests or industrial units. As forest practice is intensified, there will be increasing divergence between general area surveys and production management inventories.

How can consistent and recurrent data that are applicable to United States and Canadian needs be obtained from the forest at reasonable cost? Very large areas are involved, and management is highly variable in intensity. The general problem is not new; it has been encountered everywhere in the world that continuing management is undertaken.

There are two general approaches, essentially complementary. One is the use of low-intensity sampling systems applicable to large areas. The other is an individual stand description and analysis covering the entire area. I should like briefly to discuss each.

Low-Intensity Sampling Systems

These systems are similar to general forest surveys and sometimes merge with them, as on the National Forests of the U.S. Forest Service, where timber management and general forest surveys are closely coordinated. The same coordination generally prevails in Canada on large leases. These systems are characterized by:

1. Low-intensity, periodically remeasured sampling employing areal sample plots or Bitterlich point sampling. Sample points are usually permanent, but a combination of permanent and temporary sampling may be employed. Intensities usually range between 0.03 and 0.1 percent of the total area.
2. Systematic or restricted random sampling, usually but not always unstratified.
3. Detailed and accurately measured stand and individual tree data obtained at sample locations.
4. Machine or electronic computation to accomplish promptly at reasonable expense an otherwise impossibly laborious compilation job.

Such systems have been widely installed on large management units, both public and private. The subject is of much interest. Few things in American forestry have been so eagerly grasped or so well illustrate American talent for exploiting procedures. There has been great technique development in the past ten years which cannot be reviewed here. Few systems have been installed long enough to yield remeasurement data.

Information obtained is of the following general kinds:

1. Total volume data by species, quality, and whatever other items are measured in the field.
2. Areas by principal cover types, age, or stand condition classes as are defined in the field. This work is often combined with delineation from aerial photographs, which, with ground checking, yield general type and stand condition maps.
3. Growth, by individual trees including, mortality and other "change" data obtained from remeasurement of sample points or plots.

Such information is valuable in total management unit planning and forest accounting. In fact, these low-intensity systems have been installed primarily as a head-office means of overall management planning and control —usually in its initial stages. They are often also used as a basis for Federal income tax timber accounting—a subject of very large importance and complication in the United States.

Valuable as are these total sampling systems in large-scale planning and control, they have sharp limitations that increasingly are coming to be recognized, as forest practice becomes more intensive and consequently local in its application.

Data are applicable only to large areas, generally over about 50,000 acres. They can be applied to smaller areas. However, because sampling error increases rapidly as the unit area is decreased, costs increase sharply as the area is reduced or the data are subdivided by categories.

In general, these systems yield good information on *what* there is on rather large areas but not *where* it is by specific areas. This is true even if sampling intensity is greatly increased. To apply continuing management, one must structure the forest by cutting compartments, identify specific areas on the ground and treat each according to their individual needs. This is a circumstance as old as forest management.

Area Stand Description

The need for on-the-ground prescriptive information has led to a second general approach to inventory control in sharp contrast to sampling systems. There is no well-established term, but it may be called "area stand description." It is increasingly being applied where management has become more intensive, primarily in the South of the United States.

The essence of the approach, which certainly is not at all new in principle, is that specific stands are individually visited, identified, and mapped down to a minimum size of about ten acres. No fixed type designa-

tions are used. A stand is defined as a reasonably homogenous area that differs significantly from others as to its condition and treatment needs. Each such stand is described and a prescription made of the treatment the area should receive—planting, thinning, overstory removal, harvest cutting, etc. What can be done, and its timing, naturally depends on the intensity of practice and the purposes of management. Volumes, especially of timber to be removed, are estimated to a level of accuracy sufficient for cutting-budget preparation, not necessarily for actual timber sales.

The work is done systematically, following a set procedure defining the kind of data to be taken, recording methods, and the like. It is done rather rapidly, inexpensively, and largely on an ocular basis by regular personnel responsible for land management. Aerial photographs are used as a base, and the work is done within whatever compartment control units have been established. Common practice is to cover about 1/5 of the total forest area each year so that each part receives examination and treatment needed every five years. This is truly a continuing inventory. It comes to specific grips with management needs on the ground.

It is my observation that most large management organizations approaching intensive practice have come to adoption of some individual stand description and treatment prescription procedure *whether or not* they also employ a low-intensity, total area sampling system. As would be expected, area description work is most widely applied in the South. The procedure followed by the Southern Kraft Division of the International Paper Company is well developed and an outstanding illustration of such work. Their management control is based directly upon it.

Regarding inventory control for management as a whole, I think it basic to recognize that definition of management objectives and needs must come first and that formulation of inventory methods to supply the needed information must come second. This has not always been done—in the U.S., at any rate. It is also necessary to recognize the stage of management one is in when designing inventory procedures. Also, since management requires several kinds of data, it is unlikely that any single approach or technique will suffice.

Management in the United States and Canada is in a stage of transition and rapid change. Our ideas and methods of inventory do and can be expected to change accordingly. I am sure foresters around the world will watch American developments with much interest, as we will correspondingly watch those in other countries.

Determination of the Cut

Large-scale application of management for sustained yield naturally focuses interest on methods of determining the cut. Time does not permit more than limited exploration of this most interesting subject, but some major trends can be indicated. There has been much experimentation and improvisation. The full range of older regulatory formulas and techniques have been applied and some new ones added. In considerable degree, regulation has been taken out of the American classroom and applied in the field.

Public agencies who produce stumpage for sale to many private operators have obvious reasons for establishing rather definite cutting limits by working circles. Such action is needed to give evidence of stewardship in managing public resources and to inform prospective purchasers how much stumpage will be available. Establishment of an allowable cut for a public working circle is an important decision to operators dependent on public timber.

It is difficult to generalize about specific methodology; so much depends on purpose, personal predilection, data available, and the character of the forest. Area, volume, and combined approaches are all utilized. Estimates are chronically conservative. As a generality, simple and rather crude volume and/or area approaches are applied in western even-aged sawlog management, where there is much virgin timber and scanty stand condition and growth information. In the national forests of the eastern U.S., which are largely composed of acquired lands that have been severely cut over, the dominant problem is usually forest rehabilitation. Area approaches naturally predominate. The major need is to cover areas systematically to do harvest and improvement cutting work needed to improve growing stock conditions.

The regulatory situation of private owners is extremely variable. As pointed out, most large-scale forest business units in Canada operate at least in part on leased public lands which they in effect manage. They are required to submit estimates of cut to the provincial authorities, and general methodology is similar to that applied by public agencies.

The situation is different in the U.S. Industrial corporations are under no compulsion to make their cutting plans known to anybody, whether they buy public timber or not. Very few can supply their needs from privately owned lands. While they manage their own lands for sustained yield, and often intensively, they also manage them with an eye to total mill needs, the competitive wood supply situation, and an estimate of general business conditions. Large private owners tend to apply some form of a direct area and volume allotment schedule, developing either a total annual cut allocated to districts by quota, or by building up a total cut, area by area and district by district.

Viewing determination of the cut as a whole, I do not feel that much new, technically speaking, has appeared on the North American scene. What is new is the large scale on which regulatory techniques are being applied and the importance of decisions based on them. One trend apparent, and which I feel will be further developed, is the attempt to base determination of the cut directly on data obtained from inventory control systems.

Somewhat counter to this trend, but also strongly apparent, is recognition that determination of the cut is, in the final analysis, a managerial-economic decision rather than a technological matter that can be solved by some set mathematical procedure. U.S. and Canadian foresters are both business-minded managers and technologists. Perhaps they have split personalities. At any rate, this dualism shows up in determination of the cut. They look and yearn for a set procedure, a formula, that will give an unequivocal answer. At the same time they are individualists, vigorous in searching for new methods,

reluctant to be bound by any set formula or procedure, and very business-minded. And business is not an exact science.

Management Planning and Plans

I wish it were possible to review management planning and preparation of working plans in the U.S. and Canada. It is here that control of the managed forest specifically comes to focus. But time does not permit, and what has been said about the general management situation, inventory control systems, and determination of the cut covers much of the subject.

In the United States, no private forest owner is under any compulsion to prepare forest working plans, or if he does, to disclose them to any public forestry agency. Few private organizations prepare formal plans in a conventional documentary sense. Such written material as is prepared is ordinarily not available outside the company because it may include competitively significant information about cutting and wood procurement plans, timber volumes, growth, etc. American forest industry does a great deal of careful forest planning, but it is not expressed in formal management plans.

What is to me significant about private-industry action is a natural and perhaps characteristic American tendency to integrate timber management and administrative operation plans. Instead of preparing a plan as a more or less separate thing, an administrative organization is set up, an inventory system and cutting-budget preparation procedure is established, and field operating procedures are defined. Given direction by corporate policy and executive action, these things collectively *are* the plan, but there is no single written plan.

This kind of approach has, it seems to me, a basic advantage of achieving and enforcing plan continuity—a frequent difficulty with timber management plans periodically prepared as a formal document. Made a part of current operations, "the plan" goes on because it has to; because there is a time schedule of jobs to be met. Periodic revision may be made on a regular schedule, but not necessarily. Corporate life is dynamic; such things as market changes, business firm consolidations, new product development, and changing business conditions do not run on a deliberate and pre-arranged forest timetable.

It may be that, in the future, private industry units will prepare more formal management plans—also assuming that their operations settle down into a more stable pattern. I am inclined to feel, however, that the present trend to combine timber-management planning with its administrative execution will continue, not as much by deliberate design but because business life goes that way.

The situation is different with public agencies. Public timberland owners do not cut their timber nor do they enter into processing and marketing of finished products. Present public ownership patterns are stable. Management is financed by appropriations rather than from profits, and basic accountability is consequently to political units of popular government. For these and related reasons, public agencies are normally committed to preparation of fairly formal timber-management plans. They are needed to give specific evidence of managing lands in the public interest. Most importantly, and as has been pointed out in connection with allowable cut determination, they are needed because there are very large areas of public timberlands in the U.S. and Canada, and what is done on them is of deep economic concern to many people. Information must be made available in an orderly and consistent manner.

Summary Appraisal

In concluding this sketch of developments in planning and control on managed lands in the United States and Canada, I should like to make four points of characterization and summary. They are directed primarily to the United States.

First, is the very strong business orientation of forest management. The country is dominated by private ownership in the ratio of four acres private to one in public ownership. Large-scale and rather intensive private forest management dedicated to sustained yield has profitably developed in recent years. This is a fact of large significance affecting public as well as private forest-land management.

Second, is the rapid and large-scale development of both low-intensity sampling systems and on-the-ground stand description procedures. This is nothing short of a movement and the most convincing sort of evidence possible of interest in sustained forest production. There has been much procedural development with more undoubtedly to come.

Third, and a somewhat negative point, I do not feel that there is particularly significant technical development in regulatory principles and methods. The present period is marked by vigorous and varied experimentation. Almost everything is being tried some place, and many points of view are likewise current. As a broad generalization, and in keeping with a characteristically business-minded approach, there is general recognition that determination of the cut is basically an administrative decision, necessarily to be made within the productive capacity of the forest. There is a constant search and desire for a mathematical system, for a super formula that will give *the* answer, and yet awareness that there isn't any.

Fourth, I think there is significance in the tendency of American forest industry to integrate timber-management planning and plans with administrative operating procedures. This is a departure from the traditional view of working plans as being something separate and apart.

RESUMES

Progrès realisé dans l'organisation et le contrôle des forêts aménagées des Etats-Unis et du Canada

La communication rend compte de la situation d'ensemble de l'aménagement des forêts aux Etats-Unis et au Canada en ce qui concerne l'état actuel et les tendances en matière d'aménagement des forêts. Elle souligne les analogies et les différences qui existent en matière d'aménagement dans les deux pays.

La communication signale, en outre, les faits saillants qui se sont produits dans quatre domaines de l'aménagement; organisation forestière et subdivisions, méthodes de contrôle des stocks, techniques et pratiques utilisées pour la détermination de la coupe, ainsi que dans l'établissement des plans et programmes d'aménagement. Elle examine en particulier l'emploi étendu des systèmes de parcelles-témoins permanentes en tant que méthode de contrôle des stocks.

Planes y Dirección de Bosques Administrados en los Estados Unidos y Canadá

En este trabajo se resume la situación general actual de la administración de bosques en los Estados Unidos y Canadá en cuanto se refiere a las condiciones y tendencias en la dirección de bosques administrados. Se destacan muy especialmente los parecidos y las diferencias que existen en la administración de bosques en ambos países.

Se indica la evolución importante que se produjo con respecto a cuatro aspectos de la administración forestal: organización y subdivisión forestal; métodos para la regulación de inventarios; técnicas y métodos para la determinación del corte y planes y dirección de la administración forestal. Se presta atención especial a la aplicación en gran escala de sistemas de parcelas permanentes para muestras, como método para la regulación de inventarios.

The Influence of Delivered Prices of Forest Produce On Silvicultural Practice in a Developing Forest Economy

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Introduction

New Zealand provides a classic instance of a developing forest economy. It likewise provides a classic instance of the influence of prices on silvicultural practice. If the country's wasteful use of its virgin forest resource was typical of colonial development, its attempted correction by large-scale planting of rapidly growing exotics has been quite abnormal. Instead of plantings of each species being more or less uniformly spread over anticipated rotations, all were compressed into short periods representing from 5 to 20 per cent of such rotations. Hardly had establishment been completed when World War II broke out to create such a shortage of manpower that just when silvicultural treatment was most needed none could be carried out. The same condition continued well into the post-war period.

With the outbreak of war, timber came under official price control, and has so continued ever since. It has in fact been under some form of price control for 24 years. As it was clear by 1952 that long continued price control was defeating the purpose of national forest policy, the matter was brought under parliamentary debate by suitable review in the Annual Departmental Report by the Director of Forestry. As a result of both Government and Opposition agreeing that the provision of cheap timber for house building was all-important, subordination of forest policy to timber price control became bi-partisan in character and still continues so. Peculiar as these conditions are it is nevertheless possible to draw many valuable lessons from the interplay between economic and political factors as they affect the silvicultural management of any country's forest resources, whether they be indigenous or exotic.

The author prepared a paper on "The Influence of Markets on Silviculture" for the 7th British Commonwealth Forestry Conference. It studied the impact of the Great Depression, World War II, and the postwar economy upon the management of New Zealand's exotic forest resource. The purpose was to show how the conditions peculiar to these periods were turned to the advantage of the over-all national forest policy both by administrative control of the indigenous resource and development of integrated industries; and how thereby it was possible to ameliorate the harmful effects of compressing the establishment of the exotic resource into a very short period. Ostensibly written to explain what had occurred, the paper in fact tended to show the compression of establishment and the lack of silviculture in the most favourable light possible. This paper has been written to highlight the technical and administrative problems created by large-scale exotic forest establishment compressed into a very few years, and the subsequent neglect of silviculture. It thus tends to present New Zealand exotic forestry in its least favourable light.

Developing Versus Highly Developed Forest Economies

The decision of the Organising Committee to distinguish between highly developed and developing forest economies was a wise one and of profound importance to the profession. Most reference works and text books the world over are based upon the concept of a stable forest economy. Much theory and practice proceeds on a similar concept even though stable conditions do not exist and there is in fact a developing forest economy.

For the purpose of this paper a developing forest economy is regarded as one in which a country is in process of creating a forest capital, as distinct from a highly developed economy in which a country is already in possession of a forest capital adequate to its foreseeable needs and under sustained-yield management for the maintenance of a widely diversified forest products industry.

The Evolution of Exotic Forestry in New Zealand

The history of forestry in New Zealand is probably typical of colonial development in the nineteenth century. Much of the country, both lowland and high country, was under a dense forest cover, a great deal of it comprising a merchantable timber crop, but so remote from the world markets that it was a liability and not an asset to those pioneers who sought land for agricultural and pastoral development. On a conservative estimate not more than 10 per cent of the merchantable forest growing on the land cleared for farming development was converted to sawn timber either for local use or for export to

Australia—the only market within practicable reach. Exploitation eventually spread from the fertile lowlands to the less attractive hinterland and at such a pace that within a century of the first land settlement it became apparent that only by the establishment of a supplementary capital resource of rapidly growing exotics would the country be able to maintain self-sufficiency in timber supplies.

In 1925, the New Zealand Government accepted and implemented a recommendation by its first Director of Forestry, Mr. L. McIntosh Ellis, B. Sc. For. (Toronto), for the establishment of 300,000 acres of rapidly growing exotics over the following ten years. The purpose was to assist in meeting an expected annual timber requirement of 650 million board feet by 1965, by which time the indigenous forest resource would no longer be capable of wholly meeting such a demand for anything but a short period.

The compression of establishment into a ten-year period, even for such a short rotation species as *Pinus radiata,* was the result of previous experience in the field of national forest policy. Originally sponsored in 1870, exotic tree planting by the State did not commence until the turn of the century. But with numerous public agitations, a Royal Commission, and repeated departmental urgings, only 40,000 acres had been planted by 1925. Fortunately, the first Director of Forestry conceived it as his duty, not only to alert the country to the seriousness of the situation, but to persuade Government to overtake the arrears of forest establishment accumulated through past laissez-faire.

A colourful personality with the prestige of overseas experience, Ellis created a wave of popular opinion which has out-lived its expected ten years to carry national forestry on its crest ever since. It resulted not only in completion of his original programme ahead of schedule, but in the generation of a boom programme of private planting which established another 300,000 acres of rapidly growing exotics. Both State and private programmes originally envisaged concentration upon the use of *Pinus radiata,* but only in the case of the private sector were suitable sites available to allow virtual attainment of this objective. In the case of State plantings, a significant acreage of *P. radiata* was established on sites which had to be replanted to more suitable species.

With the development of the Great Depression of the early Thirties the State programme was accelerated and completed ahead of schedule, just at the time when public works of all kinds became essential for the relief of unemployment. However, an overseas visit at that time by the author confirmed the growing conviction that *Pinus radiata,* because of its vulnerability to a wide variety of insect and fungal pests, was being "over-planted." It was therefore decided that with the availability of unemployed labour at low wage levels this inherent risk should be corrected by extensive planting of the widest possible diversity of other rapidly growing exotic conifers, the limiting factors of course being site and seed supply. *P. radiata* continued to be planted, but only on the most suitable sites. The objective was to produce as rapidly as possible an annual surplus of 50 million cubic feet of raw forest produce for export in the form of timber, pulp, or paper, according to the manner in which Australia and eastern markets for these commodities might develop in the interim between planting and maturity. The total acreages and percentage composition by species planted by the State for the three 5-year periods 1925-29, 1930-34, and 1935-39 are shown in Table I.

Table 1. State exotic planting in New Zealand, showing total area planted and percentage distribution by major species

Species	Period		
	1925-29	1930-34	1935-39
	%	%	%
Radiata pine	63	30	14
Ponderosa pine	7	24	52
Corsican pine	10	13	12
Douglas fir	7	12	17
Other and Mixed	13	21	5
Total Planting	100	100	100
	185,000 acres	153,462 acres	29,654 acres

In retrospect, it might appear that much of the low-cost unemployment labour available during the Great Depression could have been more usefully employed on tending some of the earlier planted stands than on planting new ones. The fact is that not only was the supervisory staff so inadequate as to preclude even satisfactory stocking or blanking of many areas, but departmental knowledge and experience of silviculture was so limited that poor value and much damage could well have resulted from any large-scale diversion of planting labour to tending work. Actually there were a few such mistakes.

With the outbreak of World War II, the Director of Forestry became Timber Controller and, as such, was charged with the responsibility of conserving manpower in respect not only to forest establishment and tending, but also to logging and milling. In the initial stages before the involvement of the United States, establishment and tending virtually ceased and timber production was curtailed. For the rest of the war, manpower was barely sufficient to provide protection services to forestry, but with the United States taking over responsibility for the South West Pacific theatre of operations, timber production had to be substantially increased, and logging and milling thenceforth commanded a high priority for available manpower.

This gave the forest and timber administration an unexpected opportunity of accelerating the development of the national forest policy—a policy directed towards the rapid substitution of exotic for indigenous timber supplies, thereby rationing and conserving the dwindling indigenous forest resources. The imperative necessity for conserving manpower in timber production thus made it both logical and feasible to integrate a national wartime timber production policy with the national forest policy. As indigenous sawmills exhausted their tributary standing timber supplies they were drifted out of production, and their staffs transferred either to other indigenous sawmills, or preferably to new or existing exotic sawmills. The premise was that consolidation of production nearer to established labour or consuming centres would be more economical, not only of manpower, but of essential supplies and transport. As a result, during World War II there was a spectacular expansion of exotic sawn timber production which has continued almost without interrup-

tion ever since. It would have been even more spectacular had the State owned a larger proportion of the standing indigenous resources.

Since 1952, it has been practicable to continue the war-time policy of withholding new State forest resources from mills cutting out on old State forest locations, but it has not been feasible to persuade owners of Maori indigenous resources to do likewise. Because of this, the production of Maori-owned indigenous timber has increased four-fold since the war. Significantly, however, other private owners of indigenous forest have refrained in most cases from increasing production in order to ration out their resources as long as possible, and in the hope that this would favourably dispose the State to their future claims for indigenous State forest.

All this has been possible only because of a world-wide shortage of timber over both World War II and its early post-war period. With such limited supplies of indigenous and imported timber available, consumers were then forced to use exotic or go without. In essence there was a sellers' market for seventeen years, during which annual exotic production increased from 30 to almost 300 million board feet. Indigenous production remained virtually static at just over 300 million board feet throughout that period. It is extremely doubtful if, in the absence of the peculiar conditions of World War II and its early post-war conditions, annual exotic production would have risen even to half its present level.

Under such conditions of acute shortage and forced usage, the sawn exotic product was poorly manufactured, badly graded, and ill-seasoned. Naturally enough, not only wood users, but architects, engineers, and specifying and lending authorities tended to resist its substitution for the better manufactured and more valuable indigenous timbers. It was not until a buyer's market developed on both the domestic and the export markets in 1956 that exotic producers were forced to improve both the production and merchandising of their product. Once this was achieved, the longer length specification of the exotics, combined with their ease of preservative treatment and of working, enabled them to capture some of the markets hitherto dominated by indigenous timbers. In particular, they captured the structural framing field in the North Island, whilst in the cut-up field the factory grade of radiata pine commands a wide market both in New Zealand and in Australia. By improved servicing, the exotic producer is now in a very much more powerful position to compete with the indigenous producer.

Diagram No. 1 demonstrates clearly the trend of both indigenous and exotic production over the period 1923-57, lending force to the claim that New Zealand is a classic instance of a developing forest economy.

The Impact of Insect and Fungal Attack

Exotic forestry in New Zealand has not been without its insect and fungal troubles, but all have been of a secondary character. Probably only because of its geographical isolation has the country been free of any epidemic attacks of a primary nature.

On the pumice soils of the North Island, many of the pine stands, and particularly those of *Pinus radiata,* are characterised by a large proportion of malforms on all sites, the malformation of individual trees increasing

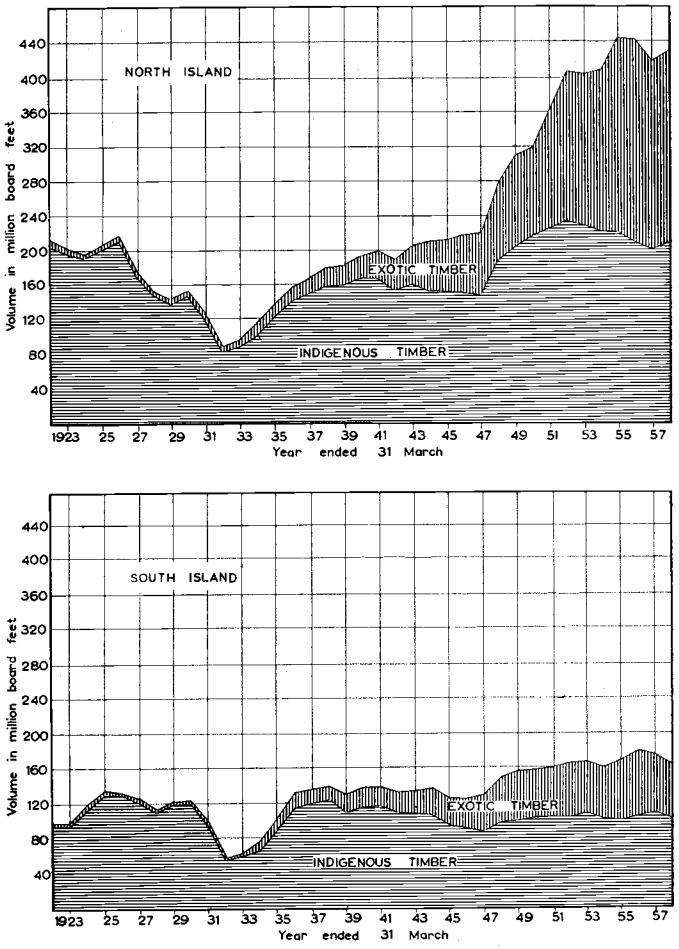


DIAGRAM NO. 1

with low stocking. Elsewhere on the poor clay sites in the far north and on the shallow gravelly sites in the south the proportion of malforms is lower than on either high-quality agricultural loams or pure sandy sites. It is generally true that the poorer sites yield shapelier trees, more lightly branched albeit smaller, and with considerably less "natural mortality" than is met with on the better soils.

Many parts of New Zealand occasionally experience late spring frosts of great severity. In young *Pinus radiata* stands, these cause localised splitting of many leading shoots, thereby allowing infection by *Diplodia* or *Phomopsis*. Death of the leader, and the subsequent development of double leaders often results. In the original 10-year establishment programme, a spacing of 8 ft. by 8 ft. was widely used. This gives a nominal stocking of 680 per acre, a number which proved quite inadequate to take possession of the site where the young stands suffered any significant mortality from drought or frost and subsequent fungal attack. And because of the pressure under which the programme operated, beating-up to replace post-planting mortality was seldom possible. Even the 6 ft. by 6 ft. spacing—1,210 per acre—adopted for some areas, often failed to yield a satisfactory final crop of well-formed trees in these circumstances.

Wet and dry periods of several years duration likewise

follow a cycle of about ten years, and a series of dry years favours the build up of *Sirex* populations to epidemic proportions. Happily, however, damaging attacks by these wood-wasps have so far been limited to trees with weakened sap flow due to the prolonged moisture deficiency. Significantly many of the malforms die, and in untended stands the damage is often spectacular. It is usually worse in the denser 6 ft. by 6 ft. stands of *Pinus radiata* than on the 8 ft. by 8 ft. stands, some of the former being decimated to the stage where only 30 green trees per acre are left at maturity. Some of these trees successfully resisting attack subsequently put on the extraordinary annual diameter growth of 2 inches for the next two years.

In essence, the epidemic *Sirex* attacks have killed virtually all those trees which should have been removed earlier in thinning, an operation rendered impossible by war. The maximum basal area of *Pinus radiata* which the pumice sites of the North Island appear to be capable of sustaining against epidemic attacks of *Sirex* is about 200 square feet, giving at 30 years on Site II quality a growing stock of 7,000 cubic feet to a 6-inch top diameter, and a current annual increment of 300 cubic feet per acre.

In view of these experiences, it is not altogether surprising that both drill-sown compartments and fire regenerated stands with stockings up to 10,000 and 500,000 per acre respectively are yielding untended, even on poor sites, more large, lightly lateralled, and better form trees than any other untended stands. To achieve the same result, much genetical research is currently being developed to reduce the high cost of thinning and pruning the 6 ft. and 8 ft. spaced stands.

Timber Price Control in New Zealand

As a result of the Great Depression of the early Thirties the bottom dropped out of the timber market, with the annual cut falling from 300 million to 150 million board feet—most of it sold at well below cost of production. Prices remained at these levels even after the advent of the first Labour Government which, on coming to power at the end of 1935, restored wages to the 1931 award levels. In order to preserve the purchasing power of these wages the Government negotiated an agreement with the timber industry whereby any advances in price were strictly limited to proven increased costs arising from both the restoration of wage levels and the increased cost of imported supplies and equipment. The idea was that the increased demand for timber arising from the Government's large-scale State house-building activities would make the depression level of prices remunerative to the industry.

This Gentlemen's Agreement on prices operated until the outbreak of World War II, when it was replaced by official control under appropriate war-time legislation. Official timber price control has continued ever since. With rare exceptions, the original basis of control has been observed, with increases limited to the covering of costs beyond the control of the industry—that is, due to increased wages and increased costs of supplies, plant and equipment. As originally adopted by the 1936 Gentlemen's Agreement, the base prices of exotic and indigenous timbers were in no way related to one another. They merely reflected the then fortuitous depression prices for two classes of timber which were at that time being used largely for different purposes, and were not much in competition, with only about 35 million board feet as compared with more like 260 million board feet of indigenous timber.

At that time exotic timbers were being used mostly for the manufacture of the poorer type boxes and crates. The only purpose for which they were used by the building industry was for concrete boxing. Then, as now, the exotic timber was knotty as compared with the clear and defect-rare grades of indigenous timbers. The latter therefore dominated not only the building and cut-up fields but virtually every other type of wood use, including manufacture of the better types of boxes and crates. Nevertheless, so great was the oversupply of the indigenous timber, that under the impact of the Great Depression, the prices for indigenous timber were relatively very much more depressed than those for the exotic timbers. Timber price control, therefore, commenced with indigenous timber prices far too low, rather than with the prices of exotic timber too high. Neither was remunerative, even in covering costs of production.

As usual with the maintenance of price control in the face of imperfect coverage and oversupply, not only has it become increasingly ineffective, but there has been a gradual retreat from the original base relationship between the prices of indigenous and exotic timbers. Until recently the basic anomaly arising out of this relationship has been that exotic producers have been forced to sell much of their production—at best, only medium quality timber—almost as highly priced as indigenous grades of very much higher quality. Naturally enough, the consumer has preferred to buy the indigenous product and has done so whilst supplies have been available.

The few exceptions to the general rule of limiting price rises to proven cost increases have been due to the development of uneconomic conditions in the industry, arising out of the time-lag between the development of increased costs and the approval of increased prices. The cumulative effect of a succession of such time-lags has forced the price control authority from time to time to approve of special increases to improve the general economic return to the industry.

Superimposed on the general situation has been the post-war evasion of price control by a realisation that legally control was limited to the prices of sawn timber. Just as soon as it became appreciated that there was no price control either over the basic raw material, whether in the form of standing timber or of logs, or over the cost of sawing or over the end-products such as manufactured joinery, and wooden houses, buildings, etc., a revolutionary change in the composition of the timber industry set in. Not only timber merchants but contractors and house builders commenced leap-frogging of sawn-timber price control. In some cases they purchased standing timber and logs and had the material logged and/or sawn to yield the finished product at costs much in excess of approved prices but for which they could reimburse themselves by changing the timbers into manufactured joinery and houses at high enough figures to return a handsome profit. In other cases merchants and contractors purchased sawmills outright with the same end result.

In face of the administrative action by the Forest

Service to curtail production from State forests, the immediate effect of this change in the industrial structure was to trigger off large sales of Maori-owned resources in the form both of standing timber and of logs at prices anything from twice to thrice their economic value as related to controlled sawn-timber prices. Eventually significant supplies of sawn timber produced via this uncontrolled route became surplus to owner-user requirements and were placed on the open market at higher than approved prices. As such producers were prepared to defend their right to recoup themselves by selling at high enough prices to return a profit on proven costs of production in efficient logging and milling operations, the industry was awarded another economic increase to accommodate the situation.

In the case both of normal and of economic rises the approved increases were invariably larger for indigenous than for exotic timbers. It was therefore only a matter of time before various developments inexorably tended to correct the disregard of economic laws implicit in the whole system of partial price control. With the ever increasing disparity in indigenous and exotic timber prices, the competitive power of the exotics increased. Likewise, as the production and costs of indigenous timber from Maori resources increased and extended from a sellers' to a buyers' market, not only did the lower grades of indigenous timber from all sources become much more difficult to sell, but the prices of standing timber and logs from Maori resources have tended to fall quite significantly. Concurrently, the prices of standing timber and logs from State forest resources have risen to the new economic levels determined by the increases in approved prices.

The basic cause of all these developments was the operation of the old law of supply and demand. With a surplus in total supply—that is, indigenous plus exotic timber—the exotic producers were forced to service the consuming public sufficiently well to overcome some of its preference for the indigenous timber. The position today is that even on a buoyant domestic market, though still in the buyers' favour, both indigenous and exotic producers are experiencing the same difficulty of quitting their lowest grades. Whilst there is some valid value relationship between alternative grades of the indigenous and exotic timber, nevertheless approved prices continue to hinder optimum integration of the two classes of timber. Similarly, there are remnants of restriction on the use of exotics based upon both prejudice and administrative inertia.

Withal, even optimum integration under existing conditions is unlikely to give the exotic grower an adequate return. Due to lack of silviculture, his first rotation crop is producing such knotty logs that they are yielding nothing but low and medium grades. Without any significant quantity of highly priced defect-free or defect-rare grades he is unable to realise a remunerative stumpage for sawlog material. It is pertinent to observe, however, that even had no war intervened, the compression of establishment of *Pinus radiata* into 10 instead of being spread over 40 or 50 years would most likely have precluded intensive silviculture of any but the best stands and would have left the bulk untended. In retrospect, there is little doubt that finance, manpower, and supervision would have been seriously limiting factors in coping with the corresponding compression of silvicultural work into the short span of years during which tending is practicable in any such short rotation species as *P. radiata.* Equally important is the point that only interim experience has developed and is still developing correct silvicultural techniques.

There is no doubt that with the removal both of price control and of use restrictions, the prices of the clear and defect-rare grades of indigenous would rise somewhat. This would have the two-fold effect of restricting their use to essential purposes and allowing the wider use of exotics for medium-grade uses, thus returning higher prices to the exotic producer. Finally this would return to the forest grower a higher price for his standing timber, which at the present time is so low that even with the high profits returned by paper and/or fibreboard products from integrated plants, it returns only about 3 per cent compound interest on the original costs of establishment and maintenance over the last 40 years. Unfortunately, these are but a fraction of the cost that it would now take, either to naturally regenerate the crop, or re-establish it *de novo* and maintain it over the next rotation. This is the essence of the financial problem which faces the New Zealand forest grower.

It is in striking contrast to the position of the Australian exotic forest owner who enjoys the advantage of having the price for his end-product determined by the high cost of landing New Zealand exotic timber in his near-by market. Thereby he secures not only the equivalent of the New Zealand price for standing timber but in addition the whole of the heavy trans-Tasman shipping costs. Australian stumpages therefore tend to be five times as high as New Zealand's exotic stumpages. As a result, the Australian growers of *Pinus radiata* are able to apply such intensive silviculture as to force converters to saw logs down to a diameter inside bark of 3 inches, as compared with a New Zealand economic minimum of more like six to nine inches. Only in its few integrated plants is New Zealand able to profitably use any large quantity of the smaller material for pulp and paper. Elsewhere the market for posts for preservative treatment is so small as to be insignificant. Likewise, the market for fuelwood is extremely small. Neither market is very remunerative.

No better instance of the influence of prices upon silviculture could be found than in this contrast between New Zealand and Australia. New Zealand, with a huge temporary surplus of exotics, is not only permitting the sale of logs to Japan, but is receiving such a poor return to the forest grower that both re-establishment and further expansion of the exotic resource, as well as the optimum silvicultural management, are threatened by the continued operation of price control and of prejudiced use restrictions. Australia, with an enormous shortage of softwood supplies, necessitating an annual import requirement of 400 million board feet, is able to protect its exotic growers so that the stumpage on their thinnings is five times that for New Zealand clear fellings, thus allowing the optimum of silvicultural management.

Without questioning the general desirability of a policy of economic stabilisation during any war period, it would appear in retrospect as if a more liberal attitude could well have been taken by Government and the price con-

trol authority in the case both of the original base prices and of subsequent price rises. With stumpage as a residual value, the forest grower has suffered the most, and though admittedly it was a shortage of manpower rather than of finance which prohibited silviculture during the war and early post-war periods, there is little doubt that interim strengthening of forest revenues would have ultimately resulted in a more sympathetic approach to such subsequent silviculture as was still practicable. The same effect would have resulted from a more liberal allowance to converters, whether they were sawmillers or pulp and paper manufacturers who were also forest owners. In actual fact, as control has relaxed and profits have increased, so have private forest owners tended to increase their silvicultural activities.

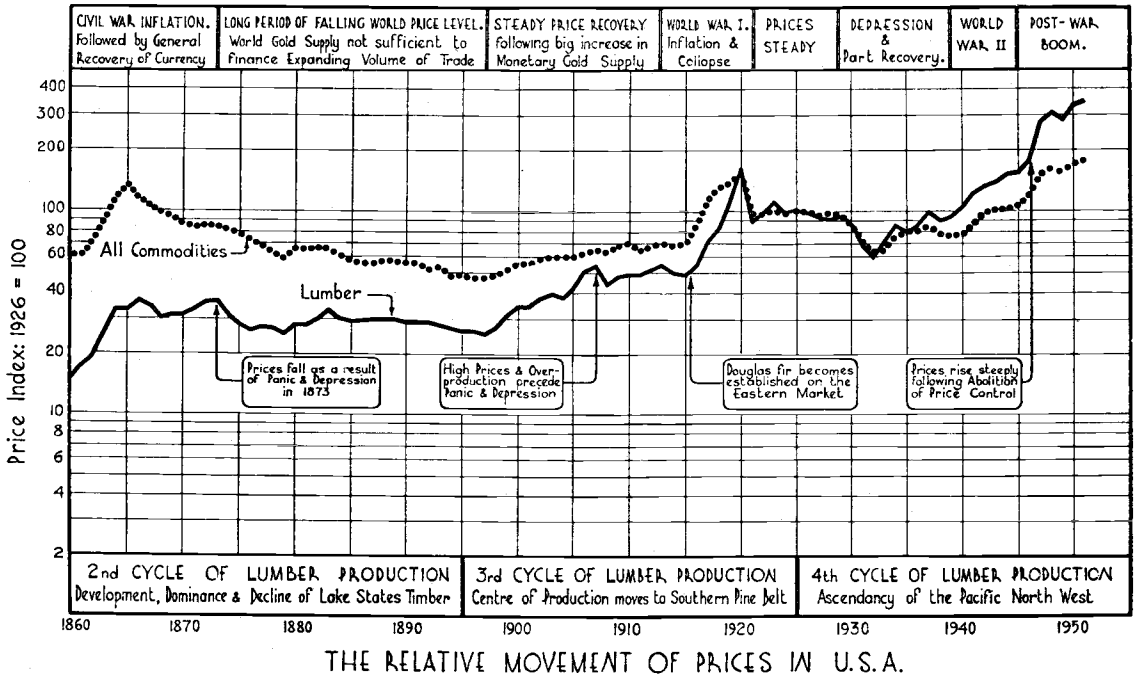
Nevertheless, it is necessary to terminate this section of the report with the inescapable conclusion that had it been possible to apply the correct silviculture as and when it was required from time to time, not only would the incidence of insect and fungal attack in the exotic forests have been trifling, but also the substituting of exotics for indigenous timbers would have occurred automatically through preference of the wood user for the easy drying, treating and working qualities of the defect-free or defect-rare grades yielded by tended stands of general purpose exotic softwoods. It follows that the exotic grower would have received a very much higher stumpage encouraging him to expand his resource and still further intensify his silviculture.

The Influence of Long-term and Short-term Prices on Forestry

In an effort to assure himself of the long-term financial prospects of exotic forestry in New Zealand as a source of supply for the international timber trade, the author ordered in the early post-war period a study of the long-term trend of timber prices relative to the movement of general prices. He wished to test a theory that with the ever-increasing remoteness of high quality virgin softwood lumber supplies as one forest region after another was exploited and exhausted, timber prices must be increasing relative to general prices.

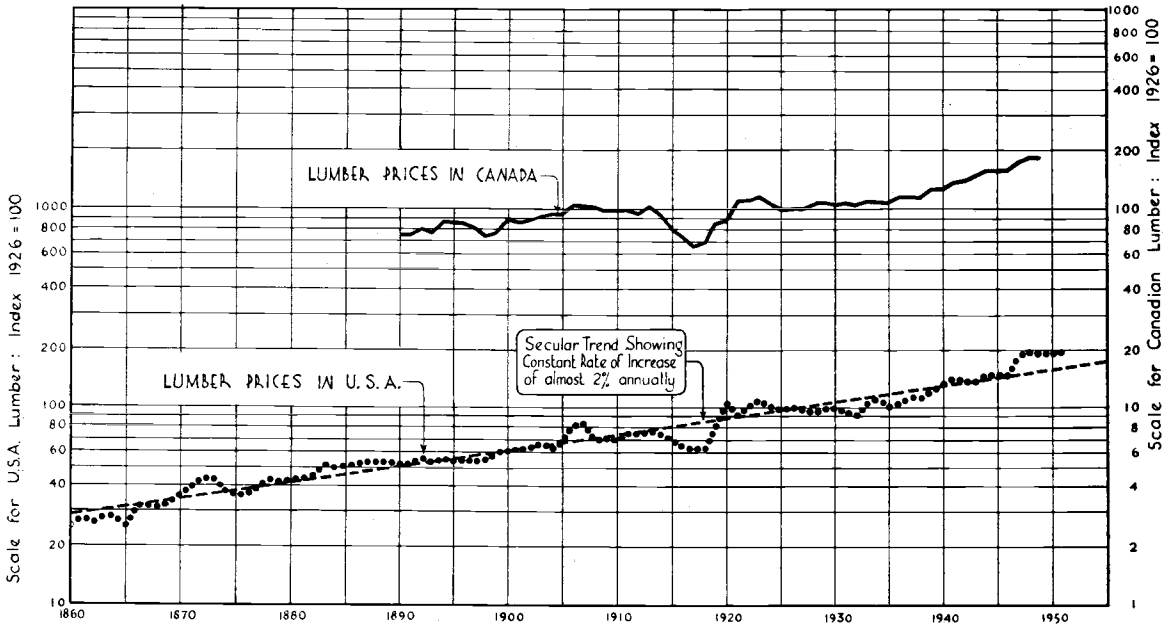
An unpublished departmental report by the Forest Service Economist, Mr. M. B. Grainger, sustained these views, as may be gathered from a study of Diagrams 2, 3 and 4, which are largely self-explanatory. As regards the basic data used for all three graphs, suffice it to say that in each case a relatively homogeneous series was available. It is largely because timber prices in North America have, on a constant currency value, moved upwards with remarkably little fluctuation for nearly a century at a constant rate of almost 2 per cent annually that New Zealand has committed itself to the growing of exotics for the export trade. Exhaustion of the Pacific Northwest resource is in sight, and the Amazon Valley is the only high-quality virgin softwood resource left. The trend is likely not only to continue but eventually to increase.

The New Zealand decision presupposes that the improvement in silviculture which has been effected on State forests and others during the latter years of the post-war period will be continued. There is a full realisation that unless silviculture can finally result in a significant yield of clear and defect-rare grades, participation in world trade is likely to be extremely difficult and unremunerative. Admittedly Diagram 4, based on export values, shows that "real" lumber prices in Sweden have increased annually at an average rate of 0.8 per cent. Even though Scandinavian forests do not yield any significant proportion of defect-free or defect-rare grades, the timber is of extremely high quality in the medium grades, as compared with New Zealand rapidly grown



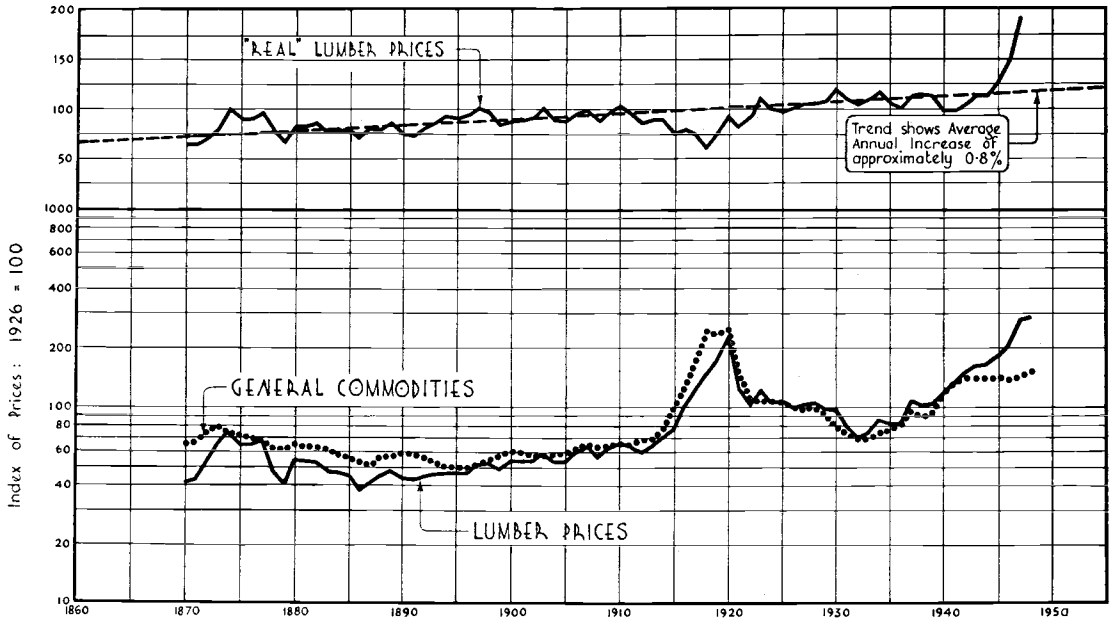
THE RELATIVE MOVEMENT OF PRICES IN U.S.A.

DIAGRAM NO. II



LUMBER PRICES IN NORTH AMERICA CORRECTED FOR FLUCTUATIONS IN CURRENCY VALUES

DIAGRAM NO. III



THE RELATIVE MOVEMENT OF PRICES IN SWEDEN

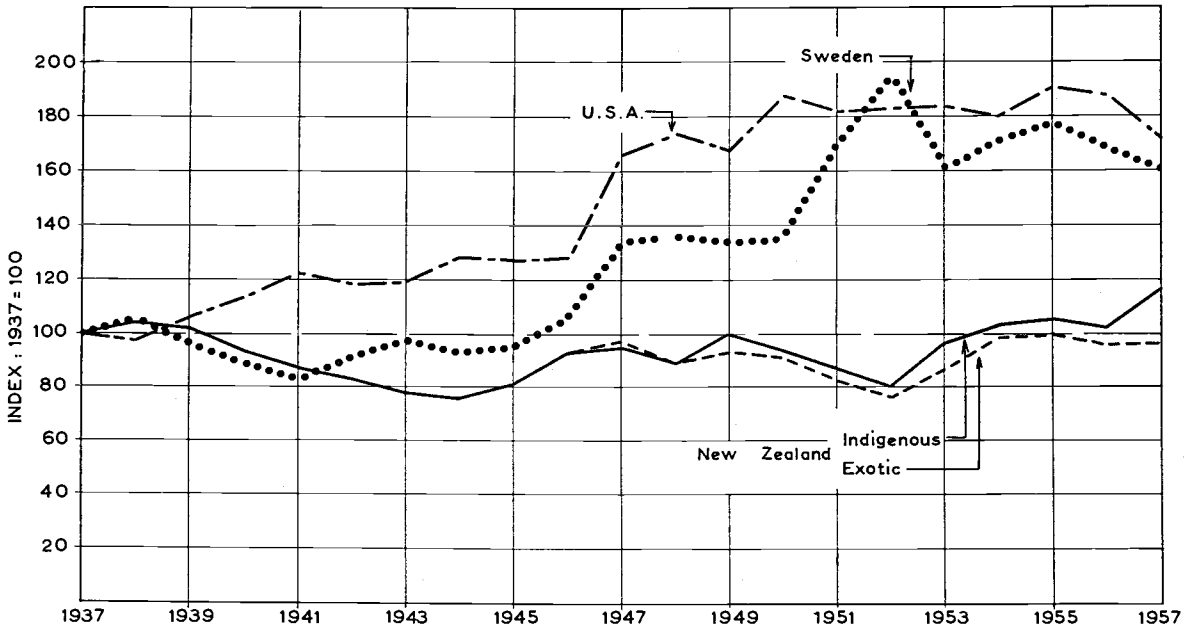
DIAGRAM NO. IV

exotic softwoods. More significantly, Scandinavia is very close to the world markets for such timber.

Experience on the export market to Australia fully confirms these views. There is little doubt that with a significant proportion of clear and defect-rare grades, the exotic export trade could be increased from the current level of 50 to 150 million board feet annually, even to the extent of completely eliminating Scandinavian competition. But it cannot be achieved except by a policy of intensive silviculture, to which the profession must address itself.

If, however, the world trend in timber prices provides a happy augury for those countries contemplating an expansion of their forest resources, whether it be for internal or external trade, it is necessary to ponder the realities of current social and economic developments.

Diagram No. 5 is taken from another unpublished report (1959) by the Forest Service Economist, Mr. M. B. Grainger, on the short-term influence of timber prices on the New Zealand forest economy. It compares the movement of sawn timber prices in New Zealand with those in the U.S.A. and Sweden from 1937 to 1957. As the common basis for comparison is in each case the level of wholesale prices in general (represented by the horizontal line 100), it can be seen that timber prices in the U.S.A. and Sweden have remained over the post-war period at anything from 40 to 90 per cent above the general price level.



TIMBER PRICES (Constant Money Value)

DIAGRAM NO. V

In contrast, the local price for the very high-quality New Zealand indigenous timber in short supply has remained below the general price level for most of the period, and even now is less than 20 per cent above, whilst that for the exotics still remains as it always has, below the general price level. This is, of course, the effect of price control, and effectively demonstrates that however soundly based any forward long-term planning for forest development may be, it is subject short-term to the unforeseen exigencies of war and its resultant social and economic upheavals. The one consolation left to the forester is that all economic laws are inexorable, and that inevitably time will remove the short-term frustrations and allow the fulfilment of long-term plans and eventual attainment of objectives.

It can be stated with confidence that lumber prices on a world wide basis have been rising steadily in relation to the general price level for the greater part of a century. The trend, moreover, is so pronounced, and the exhaustion of virgin softwood forest areas now so well advanced that this appreciation of real lumber prices is certain to continue well into the foreseeable future. Such a trend is fundamental to the future of forestry and silvicultural treatment of the forests. It shows that over long periods there need be no fear that the increasing amount of necessary silviculture will be frustrated because of economic considerations, and it will give assurance to foresters to plan and work to optimum effect.

There is, of course, a school of thought that by disintergrating wood chemically and mechanically for the production of particle or fibreboard in substitution for natural wood products, the silvicultural problems of the forester could be simplified. There have even been claims that thereby the profession would be justified in following a concept of quantity rather than quality production, the principal manifestation of which is the cult of open or widely spaced planting.

It is the author's contention that only by following the concept of quality production can either quantity production be achieved or forest soils be put to the optimum use for the satisfaction of the diverse requirements of mankind. Even though the geneticists are finally able to produce disease-resistant stock to yield inherently good-form trees, the fact remains that only by a relatively high initial stocking can the soil be put to early optimum use. As the stand progresses from stage to stage and as the site finds itself unable to sustain continued growth of all living stems, either deaths must occur or the weaker must be removed by thinning. Followed to an (il)logical extreme, the forester would finish up with the equivalent of Nature's prolific regeneration by either windthrow or fire which are so commonly the origin of the high quality virgin softwood resources of the world.

Obviously, density of stocking must be determined by the two factors of labour costs and utilisation practices. Of all people in the world, it augurs most for those of the

undeveloped countries in which low labour costs can be perfectly integrated with the utilisation of almost miniature-sized stems for fuelwood. At the other end of the spectrum, a still fairly high density of stocking will be justified because of the increasing possibility of integrating chemical utilisation of thinnings with saw timber conversion for the final crop trees.

The strength of the pulp and paper industry in particular, and of disintegrated products in general, in the world forest products economy is largely due to the fact that a significantly large proportion of its raw material is secured as a low-value residue from both forest and sawmilling operations which carry by far the greater part of the cost of both growing and conversion. Had chemical utilisation to carry its full share of growing and conversion costs, its competitive power in the world economy would be significantly lowered. Slowly but surely, however, it is being forced to make a greater contribution to both growing and converting costs. Concurrently, the premium on high-grade over low-grade lumber is increasing, and as the high-quality virgin softwood resources disappear, so will this premium increase.

Because of the relatively low labour, power, plant and investment costs in sawn timber conversion and plywood manufacture, as compared with the relatively high corresponding costs for chemical utilisation, the natural products will forever remain strongly competitive with the chemical products, there being little doubt that combinations of the two classes of product may afford the most economical utilisation of the raw forest material.

Against this background, it is believed that silviculture must remain forever the principal tool of the forester in the economic use both of the forest soils and of their products.

RESUMES

Influence des prix des produits forestiers primaires délivrés sur la sylviculture

Les forêts de Nouvelle-Zélande sont d'origine à la fois indigène et exotique. Les forêts indigènes, autrefois étendues, ont aujourd'hui considérablement diminué, et continuent à diminuer en raison des coupes claires, de la conversion des terres forestières en terres agricoles et d'une exploitation destructrice. Elles fournissent des bois tendres de qualité, dont un pourcentage élevé tombe dans les catégories de bois sans défaut. Leur contribution actuelle au commerce du bois—la moitié environ de la production totale—a tendance à fléchir et continuera de fléchir dans l'avenir en raison de l'épuisement des ressources. La plupart des forêts indigènes se caractérisent par un rythme de croissance extrêmement lent, et par un comportement rebelle à la sylviculture ce qui rend difficile sinon impossible de les soumettre à un régime forestier permanent. Les forêts exotiques représentent un total de plus de 900.000 acres et sont presque entièrement composées de conifères (en peuplements uniformes) d'origine nord-américaine et européenne. Le *Pinus radiata* est l'espèce principale et constitue environ 60% de la superficie totale plantée. L'une des caractéristiques les plus remarquables de ces forêts est la rapidité de leur croissance, le *Pinus radiata* en particulier étant capable de produire un rendement rentable de grumes de sciage par rotations tous les 20 ans.

Environ deux-tiers de ces forêts exotiques (640.000 acres) ont été plantés pendant la période allant de 1925 à 1934. Pendant cette période d'essor, les arbres ont été plantés sur de nombreux sites, à des écartements relativement grands (8 pieds x 8 pieds ou davantage) et le replantage était rare. Les peuplements résultant ont manifesté et manifestent encore une grande diversité quant à la concentration du stock sur pied qui va d'une couverture complète du terrain à des arbres clairsemés à raison de quelques-uns par acre. Il n'y a pratiquement pas eu de travail de sylviculture après le plantage.

Des épidémies mineures d'insectes et de fungi ont attaqué les forêts exotiques à diverses reprises; elle sont essentiellement attribuables à un manque de compatibilité entre le site et l'essence, ou à un affaiblissement des peuplements dû à une surpopulation, découlant elle-même de coupes d'éclaircie insuffisantes. Le taux de mortalité dû à l'attaque du *Sirex* est parfois spectaculaires, mais une mortalité catastrophique due à une cause quelconque ne s'est encore produite que sur de petites superficies insignifiantes.

On peut dire à juste titre que la Nouvelle-Zélande a fait preuve de segesse et d'énergie dans l'établissement d'importantes ressources forestières en essences exotiques destinées à remédier à l'insuffisance des forêts indigènes en voie de disparition et à les remplacer. Mais en comprimant en quelques années ces travaux de plantation, et en négligeant de prendre les mesures sylvicoles qui auraient pu améliorer la qualité du produit fini, on a créé de nombreux problèmes techniques et administratifs. Ces derniers persisteront pendant longtemps encore.

En Nouvelle-Zélande, la vente du bois scié est soumis à un contrôle des prix, le prix maximum étant spécifié et légalement applicable à chaque espèce et à chaque qualité. Il n'existe toutefois pas de contrôle légale applicable aux prix pour les arbres sur pied, les grumes, ou le bois transformé sous forme de pièces menuisées, ou employé pour les habitations, les constructions, etc. A part quelques petites modifications, ce système est en vigueur depuis 1936, et il est fondé sur le fléchissement marqué du niveau des prix qui a eu lieu à cette époque. Il y a 25 ans, la production d'essences exotiques représentait moins d'un huitième de la production totale et la quasi-totalité du bois d'oeuvre utilisé en construction provenait des forêts indigènes. Ainsi, le système de contrôle des prix se fonde sur la production "gratuite" des forêts vierges qui, en dépit de la haute qualité du bois qu'elles fournissent, n'ont jamais représenté pour leurs propriétaires qu'une valeur sur pied négligeable. Les forêts exotiques, passées du stade de la plantation à la maturité sans l'intervention d'un régime forestier quelconque, produisent un bois qui est noueux. En raison de la grande pénurie de bois causée par la guerre, ces bois ont été largement utilisés pendant la Deuxième Guerre mondiale et pendant la période immédiate d'après-guerre. A l'heure actuelle, toutefois, l'offre étant abondante sur le marché intérieur, et les bois indigène sde bonne qualité étant offerts librement à des prix fixés bien au-dessous de leur valeur relative véritable, la demande pour les produits indigènes est naturellement restée la plus importante. Ainsi, malgré le contrôle exercé sur les prix des bois exotiques, peut-on observer chez ces derniers une tendance à se vendre audessous du prix maximum autorisé, avec le résultat inévitable que le propriétaire forestier ne tire qu'un faible revenu de son bois sur pied.

Le propriétaire de forêts exotiques de Nouvelle-Zélande se trouve aux prises avec une situation particulière, voire décourageante. Le pays dispose d'excédents de bois exotiques de qualités partie appartenant pratiquement à la même génération et prête à être récoltée. En règle générale, ces ressources ont depuis longtemps dépassé le stade de développement auquel un traitement sylvicole applicable aurait pu améliorer leur rendement. Elles ont été créées dans les conditions financières les plus favorables—pour leurs propriétaires—c'est-à-dire pendant une période de crise économique où l'on disposait en abondance de terres peu coûteuses et de main d'oeuvre à bas prix. Etablir ou rétablir des forêts semblables à l'heure actuelle exigerait peut-être un capital cinq fois supérieur à celui investi il y a 25 ou 35 ans lorsque les travaux ont été entrepris. Toutefois, des barrières de prix artificiels empêchent les bois indigènes de qualité d'atteindre leur valeur véritable, et restreignent en conséquence le développement et l'utilisation des ressources exotiques. En retour, ceci, signifie des revenus insuffisants pour le propriétaire de forêts exotiques et affaiblit sa position financière dans le domaine de production forestière. Peut-être plus important encore est le fait que la situation actuelle décourage activement les mesures sylvicoles mêmes qui ont été prouvées par l'expérience comme étant d'une nécessité vitale pour la production de bois de qualité et pour l'utilisation optima des terres forestières.

L'expérience de la Nouvelle-Zélande, jusqu'à présent, dans le domaine de l'exploitation des essences exotiques n'a abouti qu'à une déception du point de vue financier, en raison d'une combinaison de facteurs économiques et politiques, et du peu d'atten-

tion accordée à la sylviculture. L'avenir est plus encourageant. Les produits forestiers de qualité deviennent rares, et dans l'avenir il atteindront, par rapport aux bois de qualités inférieures des prix supérieurs à ceux qu'ils rapportent aujourd'hui. Devant ces perspectives, nous sommes convaincus que la sylviculture demeurera toujours l'outil principal du forestier lui permettant de faire une utilisation profitable des terres forestières et de leurs produits.

La Influencia de los Precios de Entrega de los Productos Primarios Forestales en la Silvicultura

El patrimonio forestal de Nueva Zelandia es, a la vez, indígena y éxotico en su origen. Los bosques indígenas, antes muy extensos pero actualmente bastante reducidos, continúan disminuyendo como resultado de las cortas, la conversión de tierras a actividades agrícolas y los daños ocasionados por la explotación. Estos bosques dan maderas blandas de calidad, con un alto porcentaje de materia prima libre de defectos. Su presente aporte al comercio maderero, o sea cerca de la mitad del total de producción, va mostrando tendencias a disminuir y tendrá que reducirse gradualmente en el futuro debido al agotamiento de los recursos. La mayoría de los bosques indígenas se caracteriza por su lento grado de crecimiento y ciertas peculiaridades silvícolas que hacen difícil, por no decir imposible, una administración permanente. Los bosques exóticos representan un total de más de 364 mil hectáreas y se componen casi todos de coníferas (en masas homogéneas), procedentes de la América del Norte y de Europa. La *Pinus radiata* es la especie principal y constituye un 60% del area plantada. Una característica sobresaliente de estos bosques es la rapidez de su crecimiento. El *P. radiata*, especialmente, es capaz de producir un rendimiento económico de trozas en una rotación hasta de no más de 20 años.

Dos terceras partes de estos recursos forestales exóticos (259.000 hectáreas) se establecieron en la década del 1925 al 1934. Durante el apogeo de este período las plantaciones se hicieron en una gran variedad de lugares, se les dió un espaciamiento relativamente amplio, de 2.4 m. por 2.4 m. y rara vez se las aglomeró. Las arboledas crecieron y todavía siguen creciendo con un grado de densidad que varía desde las masas arbóreas más sólidas hasta lugares en que los árboles crecen solamente unos cuanto de ellos por hectárea. Después de plantados, se les dió muy poco cuidado de silvicultura.

En varias ocasiones los bosques exóticos han sido atacados por plagas ligeras de insectos y hongos debidas, en la mayoría de los casos, a que el sitio de plantación no era adecuado o al debilitamiento de la arboleda, causado por la aglomeración y por no haberse realizado operaciones de entresaque. Los daños causados por el *Sirex* son a veces espectaculares; pero casos de mortalidad catastrófica por diversas causas no han ocurrido nada más que en áreas pequeñas e insignificantes.

Quizás haya algunos que digan que Nueva Zelandia dió señales de energía y buen criterio al establecer estos recursos forestales exóticos para suplir la falta y hacer el reemplazo de los bosques indígenas que iban desapareciendo. Pero también es cierto que, como resultado del corto período de tiempo en que se hicieron las plantaciones y de no haberse adoptado medidas silvícolas destinadas a mejorar la calidad del producto final, se crearon muchos problemas técnicos y administrativos que han de persistir por largo tiempo.

En Nueva Zelandia, la madera aserrada y vendida como tal está sujeta a regulación de precios, con un máximo específico y legalmente cotizable para cada especie y grado. Sin embargo, no hay regulación legal de los precios cotizables para árboles en pie, trozas o madera trabajada de piezas de armazón, para casas, edificios, etc. Este sistema ha venido funcionando desde 1936 con ligeras variaciones y se basa en los bajos niveles de precios de aquella época. En aquel tiempo la producción de maderas exóticas apenas si llegaba a una octava parte del total y casi todas las que se usaban entonces en las construcciones provenía de los bosques indígenas. El sistema de regulación de precios se basa, pues, en la producción obtenida de bosques vírgenes "sin costo", que a pesar de la alta calidad de rendimiento maderero, tradicionalmente han dado una recompensa monetaria muy baja a su propietario.

Los bosques exóticos, crecidos desde que se plantaron hasta que llegaron a su madurez sin intervención de la silvicultura, producen madera que tiende a ser característicamente nudosa. Debido a su escasez durante la Segunda Guerra Mundial y el período de la postguerra, esta madera se usó practicamente para todo. Pero ahora, con el mercado nacional bien abastecido, y con maderas indígenas todavía disponibles a precios regulados muy inferiores al relativo valor de éstas, el volumen de la demanda continúa siendo, naturalmente, en favor del producto indígena. De esta forma, aunque el precio de las maderas exóticas está también regulado, la tendencia es a venderlas por menos del máximo permitido, con el inevitable resultado que los propietarios de bosques reciben muy poco por los árboles en pie.

En Nueva Zelandia el propietario de bosques exóticos arrostra una situación peculiar y, quizás, hasta desalentadora. El país tiene un enorme, aunque transitorio, excedente de madera exótica de baja calidad, que incluye una amplia edad-clase y lista para su corta. En general, estos recursos han pasado hace tiempo del estado de desarrollo en que los métodos de silvicultura podrían mejorar la calidad de su rendimiento. Estos bosques se establecieron en lo que eran para sus propietarios las circunstancias financieras más favorables, en una época de crisis económica cuando el precio de la tierra era bajo y había abundancia de mano de obra con jornales muy bajos. Hoy día, el establecimiento o repoblación de esos mismos bosques requeriría, posiblemente, cinco veces más capital del que entonces se invirtió cuando se hizo el trabajo hace 25 o 35 años. Por desgracia, las normas artificiales de precios impiden a las maderas indígenas alcanzar su verdadero precio y ello contribuye a restringir el máximo desarrollo y empleo de los recursos exóticos. Esto, a su vez, significa que el propietario de bosques exóticos recibe utilidades inadecuadas y debilita sus recursos económicos para continuar sus negocios forestales. Quizás, lo más importante es que la situación actual desalienta la adopción de las mismas medidas silvicultoras que la experiencia ha probado vitalmente necesarias para la producción de madera de calidad y para el óptimo empleo de los suelos forestales.

La experiencia adquirida por Nueva Zelandia hasta la fecha en el cultivo de bosques exóticos ha sido pecuniariamente desalentadora debido a los factores económicos y políticos que han intervenido y al abandono en que se tiene a la silvicultura. El futuro parece más halagüeño. Los productos forestales de alta calidad comienzan ya a escasear y en el futuro van a alcanzar un precio mayor que el de los de baja calidad y más alto del actual. Con estos antecedentes, es de creerse que la silvicultura deberá ser siempre el principal instrumento del funcionario forestal en el aprovechamiento económico tanto de los suelos forestales como de sus productos.

The Influence On Silviculture of the Price of Primary Forest Products

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Introduction

It is obvious that there should be a certain relationship between delivered prices of primary forest products and the intensity of silviculture in a country. Insofar as the income from a given forest property has a bearing on the intensity of silviculture it should be observed, however, that this income primarily is made up by the stumpage value realized in cutting, as this is what remains of delivered prices after the cost of cutting and transportation to the place of delivery has been paid. In Sweden as an average the stumpage value will be of about the same order as the cost of bringing the primary forest products to the place of delivery, although of course this cost and, hence, also the stumpage value will vary considerably according to local conditions and also between the different parts of the country, on the whole declining from the south to the north.

By negotiations about delivered prices between the forest industries and the forest owners' associations in Sweden, prices agreed upon refer to river mouth in northern Sweden, where the mills are located, and to truck road or railroad in southern Sweden, irrespective of the distance to a mill. The small forest owners will, to a certain extent, do the cutting and hauling to river bank or truck road from their own forests.

In the following paper the stumpage value will be used in the discussion of the relationship between timber prices and silviculture.

General Remarks

As previously said, it is obvious that there should be a general relationship between silviculture and the stumpage value realized in cutting. Only when the stumpage value is high enough, can the forests be cut irrespective of species and tree sizes in the way best suited to promote silviculture, i.e., to bring about a sustained yield which takes advantage of the productive capacity of the forest site in the most economic manner. The cost of establishing and tending the new stands must be met from the stumpage value obtained in felling. It is therefore only natural that the extent of these activities, and hence to a certain degree the intensity of silviculture, will be dependent on the stumpage value, insofar as the forest owner can supposedly only be willing to dispense with part of the stumpage value to finance silvicultural activities. How large a part he is willing to dispense with will depend on quite a number of factors. One of these should naturally be the profitability which can be calculated, albeit on uncertain grounds. Another important factor is the integration of forestry with other activities of the same owner. In the Scandinavian countries, this is especially the case with agriculture and the forest industries. In most countries the integration of forestry with the national economy has given rise to special forest legislation and supporting measures intended to promote a sustained yield of desired order. Finally, the financial standing of the forest owner and his personal interest in forestry are of great importance. Particularly in private forestry, personal interest is a factor of importance in determining the level of silviculture, which, for this reason, can vary considerably under otherwise identical circumstances. Taxation, rate of interest, and possible inflationary tendencies also play their part, but their effects are difficult to determine more accurately.

Developments in Sweden

The exploitation of the Swedish forests can be traced back for centuries. However, they did not acquire any greater importance until exports rose towards the end of the last century. Owing to the low stumpage value, for a long time only the best specimens of pine for the sawmilling industry could be taken out. As late as the turn of the century the pulp industry could only absorb part of the small trees, which in most cases in northern Sweden had to be left when the forests were exploited. Hereby the stands were opened but yet did not allow enough light for natural regeneration to be possible. Not until the beginning of this century could clearfellings of limited extent be made in Norrland, i.e., the northern part of Sweden, and not until the end of World War II did the considerable rise in stumpage value make it possible to clearfell and replant the residual stands on a large scale.

Behind this development there was also the increased knowledge of the biological conditions of silviculture in Norrland, which had been gained by forestry research, particularly concerning the possibilities of obtaining natural regeneration and of establishing satisfactory plantations under the difficult conditions at high altitude in northern Sweden, where there is a tendency to raw humus formation.

In southern and central Sweden, silviculture developed under more favourable conditions of climate and soil, which facilitated regeneration even at that early stage when only the bigger trees could be cut for the sawmills and for local requirements. But apart from this, the Swedish iron industry with its centre in Mid-Sweden (Bergslagen) provided, from the 17th century, a market even for the smallest trees, which were used for charcoal.

However, the wood which was cut for charcoal did not acquire a stumpage value, as the farmers got the same price for their charcoal whether the wood was cut in their own forests or in the forests reserved for the iron industry. Nevertheless, silviculture in a primitive way was applied at an early stage in these parts of the country, since all timber on clearings of a suitable size could be cut for charcoal. Regeneration was obtained from the surrounding forest or from seed-trees left standing. Owing to the great importance of the iron industry and its dependence on charcoal, it also became necessary to ensure sustained-yield forestry, which was done by regulating the amount of iron produced. We here find an interesting example of silviculture and sustained-yield forestry developing on a large scale, without any stumpage value benefitting the forest owners. What was important for the forest owners, i.e., the farmers, at this early stage, was that they could obtain a cash income by working in the forests, which they could not easily obtain by other means.

The next step in the development of silviculture in southern and central Sweden was the increasing diversion of the wood production to other uses, which gave a stumpage value, first sawlogs and later pulpwood. Charcoal continued to be manufactured from the smallest trees and from broadleaf trees, and hereby thinnings were possible even in young stands which did not yield pulpwood.

After the first world war, when coke and electricity reduced the production of charcoal, silviculture in southern and central Sweden was faced with a grave problem, since it was no longer possible to carry out the early thinnings required by rational silviculture. Although the minimum size of pulpwood has been lowered, sometimes to less than 3″ in diameter at a length of 6′, and although broadleaved trees are now beginning to be used for pulp, the cost of exploitation for the smallest timber is very high, and a market cannot be found for all that should be cut from a silvicultural point of view. Under these circumstances, it has become desirable to adapt silviculture to the changed situation. In order to do this, one tries to establish the new stands in such a manner that they need not be thinned until they have reached pulpwood size. When planting, especially in the case of spruce, the planting espacement is therefore chosen so that pulpwood will be obtainable already at the first thinning at an age of 20-30 years. In the case of natural regeneration and sowing, the young plants are thinned out to the desired espacement when they are a few years old. This is a fairly new development. Earlier, cleanings were made in somewhat older stands, but this makes them considerably more expensive and retards development. However, in some parts of the country the early cleanings in pine must be postponed until the stands have grown out of that stage, during which the moose still may damage the stands through their browsing.

As pulpwood has a stumpage value over practically the whole forest area, except in periods of depression, thinnings are a regular feature in Swedish forestry. Thus the actual problem is regeneration.

In a certain way this is taken care of by the Swedish forest law by which reforestation after cutting was prescribed in 1905. However, there still remains to ascertain what relationship there may exist between stumpage values and the actual extent of regeneration measures. Certain data have been computed from official sources in order to illustrate this matter.

Present Position. The Extent of Regeneration Measures, Corresponding Investments and Relation to Stumpage Value

In Table 1, data have been computed about the extent and cost of the principal regeneration measures, i.e., clearing of brush, scarification and broadcast burning, sowing or planting, and cleaning in seedlings. The total cost for these measures in 1957 was 86.5 million Swedish Crowns*. However, this sum gets its true significance if it is regarded in relation to the stumpage value of the total cut, which for the same year was estimated at 1,350 million Swedish Crowns. It is then seen that the cost of the silvicultural measures mentioned above amounted to 6.4% of the total stumpage value realized in fellings.

However, this proportion varies considerably between the different parts of the country. It is highest in the two northernmost counties (Regions I and II). In other parts of the country, the cost of silviculture in relation to the stumpage value of the fellings is considerably lower.

There are several reasons for this. The northern climate, and the tendency to raw humus formation which this gives rise to, render natural regeneration more difficult and therefore increases the need for measures promoting the latter and for sowing and planting. For the same reason there is a large accumulated need for regeneration measures in these parts of the country. Extensive clearfelling of old thinned-out forests followed by sowing and planting have therefore taken place after the second world war, when the stumpage value, which was previously very low in this part of the country, had improved and made larger expenditures possible. The stumpage value is still considerably lower than in southern Sweden, however. Even if the stumpage value had not risen after the war, it is probable that the need for a sustained yield would have prompted increasing regeneration measures, in any case in the forests of the state and the forest industries, though not to the present extent.

Another way of estimating the extent of silvicultural work, which gives a more direct measure of silvicultural intensity, is to state them in relation to the forest area in various parts of the country. This is done in Table 2, to which the following comments should be made.

Since the rotation period in northernmost Sweden is about twice as long as in southernmost Sweden, i.e., 120-140 years and about 70 years respectively, the need for regeneration measures will consequently be smaller in relation to the forest area in northern than in southern Sweden. If the final cuttings were made entirely as clearfellings, these would make up a total area of about 230,000 hectares, supposing that there is normal distribution between age classes and that the rotation does not comprise any time lag between felling and regeneration. The total extent of sowing and planting in 1957 was only 42 per cent of the above figure. This is because a considerable part of the cut, especially in the farm forests and where the conditions for regeneration are favourable, is made according to the selection method. Otherwise,

*One Swedish Crown is equivalent to 0.19 U. S. $.

Table 1. Regeneration measures in different regions of Sweden in 1957.

Region	Forest area	Brush cleaning		Scarification incl. broadcast burning		Sowing and planting		Cleaning in seedlings		Total cost	Stumpage value of total cut	Total cost in relation to total stumpage
	1,000 ha	1,000 ha	1,000 Sw. Crs.	1,000 ha	1,000 Sw. Crs.	1,000 ha	1,000 Sw. Crs.	1,000 ha	1,000 Sw. Crs.	1,000 Sw. Crs.	Million Sw. Crs.	Per cent
I	4,052	62.13	4,363	11.13	1,573	7.14	2,235	42.17	4,000	12,171	60	20.3
II	3,227	34.13	2,389	16.60	1,968	16.78	5,236	45.10	4,249	13,842	80	17.3
III	4,593	29.08	2,164	10.52	1,126	12.58	4,293	18.64	1,752	9,335	140	6.7
IV	4,717	47.32	3,857	17.13	2,035	20.55	9,198	44.01	5,256	20,346	405	5.0
V	5,333	28.39	2,294	9.77	1,628	32.87	15,131	45.13	5,685	24,738	575	4.3
VI	1,008	5.27	527	1.02	156	8.30	3,998	12.72	1,434	6,115	90	6.8
Totals and average	22,930	206.32	15,594	66.17	8,486	98.22	40,091	207.77	22,376	86,547	1,350	6.4

1 hectare (ha) = 2.471 acres
1 Swedish Crown = 0.19 U.S.$
As for regions, see map.

Brush cleaning is often a preparatory stage in scarification and sowing or planting which means that the total area treated is less than the total of regeneration measures given in the table.

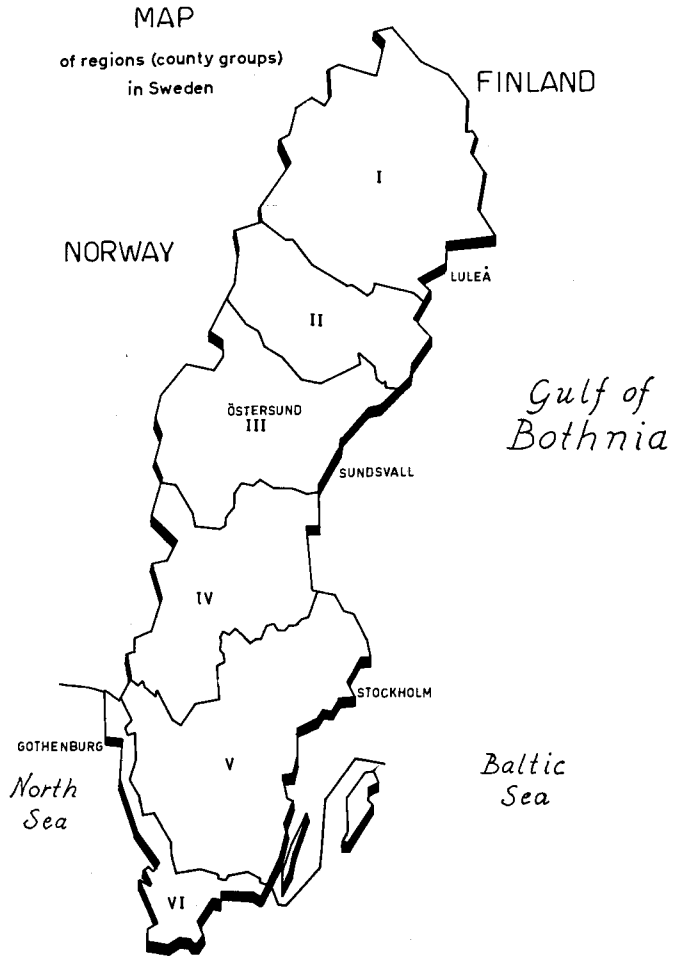
clearfellings with seed-trees or the shelterwood system are still the most common where raw humus formation is not a serious problem, in which case natural regeneration can be counted upon. In these cases, however, it is often necessary to clear the regeneration area of brushwood, and it is therefore natural that this is the measure which has the largest extent. Sowing and planting, which is the most expensive measure, have doubled since before the war, which is probably to a large extent due to the increased stumpage values. On the other hand, the cost of sowing and planting per hectare and also of other regeneration measures has increased considerably more than stumpage values.

The cost of planting in 1957 varied between 300 and 800 Sw. Crowns per hectare, while the cost for sowing was between 200 and 400 Sw. Crowns. The planted area has increased at the expense of the sown for several reasons, one of which is the difficulty of procuring sufficient quantities of good forest seed, particularly in northernmost Sweden. The average cost of brush cleaning for the whole country in 1957 was 80 Sw. Crowns per hectare. Soil preparation is usually done by tractor. The average cost for this operation was 130 Sw. Crowns per hectare.

Table 2. Regeneration measures in relation to the forest area in different regions of Sweden in 1957.

Region	Forest area	Brush cleaning	Scarification, incl. broadcast burning	Sowing and planting	Cleaning in seedlings
	1,000 ha	Percentage of forest area			
I	4,052	1.5	0.3	0.2	1.0
II	3,227	1.1	0.5	0.5	1.4
III	4,593	0.6	0.2	0.3	0.4
IV	4,717	1.0	0.4	0.4	0.9
V	5,333	0.5	0.2	0.6	0.8
VI	1,008	0.5	0.1	0.8	1.3
Total and averages	22,930	0.9	0.3	0.4	0.9

It is also evident from Table 2 that the extent of sowing and planting in relation to productive forest area generally rises from north to south, although with considerable variations which cannot be discussed here. However, it should be noted in this connection that, as previously



mentioned, the rotation period increases towards the north, which means that the need for regeneration measures decreases correspondingly. Against this background, the large extent of the relatively expensive sowing and planting in the county of Västerbotten (Region II) is noteworthy. This can mainly be explained by the great interest in silviculture among the forest owners in this county.

What has been said above has confirmed the, in itself, rather natural state of affairs that the *need* for silvicultural measures is of fundamental importance for their extent. As suggested above, the actual extent will be dependent on a number of factors. Of these, *profitability* should be of special importance.

The Profitability of Silvicultural Measures

It is reasonable to assume that the profitability of silvicultural measures will vary with site quality and stumpage value per cubic metre in various parts of the country. On the other hand, this need not mean that the extent of silvicultural measures in the different parts of the country must vary correspondingly since the extent of silvicultural measures are, as has been shown above, to a large degree dependent on the need for such measures. However, it is of interest to see how costs for the above-mentioned silvicultural measures relate to site quality and stumpage value per cubic metre in different parts of the country, as shown in Table 3. In this table, the comparison has also been made between silvicultural costs per hectare and the stumpage value of the 1957 cut per hectare.

Table 3. Regeneration measures in relation to stumpage values in different regions of Sweden in 1957.

Region	Forest area	Average site class[1]	Total fellings[2]	Stumpage value of fellings		Cost of regeneration measures
	1,000 hectares	m³ per hectare	1,000 m³	Sw. Crs. per m³	Sw. Crs. per hectare	Sw. Crs. per hectare
I	4,052	2.3	3,800	15	14	3
II	3,227	2.8	4,200	19	25	4
III	4,593	3.1	6,600	21	30	2
IV	4,717	3.9	14,600	28	87	4
V	5,333	5.2	19,100	31	111	5
VI	1,008	5.7	3,000	30	89	6
Totals and averages	22,930	3.7	51,300	24	54	4

[1] Theoretical growth capacity (with bark).

[2] In terms of standing timber.

1 m³ = 35,3 cubic feet.

1 Sw. Crown per m³ = 0.54 cent per cubic foot.

1 Sw. Crown per hectare = 7.7 cents per acre.

It is hardly possible to discern any clear relationship between silvicultural costs and stumpage values per cubic metre in different parts of the country. Other factors also play a part. Above all, the work of rehabilitating the forests in the two northernmost counties increases the regeneration work here to an extent higher than that which one would have expected, considering the low profitability in these northern parts.

Other Factors Influencing the Extent of Silviculture

The Integration of Forestry

A closer scrutiny of the profitability of the costs spent on regeneration shows that this is to a large extent lower than the current rate of interest, and also lower than 3 to 4 per cent. This is especially the case in northern Sweden, where stumpage values are low and forest growth slow, but where nevertheless relatively large amounts of money are spent on regeneration.

This is explained by the integration of forestry with other activities, whereby the investments in forestry are judged with regard to their beneficial effects within the integrated undertaking as a whole.

This is especially noticeable in the case of the integration of forestry and forest industry. The effort to ensure raw materials for the expensive establishments, above all in the paper and pulp industries, has had a noticeable effect on silvicultural investments in this group of forests, which comprises a quarter of the country's forest area. As regards the farm forests, which comprise nearly half the country's forest area, and the most fertile and best situated half at that, the timber production has a value over and above the stumpage value insofar as the forest owner has surplus labour, which he cannot use to a greater advantage in agriculture or other gainful activity. It has been said that the advantage of our integration of agriculture and forestry was largely to be found in the possibility of making full use of the agricultural labour force, men as well as draught-animals, during the off-season, namely for the winter fellings. This advantage has diminished as agricultural labour has become scarcer and fellings more mechanized, but it is still to be taken into account. In the same way, it can be said that the regeneration measures can be carried out by the small forest owners themselves, whereby costs will be less important. The extent to which these possibilities are actually taken advantage of, insofar as they really exist, varies considerably according to the interest of the forest owner in forestry, and for other reasons.

According to their statutes, the state forests shall be managed "so as to ensure the highest yield in money compatible with a sustained and, as far as possible, even yield." The application of this has resulted in large investments in regeneration work, especially in northern Sweden, where the main part of the state forests are situated. However, these investments must also be regarded as part of a general policy to provide employment for the population in this part of the country where industries other than those dependent on the forests are little developed.

Ultimately, forestry plays an important part in the national economy of the Scandinavian countries. A reduction in the forest yield would thus have serious consequences. The general forest policy has therefore been to prevent this through a forest legislation which, in the case of Sweden, has made it compulsory since 1905 for forest owners to ensure satisfactory regeneration after felling. Since 1923, felling of "young" forests has likewise been prohibited except in the form of suitable thin-

nings. But the government has also tried to bring about a further rise in the sustained yield from the forests of the country. This has mainly been done through the County Forestry Boards, which have been active since 1905. These have helped with advice and instruction; they have organised training courses for forest owners and placed professional staff at their disposal. This has contributed in a decisive way to the creation of an interest for silviculture among these forest owners, who do not have as strong motives for investments in silviculture as the companies and the state, and who also have a shorter range of view.

The question of the standard of silviculture among different groups of forest owners has been the subject of much discussion in Sweden. It has long been maintained that the farm forests are not as well managed as the state and company forests, although they are better situated, more fertile, and with higher stumpage values, especially when compared to the state forests. This was certainly the case formerly. Through the activity of the County Forestry Boards, in combination with rising stumpage values and the progress in all lines of forestry, there has been a marked improvement in silviculture in the farm forests, although it is not possible to say which part the rising stumpage values and other factors have had in this development.

On account of the great public interest in keeping up the yield from the forests, certain data about the standard of silviculture have been collected at our last national forest inventories. Besides information on the above-mentioned measures, information has been collected on the extent of thinnings and on the volume and composition of the standing timber on the forest area belonging to different owner groups. A recent analysis of this information shows that there is usually no considerable difference concerning the extent of silvicultural measures or the size and composition of the growing stock between the different groups of forest owners in the same part of the country, when due consideration is taken to variations in site class and other relevant factors, and that the averages for the country as a whole vary even less from group to group.

Other factors which influence investments in forestry and hence the standard of silviculture are taxation, rate of interest, and the apprehension of inflation, which has been particularly pronounced after the second world war. It is not necessary to go into details concerning their effects. What is important is that these factors, too, more or less overshadow the relation between stumpage value and the standard of silviculture. A certain, not too low, stumpage value seems, however, to be a fundamental prerequisite for the ability and willingness to make the sacrifices which are necessary to maintain the forest production at a level considered compatible with good silviculture.

Influence of Expected Future Prices on Silviculture

Logically, it is the expected future stumpage values which should be used in the investment calculations of the forest owners regarding measures aimed at increasing the yield of the forest. As far as profitability influences the investments of the forest owners, their opinion regarding future stumpage values should therefore be of importance.

The classical expression of the importance of future stumpage values for the calculation of the profitability of investments in forestry is provided by the soil rent theory. The advocates of this theory considered that one should use a lower-than-normal rate of interest for investment calculations in forestry, partly because of an expected rise in the price of forest products relative to other prices. Only hereby could the calculations justify the costs connected with reforestation and retention of the long rotation periods which were considered part of rational forestry, as it was practised under professional guidance in state and estate forests in Germany.

It is evidently not possible to forecast today with any certainty the future development as regards the price of forest products and stumpage values. In Sweden, as well as in other countries, these prices and stumpage values have risen continually in relation to other prices ever since a stumpage value arose in our forests. This increase in stumpage value has been very varied for different assortments (sawlogs and pulpwood, etc.) and in different parts of the country. It has, however, caused a general belief in continued increase in the price of forest products and in stumpage values, although one can, of course, not form a true notion of its size. In any case, one does not count with a long-range decrease in stumpage values. This, in itself, tends to create a confidence in long-term investments in forestry, including silviculture.

With regard to the uncertain opinions about a continued rise in stumpage values and the importance hereof for the attitude of the forest owners towards silviculture, it is of interest to study this question against the background of what has been said above about the attitude of different groups of forest owners towards investments in forestry.

For the state as forest owner, the essential thing is to ensure the future of the forest industries and of those sections of the national economy dependent on them, by maintaining a sustained yield. In comparison herewith it should be of secondary importance, which share the stumpage value has of that part of the national income which one intends to secure. It is another matter, that the possibilities of the state forests to finance silvicultural investments in the future as well as in the past, must be dependent on the income, which in its turn is determined by the stumpage value.

Concerning investments in silviculture by the forest industries, it has already been mentioned that these are intended to ensure the future raw material supply of the industry. They should consequently not be regarded as investments primarily made with a view to profitability. What is important from the industry's point of view is to obtain a maximum quantity of raw material for the sum allocated to forestry, with due account taken to the period in which it may be available. Under these circumstances, the future stumpage value should be regarded as of less importance. However, even in this case the stumpage value will be of importance for financing silvicultural costs.

Finally, as regards farm forestry, it has already been mentioned that its range of view is shorter than that of the two other groups of forest owners. For this group the

uncertain prospect of a future increase in stumpage value is probably of minor importance. On the other hand, these forest owners are probably particularly keen to know, or to believe that they know, that money invested in forestry is at least as safe as if it had been invested in the savings bank, which besides agriculture is the main alternative investment for this group.

Insofar as the above is correct, it would mean that the more or less vague expectations of a reasonable increase in future stumpage values relative to other prices does not have any appreciable importance for investments intended to bring about a further increase in forest production. What is important, particularly for farm forest owners, seems to be that present values of forest products will not diminish. To a certain extent the same can be said of other forest owners insofar as they consider this to confirm that the greater values, which they are trying to ensure by investments in forestry, will maintain their relative value as a source of income and employment.

It remains to be said that the stumpage values given above are not representative for the yield from forests managed at the present standard of silviculture, neither in the case of stumpage realized per hectare, nor per cubic metre, as the future yield can be expected to be considerably higher. The desire to improve the yield of the forests of the future, in timber as well as in value, undoubtedly also has a bearing on the investments in silviculture in this country.

RESUMES

Influence du prix des produits forestiers primaires sur la sylviculture

Il est évident qu'il devrait exister un certain rapport entre les prix des produits forestiers primaires livrés et le niveau de la sylviculture d'un pays. Dans la mesure où le revenu d'une propriété forestière donnée exerce une influence sur l'état de la sylviculture, il devrait y avoir un rapport plus étroit encore entre la valeur du bois sur pied et la sylviculture. Ceci posé, le document présenté sur cette question traite de ce dernier rapport.

En suède, comme dans d'autres pays, c'est seulement progressivement que les forêts ont une valeur due à leurs réserves sur pied, et ceci essentiellement grâce à l'augmentation des exportations de bois scié et, depuis le début du siècle, de pâte de bois et de papier. Il en découle que pendant longtemps la méthode d'abattage la plus couramment pratiquée en Suède était celle de la coupe sélective avec certaines limites de diamètre et des exigences décroissantes quant à la dimension et à la qualité des grumes. Du point de vue forestier, cette manière de faire convenait moins bien à la régenération des forêts, particulièrement dans le nord de la Suede et à des altitudes elevées, où il existe une tendance à la formation d'humas brut.

Depuis le début du XXème siècle le besoin croissant de couper à blanc les arbres utilisés pour la fabrication de la pâte ou par le système d'arbres porte-graines ou coupes d'ensemencement, a généralisé l'usage de méthodes de coupes plus sélectionées lorsque les conditions naturelles ne sont pas contraires à la régénération naturelle. Dans de tels cas il faut faire suivre la coupe à blanc de semis ou de plantation. Ceci s'applique particulièrement dans le cas de terres forestières déjà coupées, ayant un peuplement éspacé telles qu'on en trouve dans le nord de la Suède, lorsque la régénération naturelle n'a pas réussi.

L'un des problèmes les plus sérieux de la sylviculture suèdoise à l'heure actuelle est le fait qu'il n'y a pas de marché pour les arbres de taille trop réduite pour servir à la fabrication de pâte, arbres de 3 ou 4 pouces de diamètre à hauteur de poitrine, et ce problème est d'autant plus sérieux que recemment l'écoulement de ce type de bois vers l'industrie du charbon de bois que l'on utilisait en sidérurgie s'est ralenti. Ceci empêche de procéder aux éclaircíes que l'on considère généralement souhaitables si elles n'entraînent pas de pertes financières. On s'efforce d'adapter la sylviculture à cet état de choses en ménageant de plus grands écartements au moment des semis et des plantations, de manière que les éclarcies soient immédiatement productives en bois à pâte. On arrive à des résultats semblables en éclaircissant les parcelles ensemencées et les repousses naturelles pour maintenir un écartement approprié.

Du fait que les arbres à bois de pâte ont une valeur sur pied dans la quasi-totalité des forêts de Suède, les éclaircies constituent un travail régulier de la sylviculture de ce pays. Le vrai problème est donc celui de la régénération.

Ce problème est résolu dans une certaine mesure par la loi forestière suédoise qui prévoit un reboisement après chaque coupe. Il faut toutefois encore déterminer le rapport existant entre les valeurs sur pied et l'ampleur des mesures de régénération. On a procédé à certains calculs pour illustrer ce point à l'aide de données concrètes.

Ces calculs font apparaître que contrairement aux prévisions c'est dans le nord de la Suède que les mesures de régénération ont été les plus importantes par rapport à la valeur sur pied. Alors que le coût total moyen de ces mesures pour l'ensemble de la Suède représentait 6,4% de la valeur totale du bois coupé en 1957, ce pourcentage était de l'ordre de 17 à 20% respectivement dans les deux comtés de l'extrême nord. L'une des raisons de cet état de choses semble être la difficulté qu'il y a à obtenir une régénération naturelle dans l'extrême nord du pays, ce qui explique également l'abondance de vielles terres forestiers destructivement coupees et qui ont besoin d'etre coupees a blanc et reboisees. De telles mesures ont ete appliquées sur une vaste échelle après la Deuxième guerre mondiale, lorsque l'augmentation des prix du bois sur pied en a facilité le financement, bien que du strict point de vue des investissements cette opération ne soit pas encore rentable.

L'intégration de la sylviculture aux grosses industries forestières, notamment celles de la pâte et du papier, justifie davantage encore que l'on consacre à la régénération des investissements qui dépassent les limites apparentes de la stricte rentabilité, ainsi que les dispositions de la loi forestière dans ces deux comtés et dans d'autres régions. Les forêts domaniales ont également ouvert la voie à cet égard, fait d'autant plus significatif que la plupart d'entre elles se trouvent dans le nord. Ajoutons que les propriétés forestières se conforment assez bien aux directives des Conseils forestiers de comtés.

Quant à l'augmentation éventuelle des valeurs sur pied, elle semble exercer peu d'influence sur les investissements consacrés à la régénération, effectués par les groupes de propriétaires forestiers mentionnés plus haut.

Influencia en la Silvicultura de los Precios de Entrega de Productos Forestales Primarios

Es indudable que debe existir cierta relación entre los precios de entrega de los productos forestales primarios y la posición relativa de la silvicultura de un país. Tomando en consideración que los ingresos provenientes de una propiedad forestal determinada afectan directamente la posición de la silvicultura, esta relación tiene que ser evidente aún más entre el valor de la madera obtenida y la silvicultura. Siendo este el caso, el trabajo que se presenta sobre esta materia se refiere a dicha relación.

En Suecia, así como en otros países, los bosques fueron valorizándose en forma muy gradual, principalmente a raíz del aumento de las exportaciones de maderas aserradas, y desde principios del corriente siglo también cobró impulso la venta de pulpa de madera y de papel. A través de los años, tal explotación intensiva determinó que disminuyeran en Suecia las exigencias referentes a límites mínimos de diámetro y a la calidad de las trozas producidas. Desde el punto de vista de la silvicultura, este sistema resultaba menos ventajoso para la reforestación de los bosques, especialmente en el Norte de Suecia y en las regiones de mayor altitud que tienen una marcada tendencia de formación de nuevas capas de humus.

Durante el siglo actual, debido a la creciente demanda de pulpa de madera, en lugares en que no resultan adversas las condiciones para reforestación natural, se adopta generalmente el sistema de corto única con árboles portagranos o el método de corta' de abrigo, además de métodos más racionales para el corte de selección. En tales casos, debe recurrirse al sistema de corte total, y a la siembra o plantación posterior. Este es especialmente el caso en tierras forestales explotadas previamente que han

quedado descubiertas en el norte de Suecia cuando la reforestación natural no produjo resultados satisfactorios.

En la actualidad, la falta de mercados para árboles de tamaño menor al requerido para la elaboración de pulpa, o sea de un diámetro de 3 a 4 pulgadas a la altura del pecho, constituye un problema grave para la silvicultura sueca. Ello debe atribuirse, en gran parte, a la declinación del mercado que anteriormente existía para este tipo de madera, que se usaba para producir carbón destinado a la industria siderúrgica. Esta circunstancia determina que resulte más difícil realizar trabajos de entresaca de árboles jóvenes, que por lo general se considera conveniente, sin sufrir pérdidas de carácter económico. Se ha tratado de adaptar la silvicultura a esta condición, dejando mayor espacio entre una y otra planta de manera que aun los primeros trabajos de entresaca rindan madera para pulpa. Iguales resultados se logran entresacando plantas en semilleros naturales y dejando espacio adecuado cuando se trate de reforestación natural.

Como la madera para pulpa tiene valor predominante en prácticamente toda la zona forestal de Suecia, las operaciones de entresaca son corrientes en la silvicultura de este país. Por lo tanto, el problema real es la regeneración.

Hasta cierto punto, este problema es resuelto por la Ley Forestal Sueca que desde 1905 establece que después del corte de los árboles debe procederse a la reforestación. Sin embargo, todavía debe determinarse la relación que existe entre el valor de la madera y el alcance real de los métodos de reforestación. Para ilustrar este tema se procedió al cómputo de ciertos datos informativos pertinentes.

Del estudio de estos cómputos surge que, contrariamente con lo que podría suponerse, estas medidas de reforestación son el factor más importante en lo que respecta a los valores de la madera en las regiones septentrionales de Suecia. Mientras que, como promedio general para todo el país, el costo total de estas medidas ascendió al 6,4 por ciento del valor total de toda la madera explotada en 1957, el porcentaje osciló entre el 17 y el 20 por ciento respectivamente, en los dos distritos más septentrionales. Se considera que uno de los motivos principales para que esto ocurra es la dificultad de lograr la reforestación natural en esta región del país, donde se encuentran bosques cuyos árboles se fueron cortando en el transcurso de los años y que, por lo tanto, han llegado a un punto en que se debe proceder a su corte total y a la reforestación. Estas medidas comenzaron a aplicarse en gran escala después de la Segunda Guerra Mundial, debido a que el aumento de los precios de la madera permitió costear con mayor facilidad los gastos de producción, aún cuando, desde el punto de vista de una inversión, esta práctica todavía no resulta provechosa.

Un motivo adicional importante para que se intensifiquen estas prácticas de reforestación más allá del límite aparente de su justificación económica y también en exceso de lo que exige la ley forestal, tanto en éstas como en otras regiones del país, puede atribuirse a la integración de la silvicultura con las grandes industrias forestales, especialmente las compañías manufactureras de pulpa y de papel. Los bosques estatales también presentan una tendencia similar lo que es muy significativo ya que la mayor parte de estos bosques esta situada en el norte del país. Los bosques administrados, con la orientación de las Comisiones Forestales de Distritos, también han adoptado normas similares.

En lo que respecta a la importancia que un aumento en el valor de la madera pudiera tener en el futuro, se estima que no influirá mayormente en las inversiones destinadas a reforestación por parte de ninguno de los grupos de propietarios forestales antes mencionados.

New Methods of Improving Stand Composition In Tropical Forests

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Tropical stand improvement is just about a century old. It began in India seventy-two years ago and appeared as a detailed technique in the first textbook on tropical forestry ever published (Fernandez, 1888).

The early efforts were, naturally, attempts to apply European (mostly German) methods to something very different, much hampered by lack of statistical science and chemical weeding which are so essential today. The principal difficulties encountered by European foresters in the tropics are:

1. Great botanical diversity leading to a high proportion of useless species, co-mingling of weeds and desirables within numerous genera and families, all of which confuses sampling (especially aerial), hinders refining and usually prevents integrated utilisation. The demand is generally limited to a very few timber species, thinnings are usually unsaleable, forest policy is therefore often weak, and public opinion hostile;
2. Lack of growth rings, except well away from the equator, gross deformities of bole, enormous differences of growth rate, frequently shedding bark and, therefore, marks, near impossibility of heighting and relascope work, all of which together make a nightmare of mensurational control and particularly of repeated inventory;
3. Dearth of operatives with silvicultural discretion and mensurational reliability in any underdeveloped country, until it has seen a century or so of social evolution and forest education;
4. Difficulty of mechanisation; aerial weed-killer spraying is of little use without intra-generic selectivity; power girdling would commonly be ineffective without poison and for that only very small cuts are required; paint guns are useless on exfoliating bark; trees are often of sizes that make mechanical felling and subsequent clearing quite impracticable;
5. Intrinsic inefficiency of most tropical angiosperms as wood producers, compared to the conifers or eucalypts which these regions usually lack. Diameter increment is sometimes phenomenal, but treespace must be vast to achieve it, making total final stocking low by temperate standards.

Faced with these difficulties, the tropical foresters look wistfully but not very hopefully at other recent advances in forestry, such as aerial and relascopic inventory, complete and integrated utilisation, aerial seeding and spray-

ing. Let us admit that we have discovered no new tools or methods of stand improvement since the Fourth Congress at Dehra Dun. The greatest real advances took place in two spurts of activity for a decade after each war, since when there has been plenty of news in the way of management systems, sampling, repeated inventory and stand-structure, but no fundamentally new ideas on stand improvement itself.

Improved applications, if not new methods have occurred in:

(1) refining,
(2) enrichment,
(3) felling systems,
(4) diagnostic sampling,
(5) dynamic sampling.

Tropical Forest Refining

The term is used in its strict dictionary sense; namely, the removal of impurities from a mixture, the impurities being mostly weed-trees, climbers, and shrubs.

Foresters faced with the very mixed natural stands of India and Burma naturally sought to remove the useless species and defective trees, and to favour the desirable elements. Thus arose the well-known *improvement fellings* of Southern Asia, prescribed along with "selection" systems in numerous working plans, and covering very large areas before this century started.

Fellings gave way to girdlings wherever the fuel demand was low, for several reasons, including the cheaper kill, lesser damage from falling crowns, and more gradual opening thereby achieved. In areas of very high demand it was generally feasible to clear-fell and sell all produce and replace with pure crops—natural or planted—so that refining did not arise.

India paid very little attention to refining of the "wet evergreen" (i.e., tropical rain) forest, and it fell principally to Malaya to wrestle with that hellish pair:

1. the vitality of rain-forest weed-trees which laugh at mere girdling,
2. the vigour of climbers and shrubs after drastic canopy opening,

as well, of course, as the even worse felling damage caused by the crowns of large rain-forest trees.

Hence, the introduction during the twenty years interbellum of arsenical poison-girdling into Malaya, (Sanger-Davies, 1919). Queenslanders had been using the method to clear grazing land since the turn of the century, and by the 1930's Malaya came to realise that here lay the essential tool for all systems of rain-forest improvement. Refining, liberation, thinning, all became practicable and, by the second war, were proceeding ahead at thousands of hectares per year, and were spreading to other areas of managed forest.

Some objections however remained; arsenic's dangerous toxicity, the near-impossibility of frilling certain *Ficus* species and other multiple or grossly fluted undesirables, immunity to arsenic of certain legumes and Annonaceae, especially in Africa. Hence, research into hormonal arboricides (2,4,5-T and 2,4-D), by Uganda, where the above objections are particularly cogent.

The hormonal arboricides (weedkillers, if you like, but *not* "silvicides," which is literally incorrect and forest-morally objectionable) may be poured into frills like sodium arsenite but are often lethal when sprayed as esters in diesel solution on to uncut bark, hence the term "contact arboricides." It is the latter type of application which has proved most valuable.

Objections still remain (Dawkins, 1957). Both solvent and solute are more expensive than sodium arsenite, and so are sprayers more expensive and more difficult to maintain than spout cans. Also, thick bark may defeat the penetrant, and some species are physiologically resistant. Therefore, even in localities where hormonal arboricides are favoured, methods could still be greatly improved by phytotoxins of greater penetrating power or lesser cost.

Weed-trees are not the most difficult. Far more baffling have been the dense blankets of climbers, often thorny, stinging, or otherwise obnoxious, which arise after heavy felling or violent refining or liberation. The dilemma is whether to:

1. slash or otherwise tend frequently in the hope of liberating regeneration, or
2. leave alone in the hope that sufficient desirables will eventually get through.

Malaya first discovered that crops inadvertently treated to (2) and neglected for six years or more produced remarkably healthy young trees in spite of thicket and climbers, which appeared to be a passing phase suffering eventual defeat by trees and taller shrubs. Later Nigeria, using method (1), found repeated slashing not only impossibly expensive but definitely rejuvenating to the climber tangle. Tendings were therefore progressively reduced and now converge with Malayan ideas (Barnard, 1955).

Thus has arisen one great advance of the last decade, the realisation that climber-tangle is frequently a temporary horror and is commonly defeated within three to seven years by trees or shrubs or both. The resulting thicket becomes increasingly susceptible to climber-cutting and tree refining, because some degree of tree-and-shrub canopy develops, and severed climbers cannot regain full vigour under it. Limited areas still exist, particularly in West Africa and North Borneo, where climber-tangle still reigns supreme. It is significant that in such areas repeated slashing is now in disfavour, on the grounds that it makes matters worse, and attention is now directed to prevention of origin and spread rather than belated cure. It has also been pointed out, optimistically perhaps, that climbers generally fruit in the canopy, and, therefore, sufficient attention to forest refining over the years should eventually deprive the climbers of their seedfall. Perhaps that will be the next significant advance in the THF (Tropical Hardwood Forestry), because the liane kingdom is undoubtedly its greatest drawback at the present day.

Enrichment

Refining is applicable only to a mixture already containing adequate desirable ingredients. Where these are lacking in an environment that yet appears suitable, it is often possible to enrich the community by inducing more regeneration or by sowing or planting, sufficient eventually to take over the site but probably inadequate to dominate at the start. It is still considered good silvicul-

ture to try the former first and to use "artificial" means only where natural fails.

In regeneration methods, the recent advances have been mensurational rather than silvicultural: firstly, in how many plants are needed; secondly, in how their development may be measured and judged (this latter part will be described later under Diagnostic and Dynamic Sampling).

Pre-occupation with de Liocourt's curve and single or few-species European forests led and still leads foresters to require literally thousands of seedlings or saplings per hectare to produce the relatively few trees needed at maturity. Two recent tendencies have caused a swing away from these requirements.

Firstly, experimental work in Queensland (Haley, 1954) and observations in Malaya (Barnard, 1954; Cousens, 1958) have shown that rain-forest trees cannot tolerate more than eighteen to twenty-five square metres basal area per hectare (depending on site) if they are to grow reasonably fast towards healthy maturity. Thus only 35 to 50 eight-foot-girth timber trees can mature on one hectare, and it is futile to try to raise more (Dawkins, 1959).

Secondly, it is being realised that, as most regenerated crops are mixed weed and desirable, the heavy casualties which result in a decreasing population *a la* de Liocourt can, by proper tending, be concentrated on to the undesirable element. Thus, if the desirables are even mildly aggressive light-demanders a relatively small number of saplings is sufficient to stock the forest. Only where the principal desirables are slow-growing shade-bearers is it still difficult to be content without a carpet of seedlings or a thicket of saplings. And in such areas there is a strong school of thought which would prefer to grow another species of lower immediate per-cube worth but of greater aggressiveness and therefore of greater ultimate economic benefit.

There is, therefore, now a growing tendency to count about a hundred sapling or pole-size desirables per hectare as a "full stocking," provided they are entirely liberated from undesirable competition and face no hazards except, perhaps, lightning and gale-force winds.

By Natural Regeneration

Current systems can be divided fairly sharply into two, depending on the regenerative power and stand-curves of the natural forest:

1. positive stand-curve (de Liocourt type) with adequate juveniles; or negative with inadequate juveniles but ready inducement by felling or post-exploitation treatment.
2. negative stand-curve with inadequate juveniles, no inducement by felling, and therefore regeneration must be obtained before felling.

The first is naturally the easiest. In Queensland rain-forest (Haley, 1954) and in much of the deciduous woodlands of India, Burma, and Africa, selection systems operate with continuous regeneration, requiring only liberation or fire-protection for survival and growth. In Nigeria, Ghana, Andamans, the "miombo" of Africa, Trinidad, Uganda, and Malaya, we have all variations from a shelterwood system with a five-year pre-felling regeneration promotion period, through clear-felling with immediate tending, to delay of tending of up to five years after felling with no previous silvicultural work whatever. There is no doubt, for the sake of certain critics in tropical Africa, that all these countries have had tremendous success over part if not most of the appropriate areas.

Regeneration type (2) is more difficult, and the writer doubts if any success has been obtained except where some—often little—regeneration already existed to imply that favourable conditions do occasionally occur naturally. For instance, Queensland, West and Central Africa, and British Honduras have obtained dense seedling regeneration in small areas limited to the vicinity of seed-trees. Such a technique is generally applicable only to species of top-rank "cabinet" value.

Where desirable juveniles are entirely absent, the foresters have generally been forced to plant or sow, often after years of failure to induce natural regeneration or to tend it for a reasonable cost.

By Planting

Where natural regeneration has failed, or is mistrusted, or has never seriously been considered, innumerable variations of diffuse planting have been tried. By far the most successful is line-planting, which simplifies the problem of tending and access by close spacing along cleared corridors which are themselves at full final-crop spacing or more. All variations from 1 m. x 10 m. to 3 m. x 20 m. have been used with success. The technique is fast developing and, although no fundamentally new techniques have arisen recently, considerable clarification of principles (Foury, 1956) has occurred, for instance:

1. Spacing must be close along the lines to give a wide choice of final crop and a relatively low cost of maintenance per plan.
2. Lines are best orientated east-west for maximum sunshine.
3. Only vigorous light-demanders are worth using; slow growers cannot be promoted in the matrix of fast-growing climbers and shrubs which spring up along the corridors.
4. The forest should be fully exploited with no further large trees to come out.
5. The method is unsuitable if large wildlife is common. Elephant, buffalo, and larger antelope can easily wreck such schemes altogether, and have often done so.
6. It is easy to underestimate the effect of overhead and lateral shade, and competition from the deep and wide roots of any large trees which may remain after felling. There is a common fallacy that rain-forest trees are shallow rooted. In fact, they may be extremely deep on raised sites and, together with their wide spread, are a menace to planted trees until de-activated by girdling or poisoning.
7. The point has been made that once the plants are established, the whole forest area should be treated just as if naturally regenerated and therefore tended throughout, not merely along the lines. Thus linear establishment may be sound, but linear tending becomes unsound long before the crop begins to occupy the whole site.

If Queensland leads tropical selection rain-forest, and Malaya the uniform, then French-speaking Western Africa leads enrichment by line-planting. Thousands of

hectares of highly successful *Terminalia, Tarrietia, Aucoumea* and others are rising to maturity in line-plantings in Gabon, the Côte d'Ivoire and the Congo. On the other hand, the method has been abandoned in some parts owing to depredations of wildlife—mainly elephant and buffalo—in favour of more concentrated and dependable close-planting or less vulnerable natural regeneration.

In some areas there is a conflict between wildlife and forest conservation, and only three roads are open. Reduce the wildlife, reduce the forests (as timber producers), or seek tree species that the animals dislike. Uganda is on to all three methods in appropriate areas, but is concentrating on the third alternative if the wildlife population can be kept below a certain, as yet unknown, limiting density.

Felling Systems

Perhaps the greatest recent advance in tropical stand improvement has been the realisation of the quantitative effect of different felling systems.

Most tropical forests were opened up on a polycyclic* system often called "selection" but better "girth-limit," by which all desirables over a certain minimum girth were felled at each cycle. That girth was fixed high to insure against over-cutting and, in theory at least, left the forests in a state sufficiently valuable to be exploited again when their silviculture should be better known. The trees just below girth-limit were generally healthy-looking and if not fast growing then, again theoretically, accelerable by the felling itself with or without further liberation.

Several factors have caused a swing of thought away from the crude girth-limit system towards either true selection or monocyclic felling.

One factor was eugenic and hygienic. Some foresters realised that the girth-limit system would rapidly remove all the fastest-growing individuals of a given species, leaving the slow or stagnant as a permanent drag on the crop (Champion, 1936). Without the European method in selection forest, whereby thinnings remove slow growers of all sizes (which is impossible without periodic inspection and marking of each tree by skilled foresters), the girth-limit system would infallibly ruin the forests. Queensland is aiming to solve this problem by a remarkable method of all-size thinning which leaves only a very limited number of trees per acre in each size-class. Provided those left are the most vigorous in appearance, the forest can hardly fail to improve. Queensland is, however, favoured by better staffing and marketing than most other tropical territories.

Two other objections to girth-limit systems have been published recently, both of which apply with equal force to true selection, at least in the rain-forest. Firstly, it appears that most rain-forest trees are highly sensitive to canopy crowding and that for a reasonable increment—say over eight feet girth in 80 years—they must have well over one and generally over two thousand square feet of crown space before maturity. The other element in crowding—basal area or root competition—has been mentioned already. Anything like an understorey position in youth or a maintained high stocking throughout life, both of which are inevitable under a high-yielding polycyclic system, generally results in small crowns and/or slow growth and long mean rotation (Dawkins, 1958; 1959).

Secondly, it has been shown that the damage done to juveniles and adolescent boles by falling mature crowns averages anything from 0.05 to 0.10 acres per tree, depending on size and degree of climber infestation (Uganda Forest Department, 1958). Directed felling is generally impossible, owing to leaning boles or asymmetrical crowns, so that for ten trees felled about half an acre is likely to be reduced to zero years or at least to the first decade of the rotation. The felling damage and crowding factors together severely limit the total possibility of tropical polycyclic forest, and render monocyclic methods more attractive wherever high-volume yield is paramount, and the principal species are heliophilous.

Such conditions apply over most of Malaysia, Africa, and the Caribbean, and highly successful monocyclic systems are proceeding in all three. Incidentally, the monocyclic systems are kinder to modern loggers, whose operations demand greater tonnage per acre than animal or hand extraction, and whose needs are difficult to meet by selective fellings in the poorer tropical areas. In Malaya, this purely economic factor was one of the most important reasons for reducing a formerly long, drawn-out series of improvement fellings into a single operation, now followed immediately by total refining (Wyatt-Smith, 1959).

Diagnostic Sampling

Improvement by liberation involves the removal of impeders. It cannot be justified unless impedance is demonstrated, either aerial or radical. And although individual cases of impedance may be obvious by visual inspection, anything like quantitative assessment of the need for tending is extremely difficult by eye.

Malaya evolved and applied the first sound system of diagnostic sampling, by which not only the effective stocking—judged according to the limits of which the forest is believed to be capable—but its silvicultural status can be measured (Barnard, 1950). Thus, the individual "leading" plants in final-crop-tree size quadrats are scored for their degree of freedom or need for liberation, and the whole crop can be expressed as so much impeded or so much free, x% stocked, of y% quality, depending on the species composition, and of z sq. ft. basal area or girth-range from the actual measurements. Diagnostic sampling modified from the Malayan original now forms the basis of silvicultural decision in Uganda and has also been used in West Africia (Bergeroo-Campagne, 1957) and Queensland, as well as elsewhere in Malaysia. It undoubtedly ranks as tool No. 2, second only to the arboricides.

Dynamic Sampling

Stand improvement moves along a scale and can therefore only be judged and planned if its position on the scale is known. It is only in the last decade that the means of doing this have been worked out on an extensive scale. Queensland led off with dynamic sampling—the estimation of improvement by means of increment—by its system of permanent yield plots sited systematically throughout

*A polycyclic system allows two or more principal fellings per rotation; a monocyclic, only one.

all productive forest types and re-measured by permanent inventory teams at regular intervals. The principle has spread and, although worked out quite independently, is now routine in at least some parts of Malaya (Cousens, 1958) and in Uganda (Dawkins, 1958). The "yield plots" are true sample plots, not in the sense of experimental research but in the literal context of an actual and representative sample of the whole forest estate. Uganda and Malaya at present prefer a stratified random layout, whereas Queensland prefers the systematic.

Plot sizes vary from a fifth of an acre in Queensland, through one acre in Malaya to 2.5 acres (nearly one hectare) in Uganda.

The peculiarity of THF dynamic sampling is that all three stems must be permanently marked, as recruitment and losses are likely to be both continuous and untraceable. Add to this the phenomenal differences in growth-rate from tree to neighbouring tree of the same species—and all Meyer, Prodan, and Seth systems of calculation and prediction become quite unworkable. Tropical sample plots are, in fact, more likely to be analysed by stand-projection based on growth curves than by calculation of area increment extrapolated by site classes. Fortunately, the tree crown diameters are generally strongly correlated with bole diameters, and aerial sampling coupled with ground control is now capable of considerable accuracy in estimating growing-stock over wide areas. Thus, the sample plots will serve as precise subsamples for the control of repeated aerial inventory.

Present Trend and The Future

The greatest single inhibitor of tropical forest improvement is its vastness compared with its degree of utilisation, and therefore its currently low valuation and the weak policy of its owners. Without demand, there is no incentive for higher productivity.

Hence, where demand is intense, as in the Asiatic tropics, we find the most advanced development. For instance, the Far Eastern manager is often able to effect complete utilisation even to the sale of grass, bark, and roots, let alone all his weed-trees and thinnings for fuelwood. Indeed, mere "improvement" is often too slow, and he is forced towards total replacement, generally by the taungya method.

This leads to the first of the two major dilemmas which face tropical foresters today—intensive replacement versus extensive improvement. Should the policy be intensive first and extensive if resources allow—or the reverse? Economists prefer the first, foresters, generally the second alternative as it involves the largest areas and therefore justifies their hold over the forest estate and ensures against its early attrition. Where the land is unsuitable for agriculture or other forms of development, there is no particular worry. Where the soil is good, the ultimate choice is inevitable—intensity must prevail. Procedure then depends on urgency; if demands are yet low, extensive methods are the best and improvement methods are chosen. If demands are already pressing, improvement is usually too slow and replacement (quite possibly by indigenous species) is inevitable.

The second major dilemma, at least in areas of low demand, is what to grow. The choice generally boils down to whether the tropical forest is to be a source just of cellulose or of ornamental and utility woods as such. The first choice means concentrating on phenomenally high-yielding, fast-growing light-demanders in genera such as *Cecropia, Ochroma, Musanga, Trema, Eucalyptus, Pinus, Cupressus* and others. The second choice involves the high-class dipterocarps, Meliaceae, Combretaceae, legumes, Moraceae, etc. This is where lack of world planning comes in; it is quite impossible to make a rational long-term decision without first deciding on regional specialisation. To assist in such planning the following considerations are submitted:

1. Tropical broad-leaved forest, at least the evergreen variety, is rarely inflammable, and in this respect provides a safer investment than temperate or dry-tropical conifer or deciduous forest, particularly under relatively unskilled management.

2. Much higher annual acre yields of cellulose can be obtained in tropical than in north temperate forest. This is true even without citing the eucalypts. If these and the tropical pines are added, yields are still further increased, but we introduce the fire factor again. However, in the humid tropics this operates at a much lower hazard than in temperate areas, as an evergreen non-inflammable understorey can be induced and evergreen fire-breaks allowed.

3. Changes of management can be introduced into tropical forests with far greater rapidity and earlier results than in temperate. Clear-felling, taungya, line-planting and even some "natural" methods can raise large saw-timber in a matter of forty years or bulk cellulose in a matter of ten—speeds practically impossible in the temperates. This is a most important point in relation to the rapidly changing patterns of modern technology.

Cynics may comment that one can ruin a tropical forest quicker than a temperate. The optimist will retort that one can also rehabilitate quicker, and what can be quicker than fire?

The fact is that the proper forest planning of every territory awaits the formation of world-wide forest policy. It is perhaps too much to expect such a thing when Time has seen only five global conferences on the subject.

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RESUMES

Nouvelles méthodes pour améliorer la composition du peuplement dans les forêts tropicales

L'amélioration des peuplements tropicaux n'a guère fait de progrès depuis le Quatrième Congrès, bien que l'usage des herbicides, les méthodes statistiques et le contrôle de la composition des peuplements se soient considérablement généralisés.

Les progrès qui ont toutefois pu être enregistrés relèvent de cinq domaines principaux: arboricides (herbicides), lutte contre les plantes grimpantes, réduction du peuplement, systèmes d'aménagement et méthodes de sondage.

Arboricides. Les herbicides à base d'hormones agissant par contact sont maintenant utilisés partout où les substances à base d'arsenic sont bannies en raison du danger qu'elles présentent, ou lorsque la forme commune d'arbres indésirables rend le "frilling" (incision annulaire) impossible, ou dans les endroits où les approvisionnements en eau sont difficiles et où le matériel peut être transporté par véhicules. Lorsque ces conditions ne s'appliquent pas, le "frilling" à l'arsenic est encore pratiqué avec succès.

Plantes grimpantes. La théorie soutenue en Malaisie—à savoir que l'enchevêtrement de plantes grimpantes qui se produit après la coupe ou après traitement sylvicultural énergique n'est qu'une phase temporaire destinée à disparaître lorsque les arbres commencent à croître—s'est maintenant répandue et affirmée dans d'autres pays. On s'est aperçu qu'il est inutile d'essayer de les anéantir en les abattant et que cela a pour effet de leur donner un surcroit de vigueur. Les méthodes actuelles tendent surtout à réduire ce fléau par affinages périodiques, lesquels ont pour effet d'éliminer les graines qui retombent normalement sur le sol, ce qui a pour résultat d'assurer un sol "propre" et des couronnes propres lors de l'abatage.

Réduction du peuplement. Des travaux accomplis presque simultanément dans le Queensland, en Malaisie et a Porto-Rico—et confirmés indépendamment en Ouganda—ont indigné que les forêts tropicales de haute futaie contiendront seulement entre 35 et 75 arbres par hectare de valeur pour la coupe finale. Les arguments relatifs à la dimension des cimes comme ceux portant sur la superficie de base mènent à la même estimation. Les conclusions qui en découlent sont en rapport avec les théories sur la régénération, les courbes de croissance et le potentiel d'accroissement annuel total, au détriment des systèmes de sélection à rendement élevé.

Systèmes de rotation des coupes. Il ressort d'une part des travaux relatifs à la limitation de la surface terrière, mais aussi d'autre part des mensurations effectuées en Ouganda et à Borneo en ce qui concerne la dimension des couronnes et les dommages causés lors de l'abattage, que le système de coupe polycyclique (deux coupes ou davantage par rotation) ne donnera vraisemblablement pas un rendement annuel à l'acre aussi élevé que le système monocyclique (une seule coupe par rotation). Sans toutefois invalider les systèmes de sélection ou de limites de diamètre, il découle de cette théorie qu'ils donneront un rendement moins élevé et ne pourront être soutenus que si tous les troncs stagnants sont enlevés périodiquement, ce qui est extrêmement difficile dans une forêt tropicale.

Echantillonnage dynamique. Les efforts tentés pour mettre au point une méthode permettant d'estimer à l'avance la composition d'une peuplement au moyen d'inventaires répétés de placettes échantillons ont mené à la conclusion que cette prédiction est impossible sans une connaissance précise de l'identité de chaque arbre. On a donc établi des placettes échantillons de forêt tropicale, situées systématiquement ou au hasard dans toute la forêt, qui permettront de prédire avec précision le peuplement d'un échantillon de variance connue. Cet échantillon peut être extrapolé au peuplement tout entier par sondage aérien ou terrestre, étant donné qu'il a été démontré que le diamètre des couronnes est en relation directe avec celui du fût.

Ce rapport examine également le statut actuel du système de plantation en ligne et de la méthode de sondage diagnostique, mais aucun progrès important n'a été accompli dans ces deux domaines depuis la dernière conférence.

Nuevos Métodos para Mejorar la Composición de Arboles en los Bosques Tropicales

La mejora de bosques tropicales no progresado fundamentalmente desde el Cuarto Congreso, aunque se ha logrado bastante en deshierba química, métodos estadísticos y control de la estructura de composición.

El progreso digno de mención se ha hecho en cinco campos principales: arboricidas, control de las trepadoras, plantación limitada, sistemas administrativos y muestreo dinámico.

Arboricidas. Los arboricidas hormonales de contacto están ya comúnmente aceptados en la práctica cuando se prohibe el uso de los arsénicos como medida protectora de la salubridad pública o la forma común de trepadoras imposibilita el anillado o escasean los suministros de agua y es posible utilizar el transporte a rueda. En los casos en que no hay que tomar en consideración las condiciones mencionadas, todavía se emplea con éxito el arsénico.

Control de Trepadoras. La experiencia ha demostrado en Malaya que la masa de trepadoras que surge después del corte o de un tratamiento silvícola radical es una fase pasajera, condenada a desaparecer con el crecimiento de los árboles. Esto mismo ha quedado probado en otras partes. También se ha demostrado que cualquier ensayo de control por medio del corte es inútil y sirve únicamente para dar mayor crecimiento a las trepadoras. Los métodos corrientes tienden a reducir el problema de las malezas y trepadoras con limpias periódicas que eliminan las semillas caídas y que con el tiempo producen un suelo limpio en el bosque y un corte limpio de las copas.

Plantación Limitada. Los estudios casi simultáneos realizados en Queenslandia, Malaya y Puerto Rico, e independientemente confirmados en Uganda, han demonstrado que en el crecimiento final los montes altos tropicales contienen solamente de 35 a 75 árboles por hectárea. Las discusiones sobre el tamaño de la copa y el area basimétrica conducen al mismo cálculo. Estas conclusiones, combinadas con las ideas sobre regeneración, índices de crecimiento e incremento total posible, tienden a argüir en detrimento de los sistemas de selección de alto rendimiento.

Sistemas Poli o Monicíclicos de Corte. En parte como resultado del esfuerzo para limitar el área basimetrica, pero también debido a los datos recogidos en Uganda y Borneo sobre el tamaño de las copas y los daños acasionados por el corte, se ha demonstrado que el corte politícíclico no brinda probabilidades de rendimiento anual en volumen por héctarea tan alto como el monocíclico. Aunque esto no invalida los sistemas de selección ye de límite de la circunferencia, la teoría de ambos insiste en que pueden dar rendimiento más bajos y pueden sostenerse sólo mediante el corte periódico de todos los tallos de poco crecimiento, lo cual resulta extremadamente difícil en un bosque tropical.

Muestreo Dinámico. La busca de un método para calcular el crecimiento mediante el repetido inventario de parcelas del área, ha llevado a la conclusión que esto no puede hacerse sin conocimiento de la identidad de los diversos árboles. Ahora se han establecido parcelas de muestreo en los bosques tropicales, situadas sistemáticamente o al azar dentro de ellos que permiten un cálculo exacto del crecimiento con muestreos de variación conocida. Los resultados obtenidos pueden relacionarse con el crecimiento del resto del bosque por medio de muestreos aéreos y terrestres porque el diámetro de la copa ha demostrado ser bastante proporcional al del tronco.

También se trata la plantación linear y el muestreo diagnóstico, aunque en ninguno de ellos se han registrado grandes progresos desde la celebración de la última conferencia.

New Methods of Improving Stand Composition

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As we gather here in Seattle, it is of interest to note that little more than 70 years ago the site of this great University was covered with virgin timber. Land clearing for the first building on the campus started in 1891.

With a few noteworthy exceptions, timber harvesting operations in this region have been conducted on a clear-cut basis, and until recent years the intentional burning of the logging residue has been the general practice.

While selective logging has played only a minor role in the Douglas-fir region and has had little influence on present stand composition, it is of interest to comment briefly on it before discussing the clear-cutting operations.

In the early logging history of the region, large old-growth fir trees, particularly along the major water courses, were cut on a selection basis. During World War I most of the high-quality spruce was removed from the spruce-hemlock coastal forests for airplane stock. Cedar, which normally makes up a small component of the forest, has been cut selectively for poles, piling, and shingle bolts on an extensive basis.

In contrast to some forest regions where selective harvesting has left a residual forest of weed species and low value trees, selective logging in the Douglas-fir region has had little deleterious effect on the forests either silviculturally or economically.

While large-scale clear-cut logging in the Douglas-fir region dates back to about 1900, concerted effort in timber growing, aside from efforts to guard against fire, barely spans a quarter of a century.

As in other forest regions of the world, changing economic conditions and expanding demands for wood have stimulated a phenomenal development in the practice of forestry in the Douglas-fir region in the relatively short space of 25 years.

It is the purpose of this paper to discuss briefly some of the forestry practices that are aimed at maintaining or improving a desirable stand composition. This can best be done by discussing: first, the treatments that are applied more or less concurrently with the major harvesting operations; second, the rehabilitation of deforested areas; and third, the cultural treatment of immature stands. In each situation there are two principal factors to be considered: first, a knowledge of the site, that is the effect of aspect, slope, elevation, drainage, and soil quality on each species; and second, the objectives of the owner.

As to the site, all experience to date has indicated that exotic species cannot compete with the species native to the region. Therefore, the choice lies in some combination of Douglas-fir, western hemlock, western red cedar, the true firs, and Sitka spruce.

In general, the objective of landowners is to favor a stand composition that will maximize the yield of any combination of these species on each site. However, one landowner may seek to favor hemlock and the true firs for their sulfite-pulping qualities, while another may favor Douglas-fir due to the fact that today, at least, it is the more valuable wood for lumber and plywood.

In mature timber harvesting operations, natural reforestation has been the principal method of securing a new crop of trees following logging. The desired composition of the new stand can be influenced both in the selection of the areas reserved for seed sources in the cutover area and by controlling the condition of the seed bed.

Control of the seed source is obtained by careful selection of seed blocks well located with respect to topography and wind currents and consisting of thrifty trees of the desired species. While tried primarily on an experimental basis thus far, soil fertilization on areas set aside for cone and seed production has substantially increased the yield of cones and seed. It now appears that aerial application of fertilizers on natural seed sources can be used to improve and speed up natural reforestation.

Aerial spraying of insecticides on seed sources to control cone and seed insects likewise promises to increase seed production, speed up the reseeding process, and give better control over the composition of the new stand.

Western red alder and Oregon maple commonly grow in groves and strips in the wetter sites in the mature stands. These low-value species are prolific, and their innumerable progeny tend to form a heavy brush cover that is worthless in itself and forms a serious obstacle to reforesting with desirable species. The traditional logging practice has been to leave these undesirable species unmolested, thus, in effect, maintaining a seed source of unwanted species. The new trend is to harvest the best of these low-value trees and to attempt to destroy the remainder in the logging process as a means of eliminating the seed source. Where this is impractical, unwanted hardwood seed sources are being killed by aerial application of 24D and 245T with good results.

Control of the seed bed following logging plays an important role in future stand composition. Cable logging exposes mineral soil, results in a relatively uniform distribution of logging residue, and is effective in uprooting and retarding the growth of undesirable underbrush.

Controlled burning of the logging debris, by further exposing the soil and reducing brush competition, improves the seedbed for Douglas-fir. This reduction of the duff and the organic content of the soil renders the site somewhat less favorable for hemlock and the true firs. It also has the marked disadvantage of destroying whatever

conifer seed may be on the ground, together with advance reproduction.

Originally, the sole purpose for the widespread practice of broadcast burning was reduction of the fire risk. Today, closer utilization of the forest leaves less logging residue, and the tremendous improvements in protection have substantially reduced the risk of accidental fire. Thus, the decision of whether or not to burn logging residue is based as much on the species that are being favored and other silvicultural considerations as on the protection aspects.

Tractor and arch logging have gained considerable prominence during the past 15 years, and it is estimated that currently 30 to 40% of the logging is performed by this method.

In contrast to the favorable seedbed resulting from cable-logging systems, the normal tractor-logged area consists of a series of cleared tractor roads, with heavy concentrations of logging debris mixed with soil between the roads. Particularly on steep topography, the resulting tractor roads, which frequently constitute 25% of the logged area, are stripped of top soil, puddled, and compacted to such a degree that the site is substantially lowered, and the ground is rendered inhospitable for the growth of seedlings. The loosely piled concentration of debris between the roads is not only an inhospitable site for germination and growth of coniferous species but it also favors the rapid development of unwanted hardwoods and brushy vegetation.

The adverse silvicultural effects of unregulated tractor logging have only recently become recognized, and today forest-land owners are attempting to devise practices that will permit their taking advantage of the cost savings in tractor logging without incurring the silvicultural disadvantages.

Some specific guides have already been developed, and while they are now being employed largely on a trial basis, it appears evident that they will come into general use in the region in the near future.

Some examples are:

1. Replacing the standard digging blade on the tractors with toothed land-clearing blades. This reduces disturbance of top soil and tends to leave a more even distribution of logging debris. Brush clumps may be uprooted with these blades and other necessary site preparation accomplished before the tractors leave the setting.
2. Determining which soils are most subject to compaction and puddling, then scheduling logging on these areas during the dry season when the damage will be minimized.
3. Scarifying the tractor roads following logging to reduce compaction.
4. Developing a tractor road system suited to the topography of each area, thus minimizing undue channelling of surface water and reducing interference with subsurface water movement.

These practices, and still others that are in initial stages of development, are feasible and practical methods of maintaining the productivity of the forest land, encouraging the development of desirable species and promoting a better distribution of trees on the land.

It was mentioned earlier that natural reforestation is the principal means of regenerating the areas being logged. It should be pointed out, however, that Douglas-fir is not a prolific tree. Two to three really effective cone crops each decade is normal, with the crops in intervening years ranging from moderate to almost complete failure. Thus, the period between the harvest of one crop and the satisfactory establishment of a new forest averages about 10 years. This prolonged establishment period is not only costly, but it frequently provides inadequate distribution of trees and often results in an undesirably high component of inferior hardwood trees in the stand.

Until very recently, protection against fire, rehabilitation of deforested land, utilization, and other pressing forestry problems of the region have diverted attention from the economic considerations of a prolonged establishment period.

As more and more forest properties are being placed under sustained-yield management, the question of rotation age is receiving increased attention. When we then begin to relate an establishment period of 10 years to rotation periods of 60 to 80 years, the high cost of natural regeneration becomes more apparent.

Two other factors are focusing increased attention on artificial regeneration following logging. First is the development of a satisfactory and still improving method of aerial seeding, and second is increased emphasis on tree improvement.

As far as commercial application is concerned, forest genetics in the Douglas-fir region has not advanced much beyond the stage of collecting seed from selected trees, but from the tree improvement research under way it appears evident that natural seeding will gradually give way to the use of seed and seedlings from carefully selected strains carrying inherent characteristics of resistance to insects and disease, rapid growth, strength factors, and fiber quality.

While some of these gains will be achieved only after several more years of development, a number of forest owners are today seeding or planting a large proportion of the area logged each year. In some instances, the seeding is in lieu of leaving seed sources; in others, the seeding is supplementary. They are using the best quality seed obtainable. Seed provenance and species mixture are carefully matched to the site. This practice is resulting in substantial improvement both in species composition and in distribution of trees in the new forest.

I should like to turn now to the rehabilitation of deforested land. There are an estimated two to three million acres of forest land in the Douglas-fir region suitable for timber production but which, largely due to recurring fires prior to 1940, are either non-productive or are so poorly stocked that they require rehabilitation.

While the condition of these areas varies widely, they are characterized by steep topography, a dense cover of hardwood shrubs, or a lush growth of perennial and annual plants. Mosses are prevalent, and many large logs and stumps, still intact many years after logging, are covered by the vegetation.

These areas are a natural habitat for large populations of animals that make heavy depredations on the seed and seedlings of conifers.

The portions of this area most amenable to rehabilitation have been reforested during the past 20 years. On the remaining area, the conditions stated above pose serious obstacles to reforestation.

Where topography permits, large tractors of the D8 or TD24 class, equipped with land clearing blades, are used to uproot vine maple, alder, and other woody vegetation. This operation also accomplishes a crude tilling of the soil. This so-called scarification prepares an excellent seedbed either for planting seedlings or direct seeding. It also renders the site less favorable for the animals that feed on young coniferous trees.

In or adjacent to most areas suitable for scarification are strips of hardwoods along steep stream banks where mechanical scarification is impractical. These areas are sprayed with herbicides to prevent them from seeding the scarified areas with undesirable hardwoods.

Controlled burning is frequently proposed as an economical method of preparing these areas for reforestation, but most foresters in the region have had too much adverse experience in attempting to control wild fires to be willing to accept the risks involved.

Along with the nonstocked areas requiring reforestation, there are substantial areas reasonably well stocked with conifers whose growth is retarded by an overtopping canopy of low-grade hardwoods. Release of the conifers is being accomplished successfully in these areas by helicopter application of selective herbicides. To date, most of this work has been performed while the hardwoods are in full leaf and growing vigorously. Dormant spraying, that is, application of the spray before the buds open, has been used on a commercial scale during the past three years. This method has proven effective in killing some species which have a high resistance to the foliage sprays.

The coast range in western Washington and northern Oregon is an area of abundant rainfall and is characterized generally by high site quality. Studies in this area indicate that the full growth capacity can best be realized by a mixture of intolerant fir and the more tolerant hemlock and spruce. Where the natural reproduction is young and almost pure hemlock, light applications of fir and spruce seed are being applied experimentally by helicopter to produce a better species balance. Where the reproduction is essentially pure Douglas-fir, hemlock, grand fir and noble fir seed is likewise being disseminated to develop better stand composition.

The third sphere of activity in which efforts are being made to improve stand composition is in thinning and weeding of sapling and second growth stands.

Pre-commercial thinnings in this region have been limited to small experimental areas, but enough work has been done to indicate that early thinning to achieve better spacing, and to eliminate space-consuming inferior trees and undesirable species will be conducted on a commercial scale within the next few years.

Thinning of pulpwood and small sawlogs has been retarded for lack of markets until very recently, but commercial thinning in these intermediate stands is presently increasing at a rapid rate, and the indications are that thinnings are destined to provide a significant part of the region's wood production within a few years.

Purely for economic reasons, practically all the thinnings today are essentially of a sanitation salvage nature. That is, a major portion of the volume removed is in trees which are dead or dying and would be lost if left for a subsequent thinning or a final harvest cut. While the major effect of these operations is to improve spacing, the health and vigor of the reserve stand is increased, and normally the lower valued hardwoods and conifers with poor form are taken out, further improving stand composition.

Due to steep topography and other obstacles, all planting in this region is performed by hand. During the fiscal year ended June 30, 1959, 164,690 acres were planted in Washington and Oregon, and practically all of this was in the Douglas-fir region.

Diagonally across the United States from Seattle in a southeasterly direction lies the southern pine region of 193 million acres. Many of you visited this area on your way to this Congress, and still more of you will pass through it on your return journey.

As it is difficult and perhaps dangerous to generalize on a forest region spanning approximately 1,100 miles of both latitude and longitude, I will draw attention only to the point that maintaining and improving a desirable stand composition is one of the major problems of this region. Over much of the area, tolerant hardwoods of inferior quality quickly take advantage of the opportunity to invade the pine sites. Once the hardwoods gain a foothold, they can be replaced with pine only at considerable expense.

Control of wild fire has long been the dominant forestry problem in the South. While the problem is far from solved, great strides have been made. For the past 15 years the task of improving stand composition on the pine lands and hardwood bottoms, and more recently the rehabilitation of non-productive lands, has been moving ahead rapidly.

The first step was the removal of cull overstory hardwoods in stands of pine timber and reproduction. Girdling with axes, power tree girdlers, and now with chemical injectors are the principal methods used.

Where pine reproduction is sparse or lacking, a combination of salvage logging, harrowing and replanting is frequently used. Aerial applications of herbicide have been used, but the intermingled pattern of forest and farm land limits the use of this treatment.

Currently, the use of tractor-mounted ground spraying equipment is showing considerable promise as a means of controlling hardwoods in the lower canopy.

Heavy tractors equipped with blades that shear off unwanted trees are finding increasing use.

Along the coastal areas, swamps are being drained to make the sites more suitable for favored species.

In most situations, a combination of two or more of the methods mentioned is used. The sequence and timing of these operations, and in many cases the integration of these treatments with reforestation operations, must be carefully prescribed for each set of circumstances.

Both machine and hand planting are used in the southern pine region, and during the fiscal year ended June 30, 1959, 1,635,974 acres were planted in the eleven southern states.

The combined effect of these treatments is bringing about a steady improvement in stand composition throughout the southern pine region.

Due to the rapid juvenile growth of our southern pines and the relatively short rotations required for the production of pulpwood, forest genetics has advanced more rapidly in the South than in any other region in the United

States. Emphasis is shifting from the yield of cords per acre to the yield of quality fiber per acre. As the ability to identify trees having inherent superior qualities is sharpened, more effort is going into the establishment of cone orchards designed to produce seed from superior strains of trees.

In this brief report it has not been possible to describe in detail the application of any one treatment nor to discuss the considerable amount of planning and study of relevant factors necessary to prescribing the treatment required for a specific situation. Likewise, I have mentioned only briefly the vital part that research by private companies and government agencies has played in developing chemicals, machinery, and methods.

It is my hope that these few comments will have given you a broad look at what is being done to improve and maintain the productivity of the land and to improve the composition of the stands in two of the major forest regions in the United States.

RESUMES

Méthodes nouvelles pour améliorer la composition des peuplements

Les méthodes sylviculturales ayant pour objet de maintenir la composition désirable d'un peuplement, ou de l'améliorer, sont présentées en plaçant l'accent principal sur la région du sapin de Douglas. Ces méthodes sont réparties en trois catégories: (1) les méthodes qui sont appliquées simultanément avec les principales opérations d'exploitation; (2) le repeuplement des coupes rases; et (3) les méthodes culturales appliquées aux peuplements qui n'ont pas encore atteint leur maturité. Chacune de ces catégories de traitement est fonction du site forestier et des objectifs du propriétaire. Etant donné que les essences exotiques n'ont pas réussi à s'imposer, la meilleure utilisation de la capacité productive de la forêt est réalisée avec des combinaisons de sapin de Douglas et d'autres essences indigènes.

La méthode d'exploitation séléctive n'a joué qu'un rôle secondaire dans la région du sapin de Douglas. L'exploitation à blanc sur une vaste échelle et le brûlage des déchets remontent aux environs de 1900, alors qu'exception faite des mesures de protection contre les incendies, ce n'est que depuis 25 ans à peine que des efforts concertés ont été tentés en vue de la reconstitution de la forêt. Ce reboisement a été effectué principalement en favorisant la régénération naturelle à l'aide de sources de semences réservées. Il est possible d'influencer de façon matérielle la question de l'enlèvement des feuillus portegraines, ainsi que l'effet sur le semis des méthodes d'exploitation par câble et par tracteur. Des méthodes sont suggérées pour réduire au minimum les mauvais effets sur le semis d'une exploitation par tracteur non-réglementée.

L'attention qui a été accordée récemment aux considérations économiques relatives à la longue période de temps nécessaire à l'établissement d'une nouvelle futaie a mis en lumière le coût élevé de la régénération naturelle. Par suite du développement et du perfectionnement continu des techniques d'ensemencement par voie aérienne, et de l'intérêt accru porté à l'amélioration génétique des arbres, le principe de la régénération artificielle après la coupe est maintenant appliqué de plus en plus par les exploitants forestiers. Aujourd'hui, un certain nombre de propriétaires forestiers procèdent à l'ensemencement et à la plantation d'une forte proportion de la superficie exploitée chaque année. Dans certaines régions, on améliore la composition du peuplement en utilisant pour l'ensemencement des mélanges de diverses essences.

On estime qu'il existe dans la région du sapin de Douglas deux à trois millions d'acres de terres forestières mal peuplées dont le reboisement rationnel s'impose. Malheureusement, ce reboisement est rendu difficile par la topographie très accidentée, la densité de la couverture végétable, les bois chablis et le pullulement des rongeurs et du gibier. Parmi les nouvelles méthodes utilisées, citons la scarification par tracteur, et des pulvérisations, par voie aérienne, de produits chimiques phytocides. Cette dernière méthode est également utilisée de façon extensive pour permettre aux conifères de s'élever au-dessus des feuillus de qualité inférieure. On emploie avec efficacité des applications dormantes sur les broussailles qui résistent aux pulvérisations sur le feuillage. Les plantations sont effectuées à la main en raison de la nature accidentée du terrain et des obstacles au sol.

Parmi les méthodes de traitement cultural appliquées aux peuplements en cours de croissance, mentionnons les coupes d'éclaircissage expérimentales pré-commerciales et le traitement des sujets indésirables. Par suite des améliorations récentes des marchés, les coupes d'éclaircissage augmentent rapidement. Elles consistent surtout à enlever les bois défectifs ou morts avant qu'ils ne deviennent inutilisables.

Un des principaux problèmes de la région du pin des Etats du Sud, qui se trouve diagonalement à l'autre extrémité des Etats-Unis par rapport à Seattle, consiste à maintenir la composition des peuplements lorsque celle-ci est satisfaisante, ou à l'améliorer. Des feuillus "tolérants" de qualité inférieure ont vite fait d'envahir les plantations de pins, et leur remplacement par des pins est difficile. La lutte contre les incendies de forêts constitue toujours un gros problème, en dépit des immenses progrès qui ont été réalisés. La mise en valeur des terres improductives s'effectue à une cadence rapide. Notre rapport passe en revue les opérations d'enlèvement des bois feuillus de rebut, le labourage, les pulvérisations, les plantations et autres activités relatives au reboisement. Des progrès rapides ont été effectués dans le domaine de l'amélioration génétique des arbres.

Il était impossible d'examiner à fond dans ce rapport les détails des nouvelles méthodes de traitement et le rôle vital joué par la recherche. On y trouvera un aperçu des travaux effectués pour améliorer et maintenir la productivité de la terre, et pour améliorer la composition des peuplements dans deux des régions forestières les plus importantes des Etats-Unis.

Nuevos Métodos para Mejorar la Composición del Rodal

En este trabajo se describen prácticas forestales encaminadas a mantener o mejorar la composición de los rodales, especialmente en la región del Douglas-fir. Estas prácticas forestales se dividen en tres categorías: (1) tratamientos que se aplican concurrentemente con las principales operaciones de corta, (2) rehabilitación de las áreas despobladas y (3) tratamiento de cultivo de los rodales inmaduros. El sitio forestal y los objetivos del dueño son factores que afectan a cada uno de estos aspectos. Teniendo en cuenta que las especies exóticas no han competido con éxito, la mejor utilización de la capacidad productiva del sitio forestal se logra mediante la combinación del Douglas-fir (*Pseudotsuga taxifolia*) y otras especies nativas de la región.

La corta selectiva ha desempeñado sólo un papel de secundaria importancia en la región del Douglas-fir. La corta a mata rasa en gran escala y la quema de los desechos se remonta al año 1900, mientras que los esfuerzos concentrados en la producción de madera, aparte de la protección contra el fuego, data apenas de un cuarto de siglo. La reforestación natural hecha con semilleros reservados ha sido el medio principal de la reforestación. La selección de semillas y el control de las condiciones del almácigo afectan materialmente la composición del nuevo rodal. Se describen la remoción de semilleros de árboles de hoja ancha y los efectos de los métodos de corta a base de cable y tractor. Se han sugerido fórmulas para reducir al mínimo los efectos adversos que tiene sobre los semilleros las operaciones a tractor no reguladas.

La regeneración natural representa un elevado costo en dólares, según ha podido apreciarse al considerar economicamente el prolongado período necesario para establecer nuevas cosechas forestales. El desarrollo y el continuo mejoramiento de la siembra del área y el creciente hincapié que se hace sobre el mejoramiento forestal genético hacen enfocar la atención sobre la regeneración artificial que sigue a la extracción de madera. Cierto y determinado número de propietarios forestales suelen echar hoy semillas o plantar árboles en grandes proporciones, sobre áreas que se cortan anualmente. Al echarlas, la composición del rodal se va mejorando en algunas áreas mediante el empleo de semillas de especies mixtas.

Se estiman en dos o tres millones de acres las tierras forestales inadecuadamente pobladas en la región del Douglas-fir, que requieren una rehabilitación. La topografía accidentada, la densa capa de suelo, los leños sueltos y la nutrida población de roedores y animales de caza presentan serios obstáculos a la reforestación. Los nuevos métodos en uso incluyen la escarificación del suelo tractor y la aspersión del área con productos

químicos letales. La aspersión viene usándose extensamente también para librar a las especies coníferas de ser cubiertas por árboles de hoja ancha de baja calidad. Las aplicaciones en estado latente son efectivas en especies dañinas resistentes a las aspersiones del follaje. La plantación se hace a mano debido a la topografía accidentada y a los obstáculos que cubren el terreno.

Los tratamientos de cultivo de rodales inmaduros incluyen aclareos y desherbas experimentales anteriores al proceso comercial. Con el reciente mejoramiento de los mercados, la poda con propósitos comerciales va en rápido aumento. La mayoría de éstas son esencialmente de índole sanitaria.

El mantenimiento y mejoramiento de un rodal de composición aceptable, es también uno de los mayores problemas de la región de pinos del Sur, situada diagonalmente a través de los Estados Unidos desde Seattle. Las especies de hoja ancha tolerantes, de inferior calidad, invaden rápidamente los bosques de pinos y son difíciles de reemplazar con los propios pinos. El control de la fauna silvestre es un continuo problema forestal sobre lo cual se han tomado grandes medidas. La rehabilitación de las tierras no productivas adelanta rápidamente. Se trata sobre la remoción de árboles de hoja ancha de inferior calidad, así como de la escarificación, la aspersión, la plantación y otras actividades de reforestación. Está lográndose un rápido progreso en el mejoramiento genético de los árboles.

En este breve informe no puede entrarse en pormenores y detalles sobre los nuevos métodos de tratamiento y el papel vital de las investigaciones. Este trabajo presenta un enfoque amplio de lo que está haciéndose para mejorar y mantener la productividad de la tierra y para mejorar la composición de los rodales en dos de las principales zonas forestales de los Estados Unidos.

SPECIAL PAPERS

Our Changing Inventory Methods And the CFI System in North America

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The task of inventory, like the change of the seasons, is endless. It seems that all human endeavor, whether in factory, farm, or forest, is burdened with the curse of stocktaking. Forest inventories are particularly difficult and costly. They disorganize management routine and add nothing to income, yet an audit of forest growing stock is essential to the management of all public and private woodland areas.

It will always be the forest manager's responsibility to make periodic accountings of his stewardship of property entrusted to his care. He has the choice of many methods, each with its own points of utility and advantage, and its standard procedures. Factors which have the greatest influence on timber inventory methods are size of area and concept of management.

Forest properties on the North American continent are extensive, and only a small sample of the trees can be measured. European methods of inventory, which often record all commercial trees in the forest, cannot be used here.

The concept of forest management has a strong influence on the inventory method. A far more frequent and intensive cruise is needed for sustained-yield management than for timber liquidation. Foresters in this country are living in a period of changeover from an inventory practice designed to satisfy the needs of buying, selling, and clear cutting timber, to the kind of cruising necessary to a planned continuity of management. This new type of inventory, the principles of which originated in Europe almost 100 years ago, is commonly called *Continuous Forest Inventory*.

The Development of Timber Cruising in the U. S.

It is interesting to trace the factors contributing to the growth and establishment of continuing inventory systems in this country over the past 75 years.

In the latter years of the nineteenth century, large public and private estates were established, mainly by government grant. Custodial policies prevailed on these lands into the early part of the twentieth century, and little was known of the timber volumes present. During this long period, inventory work was done by land-lookers and oldtime timber cruisers who roamed the woods searching for minerals and blocks of pine and spruce timber. Much of the forest land in those days was held for ultimate agricultural use, and little thought was given to any form of continuing inventory or management, except on certain public lands.

This attitude toward the forest changed before and during the second world war. Economic pressures between 1929 and 1950 caused management policies of most large-scale industrial forest-land owners to veer strongly toward sustained yield and more permanent inventory systems. The most important reasons for this change were: (1) the employment of many foresters in timber industries; (2) widespread acceptance of the scientific method; (3) advances in aerial photography and the fine art of photo interpretation; (4) increasing use of data-processing machinery in the solution of forest problems; and (5) efficient American business methods, and their spread to the treatment and care of the forest. The industrial accountant, policy maker, administrator and forester

began to encourage the establishment of the permanent sample plot during this period. They introduced the principles of frequent repetition and direct comparison into forest inventory work and looked with strong favor upon forest management control through continuous stocktaking.

There is little doubt about it; forest inventory practice, properly planned, can be used to guide and even control the rate of timber removal, measure growth and mortality, direct silvicultural practice and the order of cutting, and satisfy many of the accounting demands of the associated timber business. To make sure that these advantages will result, there must be a frequent measurement of the changes constantly going on in the forest. We are not cruising a forest in final equilibrium but an ecological habitat in constant motion. There can be no continuity of control over the forest without continuity of inventory.

A Short History of Continuous Forest Inventory

Although Continuous Forest Inventory, or CFI, is a recent method, it has already passed through several developmental stages. Beginning in 1937 and 1938, with a few hundred permanent sample plots on industrial lands in the Middle West, the techniques soon spread to the farm woodlot.

By 1948, almost 1,000 plots had been established on farm woodlands in Ohio and Wisconsin. Most of these systematically spaced plots are still being measured periodically. It was in the farm woodlot that the efficient plot taking techniques of the present day were developed. Paint numbering trees, individual tree records, vigor and quality grading, and precise measurements, all began with the tens of thousands of trees tallied on permanent plots in farm woodlots between 1940 and 1948.

During the period 1949 to 1951, several large public forests were inventoried for volume, growth, and mortality, with 1,200 permanent plots. These plots, in line with the thinking of the times, were established to secure a predecided standard of accuracy for each predetermined area of cover, size, and density class. The plots were stratified, and there was no way to measure forest changes from the plots themselves, but only by re-flying and interpreting new pictures. Since this is a method far too costly and involved to be repeated in the five-year intervals generally used with the CFI system, half of these permanent plots were dropped at the first remeasurement, and a systematic sampling plan was built around the remaining plots.

By 1952, the American Pulpwood Association became interested in more business-like inventories for industrial forest lands and had the CFI system presented to its members. This cooperation between the APA and the USFS resulted in large-scale applications of CFI in pulpwood and sawlog forests east of the Mississippi Valley. The five original growth plots established in northern Wisconsin in 1937 have expanded to 50,000 plots throughout the United States. Since 1949, more than 50 owners of large industrial forests have inventoried 25 million acres with the CFI system in the U. S., and a fourth as much in Canada. All of this coverage is systematic or mechanical in sampling design.

Continuous Forest Inventory or CFI Defined

CFI was developed and first applied on a large scale in the Middle West. It is a method of inventory which samples the forest realistically in terms of its natural composition. It does not merely measure separate, scattered trees within the ecological habitat of the forest, but the entire habitat. All commercial trees are tallied within the plant association represented by each plot.

Widely used in the New England, Lake, and Southern States, the true principles of the CFI system will help to assure the forest owner of continuity of control over most of his technical and business problems. The CFI of the past and present is quite simply defined:

> Continuous Forest Inventory, or CFI, is a precise, frequently repeated, and directly comparable measurement of all commercial trees in systematically placed sample plots. These plots have fixed radii and are permanently located in the forest. Their treatment, and the treatment of the surrounding forest must be analogous.

The Changing Objectives of the CFI System

The original purpose of CFI was to collect volume, growth, and mortality information indispensable to the establishment of broad management policies on large forest areas. The basic thought was to encourage better forest management and periodically gauge the effects. It was not originally planned to gather a great many interlocking details, but time and professional opinion have somewhat modified the early viewpoint. Today volume, growth, and area segregations of field data are finer, and so it has become necessary to increase the precision of work and number of samples taken. Whether the method will revert to its original purpose in the future, or become even more intensive remains to be seen. There seems now to be a slight trend toward greater intensification, with the use of CFI data in accounting records and operating schedules.

Proportionate Sampling Essential

Since 1951, CFI has applied a sampling pattern which is directly proportional to nature's distribution of trees and cover types in the ecological habitat of the forest. Circular plots of one-seventh or one-fifth acre size are used. Today, the single plot station is most common, but multiple-plot stations have been used in the past. Plot locations are pricked through to forest maps from a master grid which establishes the plot points on the corners of squares. The plot center locations on the map are tied by distance and direction to permanent landmarks easily identifiable on the aerial photographs. Deviations from the standard grid are permitted only when plots fall on ownership boundaries.

CFI is a record of tree and forest relationships. A basic function of the system is to measure volumetric and planometric changes in the forest. To facilitate this, every tree within each plot is a separate or unit record available at all times for correlation or simulation studies. Marginal or borderline cover conditions which often occupy a third to half of the total forest area are adequately sampled with the mechanical plot distribution of CFI. Since each fixed radius plot is representative of a particular area of

the forest, any change in the habitat within the plot gives a measure of the habitat change within the forest.

Precision and Comparability Are Important

CFI, with its repeated records on the same trees and plots, has pinpointed the twin problems of errors in measurement and judgment. Hidden, in the non-comparable inventories of the past, these errors are now exposed to the full light of reason and are sometimes serious. To overcome the cruiser's most flagrant mistakes, CFI uses a stepped-up program of demonstration, training, supervision, and measured check. Errors which escape this procedure are caught in the finer screening of the second inventory, at which time the individual tree data-processing cards used for the field tally are coded for obvious errors, and corrections are noted. Mistakes are gradually eliminated in this way, and there is always a firm, new foundation of accuracy for new and old inventories. Meticulous accuracy is firmly built into the CFI system. The prospect of random checks on identical trees and the long-term value of every phase of the work encourage precise work habits on the part of the cruiser. This is in considerable contrast to the more ephemeral qualities of the temporary plot cruise.

Regardless of the fact that nature's universe is endlessly variable, it can be precisely measured in the dormant season. The difficulty of securing absolute answers in nature does not remove the need for precision and care in taking the records. The most strict and glorified application of the scientific method in cruising can be nullified or made ridiculous by careless work, faulty techniques, or thoughtless deviations from standards.

Sampling Error

While there is no predecided accuracy standard for each stratum of the forest in CFI, post-inventory accuracy checks are data processed for every stratum. It is sometimes pointed out that a systematic distribution of fixed radius plots both over-samples and under-samples certain strata of the forest. This is true, but those who use the CFI system, particularly in the pulpwood regions where 90 percent of the trees are under 15 inches in diameter, are not concerned about this. Repeated statistical checks show that the answers for all species combined in three quarters of the area breaks are satisfactory and acceptable with the recommended sampling intensity. Total volume figures on most CFI surveys have been within ± 5—10% on a probability of 95 percent.

Time and Cost Factors

One of the most costly inventory methods with sustained-yield management is the temporary plot or one-shot cruise, where the opportunity for periodic comparison of results is long delayed or often completely lost. In contrast, continuing inventories at five-year intervals, with direct comparisons of both sample and expanded data, are reasonable industrial investments.

CFI costs in Minnesota, Michigan, and Wisconsin range between 9 and 12 cents per acre for plot establishment and 6 to 8 cents per acre for remeasurement. Initial inventories generally take about one-third more time than subsequent inventories. These costs are typical of projects in which 500 to 1,000 plots are set out at a sampling rate of one plot for 200 to 400 acres of forest land. Data-processing costs on individual tree record cards are included in these estimates.

In the Lake States, with systematic sampling, sound plot techniques, and careful work, a two-man crew will complete 2 to 3 permanent plots in the average working day. Half to three-fourths of the time is spent getting to and from the plots and the balance is needed to measure and record the trees within the plot.

Summary and Conclusions

CFI is one of the first and most important steps providing the forest-land manager with facts essential to the stability and continuity of his forest. An inventory made by foresters directly interested in the business of timber production, CFI gives a periodic trial balance of the condition of the trees as individuals, and of the forest as a whole.

CFI is used by timber industries in their regular accounting procedures, for determination of timber depletion rates, and other tax problems, establishment of forest values, and periodic decisions on production goals, and management accomplishments. Business, and technical controls are expedited by the records from the permanent plots. The industrial accountant, business manager, and forester are today working together to control and improve the forest, using growth, mortality, and volume information secured from the permanent plots of the CFI system. It is the view of most of the industrial forestry agencies using the system that the many advantages of CFI far outweigh the few disadvantages and that costs are reasonable.

RESUMES

L'évolution des nos méthodes de recensement forestier et le système de l'inventaire forestier continu en Amérique du Nord

Le recensement des bois constitue, pour les sylviculteurs du monde entier, une tâche jamais terminée et une obligation qui ne peut être ni esquivée, ni reléguée à une place secondaire dans les travaux de sylviculture. Essentiel au début en raison du caractère à court terme des affaires, le recensement forestier est maintenant effectué à l'aide de procédures nouvelles, et ses objectifs sont en harmonie avec les concepts modernes du rendement continu. On a tendance de nos jours à s'écarter du système de placettes temporaires et à adopter de plus en plus celui de l'inventaire forestier continu avec des placettes permanentes.

L'inventaire perpétuel s'est imposée progressivement depuis vingt-cinq ans dans les états du centre ouest, de la Nouvelle Angleterre et du sud des Etats-Unis. Elle a été adoptée à l'occasion des inventaires forestiers nationaux entrepris par le Service Forestier des Etats-Unis. C'est en 1937 que le Service Forestier a commencé d'établir quelques placettes-échantillon permanentes dans le nord du Wisconsin. Il existe aujourd'hui aux Etats-Unis 50.000 placettes permanentes réparties sur 25 millions d'acres de forêts industrielles ou publiques.

Bien que la méthode des inventaires perpétuels, ou de contrôle, subisse au cours des années une évolution progressive, il n'en demeure pas moins un noyau d'objectifs assez fixes, parmi lesquels il nous faut mentionner la répétition fréquente et la comparaison directe des inventaires, l'échantillonnage systématique, l'adoption de placettes permanentes à rayon fixe, et le traitement uniforme des placettes dans la forêt. Mais la méthode de contrôle n'est pas utilisée uniquement aux fins d'inventaire: c'est un outil permettant d'encourager l'amélioration de l'aménagement et d'en apprécier les résultats; il permet également de recueillir sur la croissance et la mortalité du peuplement des renseignements qui

ne sont généralement pas fournis par la plupart des autres systèmes de recensement.

Etant donné qu'elle offre la possibilité d'effectuer périodiquement des comparaisons portant sur chaque arbre de la placette, la méthode de contrôle a permis d'améliorer dans des proportions considérables les estimations au cours des dernières années. Les vérifications effectuées après inventaire montrent que les estimations de superficie et de volume, pour la plupart des types de peuplement, ont une limite d'erreur de plus ou moins 10 à 25 pour cent, avec une probabilité de 95 pour cent.

Afin de mesurer de façon économique et continue les changements sans fin qui se produisent dans la forêt, on applique un système d'échantillonnage systématique. Tout changement d'habitat à l'intérieur de la parcelle constitue ainsi une mesure du changement qui se produit dans l'ensemble de la forêt.

La méthode de contrôle n'est pas une méthode très coûteuse, ni en temps, ni en argent. Une équipe de deux hommes établit généralement deux à trois placettes par jour. Le prix de revient, y compris le classement des données, varie entre 9 et 12 cents par acre.

Cambio Constante de los Métodos de Inventario y el Sistema de Inventario Continuo Forestal de la América del Norte

El inventario forestal es para los silvicultores de todas partes del mundo una tarea que nunca termina y que no puede ser evitada ni relegada a un lugar de importancia secundaria en la silvicultura. En los primeros tiempos era esencial por razones comerciales de corto alcance; pero actualmente el inventario forestal sigue métodos y encierra propósitos en armonía con los modernos conceptos de rendimientos sostenidos. Las tendencias actuales son a abandonar los métodos de parcelas provisionales y a adoptar el de Inventarios Continuos Forestales, con parcelas permanentes.

El empleo del Inventario Continuo Forestal ha ido aumentando constantemente durante los últimos 25 años en el Medio Oeste, Nueva Inglaterra y los estados del sur del país. Sus inicios coinciden con los estudios nacionales comenzados por el Servicio Forestal de los Estados Unidos. El muestreo regular comenzó en unas cuantas parcelas de crecimiento establecidas en 1937 por el Servicio Forestal en la parte norte del estado de Wisconsin. En la actualidad, el país cuenta con 50.000 parcelas permanentes en más de 10 millones de hectáreas de bosques públicos e industriales.

Aunque el Inventario Continuo Forestal ha ido cambiando de forma gradualmente a través de los años, retiene un núcleo de objetivos bastante fijos. Estos incluyen la frecuente repetición y la comparación directa de inventarios, el muestreo sistemático, el radio fijo de parcelas y el tratamiento análogo de las parcelas y de los bosques. Pero el ICF no es sólo una forma de inventario, sino que es también un medio de alentar las buenas prácticas administrativas y juzgar los resultados y además suministra datos sobre crecimiento y mortalidad que no suelen obtenerse por ninguno de los otros sistema de inventario.

El ICF, con la oportunidad que brinda para la comparación periódica de árbol por árbol, ha contribuído en años recientes a dar mayor precisión a los cálculos forestales. Las comprobaciones de exactitud realizadas después de los inventarios indican que los cálculos sobre el área y volumen de los tipos de cubierta boscosa tienen un límite de error de un 10 a un 25 por ciento más o menos, con una probabilidad de 95 por ciento.

Para asegurar una verificación económica y continua de los cambios sin fin de los bosques se emplea un método sistemático de muestreo. Cualquier cambio de aspecto dentro de la parcela es, de esta manera, una medida de lo que ha ocurrido en todo el bosque.

Los elementos de tiempo y costo son bastante moderados en el ICF. Dos hombres en un día de trabajo corriente pueden hacer el muestreo de 2 ó 3 parcelas permanentes. El costo, inclusive los cálculos de los datos, varía entre 9 y 12 centavos de dólar por 0.404687 de hectárea.

"Orchard" Versus "Naturalistic" Silviculture

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The forests described lie between latitudes 19° and 24° N. and longitudes 71° and 80° E. in the State of Madhya Pradesh.

Teak, which occurs in varying proportions, is by far the most valuable species. Economically, the ideal forest that can be grown here is a pure teak forest with an understorey of *Dendrocalamus strictus* bamboo.

Elevation varies from 250 to 2,500 feet above M.S.L., the general elevation being 1,000 to 2,000 feet. The terrain is undulating and cut up by small streams which get flooded during the monsoon, but practically cease to flow after January. The hills seldom rise to more than 500 feet and are flat-topped. The slopes are gentle.

The main geological formations exposed are trap, a volcanic rock of recent origin, and metamorphosed sandstones of the Archaean area. The soils derived from the former are a reddish brown loam along slopes and a stiff clay in the basins. The loam is very suitable for teak but not so the clay, because teak requires a well-drained soil. The soils derived from the sandstones are coarse and carry a poor forest except in the valleys.

The average annual rainfall varies from 30 to 75 inches. Nearly 60 per cent of the rain is received between mid-June and mid-September, and another 20 per cent in October and November. The summer is practically rainless, and the humidity goes down to less than 5 per cent.

The temperatures are high, the maximum in shade in summer going up to 115° F. but the minimum seldom goes below 40° F.

In the virgin state, that is before human intereference started, the forest must have been a mixed one with *Terminalia tomentosa, Anogeissus latifolia, Diospyros melanoxylon, Madhuca latifolia,* teak, etc., as the principal constituents, with an admixture of *Lagerstroemia parviflora, Acacia catechu, Boswellia serrata,* etc., in areas with lower rainfall and *Adina cordifolia, Dalbergia latifolia, Syzygium cumini,* etc., where the rainfall was higher. Certain species must have occurred in greater abundance for edaphic reasons, *e.g., Butea monosperma* on stiff soils, *Chloroxylon swietenia* on sandy soils, etc.

As a result of biotic influence, fires, grazing and preferential treatment to certain species, today three types of teak forests are distinguishable:

Moist Type.—This occurs where the rainfall varies from

60 to 75 inches or where a comparatively moister habitat has been created by the absence of adverse biotic factors. The canopy is almost close. The species in the uppermost canopy are deciduous, but for a shorter period than in the next two types. A distinct second storey of smaller trees is formed, which contains some evergreen or semi-evergreen species such as *Saccopetalum tomentosum, Ixora arborea, Syzygium cumini, Buchanania lanzan,* etc., and a thick growth of *Dendrocalamus strictus* bamboo. Climbers are plentiful and large, chiefly *Bauhinia vahlii, Butea superba,* and Lantana.

The undergrowth is dense and consists chiefly of *Petalidium barleriodes, Strobilanthes,* etc. There is a thick growth of coarse grasses such as *Chionachne barbata, Coix,* etc.

Regeneration of teak is absent except for occasional plants, because the seed cannot reach the soil due to heavy weed growth, and the few seedlings that come up cannot develop for want of light.

Semi-moist type.—Here the rainfall varies from 45 to 60 inches, or else the soil-moisture and light conditions have been made favourable in the drier type by a careful closing of the canopy, fire protection, and closure to grazing or *per contra* in the moist forests by canopy opening and light fires. The canopy is somewhat broken and consists entirely of deciduous trees. There is an undefined lower storey of species which are all deciduous. The number of species is less than in the preceding type, and there is a higher proportion of teak. There are fewer weeds and climbers, and the grass growth is sparse. There is plenty of humus in the soil, and enough light reaches the forest floor. Under such conditions teak reproduction is induced. The seedlings survive the hot weather by dying back, the roots still remaining alive. A more and more vigorous shoot is produced and it goes on dying back, until the root-stock becomes strong enough to throw out a shoot which can survive the hot weather, albeit in a moribund condition for want of sufficient overhead light. This process goes on throughout the life of the overwood. If after sufficient advance reproduction has been induced the overwood is clear-felled and the seedlings are cut back, vigorous coppice shoots of teak are obtained from the middle-aged trees and the suppressed seedlings. As teak is a vigorous coppicer and a strong light demander it suppresses other species, and a more or less pure coppice stand of teak is obtained. If bamboos were present in the overwood, they recover from the shock of clear-felling and begin to produce bigger and bigger culms every year. Within 3 to 5 years a condition is reached when the bamboo begins to overtop the teak and retard its growth. If the bamboo growth is kept back by repeated cutting the teak gets up, and eventually a more or less pure stand of teak with bamboos underneath is obtained. Thus is created the ideal forest from the economic point of view, namely an overwood of teak with an understorey of bamboos.

Coppice shoots from the middle-aged trees are more vigorous and vary in number from two to as many as six per stool. The seedling coppice is less vigorous and ordinarily gives only one good shoot. In short, the young crop varies greatly in size and density.

Dry type.—Here the rainfall varies from 30 to 45 inches, or else the conditions in the moister type have been made drier by repeated fires and heavy grazing. The canopy is very open and consists mostly of xerophytic species such as *Boswellia serrata, Sterculia urens,* etc., all of which are leafless for several months. The number of species is much less than in the preceding two types, and the proportion of teak which is a hardy species is higher. The lower canopy mostly consists of deciduous shrubs. There are some thorny climbers, chiefly *Acacia pennata* and *Zizyphus oenoplia.* Grasses are mostly annual. The forest floor receives the full force of the summer sun, and occasional seedlings that come up in the rains are killed. The soil gets tamped by the weight of grazing animals and is also pulverised and later washed away in the monsoon. In short, the conditions are not at all favourable for any advance reproduction of teak to come up.

Formerly, the moist forests were worked by selection-*cum*-improvement fellings, under which teak trees over a specified girth were removed. In congested crops thinnings were carried out. Although these fellings were an effective safeguard against overfelling, by and large, they neither improved the crop nor induced much natural regeneration of teak.

The semi-moist and dry forests were worked under the classical Coppice-with-Standards system, whereunder 20 to 30 standards of teak, and if these were not available of other species, of about 2-2½ feet in girth were left more or less uniformly spaced. As the forests were far from uniformly stocked with good teak trees, in well-stocked patches of teak, poles were cut back immaturely, whereas elsewhere malformed and less valuable trees had to be reserved as standards. The coppicing of the remaining crop also resulted in large blanks or regrowth of less valuable species.

By 1935, the need for suitably modifying the treatment was keenly felt. In so far as the moist forests were concerned, it was decided to create plantations by burning the unutilised debris and planting root-shoots of teak, and attempts were to be made to create conditions for inducing teak reproduction by light burning, advance cutting of bamboos, and opening up the canopy.

In the dry and semi-moist forests, the revised prescriptions aimed at retaining all financially immature trees of teak. When in any place two trees were standing too close to each other, the smaller—which has a lesser value increment, per acre, per year—was removed in the interest of the bigger. Besides this, certain well-formed trees of other species which gave fruit, flower, or other products of economic importance, such as *Madhuca latifolia, Terminalia chebula, Sterculia urens,* etc., were also retained. Some trees were also retained to act as seed bearers or to shade the soil. Such retained trees were collectively referred to as *Reserves,* which were of various species and sizes in a heterogeneous mixture. All other growth was coppiced. By this method, growing space that was occupied by stagnating growth was made available for growth of greater promise to come up, and sacrifice of immature growth was minimised. Grazing was regulated and the forest fire-protected. In consequence, advance reproduction of teak was induced. The value increment of the forests has steadily risen, and the second round of C. W. R. fellings is giving substantially higher returns.

As a further improvement, enrichment plantings have now been prescribed. After the coppice of teak is one or

two years old, the understocked patches can be clearly seen. Stakes are to be put at intervals of 6 feet in lines 18 feet apart, and wherever there is no good coppice within 3 feet of the stake, 1 cubic foot pits are to be dug, spoil earth dispersed, and the pits filled with scraped live-soil and then teak stumps planted.

Later, to create a more or less uniform-sized forest capable of producing large-sized trees it is proposed to convert them by the system of *Balivage Intensif*.

As already pointed out, in the naturally regenerated teak forests the crop was far from uniform in stocking, size, or vigour. Purely mechanical or 'rod' thinnings were, therefore, out of the question. Even the classical 'grade' thinnings were impracticable, as such thinnings are primarily designed for one-aged crops with uniform density and vigour.

Therefore, a rough-and-ready method of selecting the best stems and giving them optimum freedom for development was evolved, which, for want of a better name, was referred to as Single Stem Silviculture, which in practice it was. It was assumed that in these coppice crops, it would be sufficient if the best stems are selected and given the same freedom as is given to individual stems of particular sizes in uniform crops.

The All-India Teak Yield Tables showed that in normally stocked plantations there was a definite correlation between *the Number of stems per acre* and *the Crop diameter*, no matter what the quality or age of the crop. Observations in crops of coppice origin which are faster growing in the beginning, however, showed that the Yield Table N per acre for a particular crop diameter was too high and left the crops congested.

The yield table N/d correlation figures were, therefore, readjusted, as set out in the subjoined table.

Crop diameter, in inches	Number per acre		Average spacing for M. P., in feet
	Yield Table	M. P. optimum for coppice	
5	2	3	4
2	900	625	9
4	440	350	12
6	240	225	15
8	145	155	18
10	105	115	21
12	80	88	24

It was found that the number of elites per acre (N), the average espacement in feet (D), and the crop-diameter in inches (d) were correlated as under:

$$N = \left(\frac{150}{d+4}\right)^2 \quad .. \quad (1)$$

$$\text{and } D = 1.5\,(d+4) \quad .. \quad (2)$$

The second formula was used as the guide for determining the optimum distance between two adjacent stems retained by taking d as the average diameter of these stems. Thus, suppose two adjacent stems have diameters of 4 and 8 inches respectively, then the ideal distance between the two will be

$$D = 1.5\left(\frac{4+8}{2} + 4\right) = 15 \text{ feet}$$

A variation of ± 2 feet was considered permissible. Thus, if the distance between them was 13 to 17 feet, they were considered properly spaced and both were retained. If they were found to be standing closer than 13 feet the less valuable one was to be felled. If the distance between them was more than 17 feet they were considered over-spaced, and to prevent lopsided development of their crown into this gap, an interior stem, courtesy elite, was retained to side-prune their branches. It was even contemplated that, in valuable forests, this gap might be filled up by teak or bamboo. The next nearest elite was then examined and a decision taken whether both were to be retained or one of them was to be removed and if so, which one. And so on.

To check the average density of elites thus retained, they were enumerated over small check-plots and the N per acre for the average crop diameter computed from formula (1). To this were added the chance gaps between elites. If the figure was within 20 per cent of the theoretical N, the crop was considered properly tended.

Extensive areas containing young coppice crops of teak have thus been treated to Single Stem Silviculture, to which they have responded so well that after a few years, when the rate of height growth more or less culminates, uniform canopied crops—but with considerable variation in size—have been obtained, which have been aptly described as "natural" plantations.

The first tending is prescribed at the age when the "top height" is 25 to 30 feet, by which time the vigorous stems more or less declare themselves. This height is reached earlier on better sites. The crop diameter at a particular age is also greater the better the quality.

It was, therefore, suggested that the cycle of thinning should be so prescribed that whenever a thinning is needed in the poorer sites an earlier thinning is done in the better sites so that entire crops are simultaneously treated to Single Stem Silviculture.

The following rough correlation between age, site quality, and crop-diameter is considered most suitable.

Thinning		Age for site quality		Crop Density		
		Good	Poor	N. per acre	Corresponding (D)	Crop diameter (d)
1		2	3	4	5	6
		Years	Years	No.	Feet	Inches
I	..	5	10	500	10	2.0
II	..	10	20	300	13	3.5
III	..	20	40	200	16	5.0
IV	..	40	60	120	20	7.0
V	..	60	—	80	24	9.0

It is not contended that this is the ideal thinning regime. The only merit claimed is practicability and the fact that it will provide a standard—albeit rough and ready—by which the merits or demerits of the so-called "Commonsense" thinnings can be gauged. Once it is established by experimentation that there is a definite correlation between N and d, which is independent of age or quality (even approximately), the proposed method can be used to tend crops to obtain the highest yield of trees of a particular

size from a plantation as the requisite number of elites can be pre-selected and then thinnings carried out in their interest.

RESUMES

La sylviculture "artificielle" et la sylviculture "naturaliste"

Le présent rapport décrit l'aménagement des forêts tropicales composées de diverses essences à feuilles caduques de la région du centre de l'Inde. Economiquement, la forêt idéale est un sous-étage de bambous sous une futaie composée uniquement de teck. On peut distinguer trois sous-types généraux:

1. la forêt *humide,* dans laquelle la régénération naturelle du teck ne peut s'effectuer en raison de la présence d'une couverture végétale épaisse et d'un dôme de feuillage très dense;
2. la forêt *semi-humide,* dans laquelle se produit une bonne régénération naturelle du teck;
3. la forêt *sèche,* dans laquelle il ne se produit aucune régénération naturelle du teck en raison des incendies fréquents, du pâturage excessif et du degré élevé d'ensoleillement.

Auparavant, l'exploitation des forêts humides se faisait au moyen de coupes sélectives et de coupes d'amélioration. Ces coupes n'amélioraient pas la forêt de façon appréciable. Les forêts semi-humides et les forêts sèches étaient exploitées selon la méthode de taillis sous futaie. Etant donné le fait que les forêts sont de composition et de densité très irrégulières, cette méthode exigeait de lourds sacrifices. Ici encore, la cépée ne renfermait pas beauco up de teck.

Pour remédier à ces inconvénients, une nouvelle méthode a été mise au point. Dans la forêt humide, les peuplements sont reconstitués dans certaines zones appropriées au moyen de plantations de teck, ou, dans d'autres cas, les conditions favorisant la régénération naturelle du teck, sont recréées au moyen d'éclaircies pratiquées dans la voûte de feuillage, de légers feux et de coupes de bambous.

Pour les forêts semi-humides et sèches, on a mis au point un système appelé taillis avec réserves qui a pour objet de "réserver" tous les arbres bien développés de teck et d'autres essences de valeur. En plus de ceux-ci, on retient également les arbres présentant une importance économique, ainsi que d'autres dont on a besoin pour des raisons de sylviculture. Ces forêts font l'objet de mesures de protection très strictes contre les feux, et le pâturage est également contrôlé.

Le taillis qui se constitue après un tel traitement contient, au second cycle, une proportion beaucoup plus élevée de teck. Les lacunes qui peuvent se présenter seront comblées par des plantations d'enrichissement de teck au moyen de semis en poquets.

Le taillis de teck résultant de ces opérations n'étant uniforme ni en densité, ni en vigueur, on a mis au point une méthode connue sous le nom de "sylviculture sélective" qui consiste à isoler les jeunes plants de teck les mieux venus et les plus prometteurs et à leur donner l'espace optimum pour leur développement.

Les résultats ainsi obtenus ont été des plus satisfaisants. Le rendement a augmenté au second cycle et l'accroissement de la valeur des forêts est également en hausse continue.

Eventuellement, on se propose, au troisième cycle, de convertir les jeunes arbres de tailles diverses en peuplements uniformes par le système du balivage intensif, ce qui permettra d'obtenir une forêt normale de teck renfermant des peuplements de taille uniforme, échelonnés depuis le jeune plant jusqu'à la haute futaie, dans des parcelles d'égale superficie.

La Silvicultura de "Huerto" y la Silvicultura "Naturalista"

Se describe la administración de bosques tropicales mixtos deciduos, sin lluvias veraniegas, de la región central de la India. La especie preponderante es la teca con un subestrata de bambú. Existe tres tipos de bosque:

1. el *húmedo,* en el cual no hay regeneración natural de la teca porque la gran cantidad de maleza y la densidad del arbolado lo impiden;
2. el *semi-húmedo* en el cual se nota en abundancia la reproducción de la teca; y
3. el *seco,* en el cual no hay regeneración alguna de la teca debido a los frecuentes incendios, y al exceso de apacentamiento y de sol.

Anteriormente los bosques húmedos se trabajaban por el sistema de cortas con selección y mejora. Con este método no se logró adelanto alguno en los bosques. En los semi-húmedos y los secos se siguió el sistema de tallar con resalvos. Como estos bosques eran muy irregulares en lo que respecta a densidad y composición, el método causó muchos sacrificios. Además, al volver a crecer el soto ampoco contenía mucha teca.

Para remediar estos defectos se han introducido nuevos procedimientos. En el tipo húmedo se procede a regenerar artificialmente las regiones apropiadas plantando nuevos árboles de teca, o si las condiciones son favorables para su regeneración natural se está cambiando y adaptando el copaje, se está quemando la maleza y cortando el bambú.

En los bosques semi-húmedos y secos se emplea el sistema de tallar con reservas, con objeto de reservar todos los árboles bien desarrollados de teca y otras especies valiosas. Además de éstos, se retienen también los de importancia económica, así como otros tipos de vegetación que se necesitan por razones de silvicultura. Los bosques están rígidamente protegidos contra incendios y se regula el pastoreo.

La cosecha de soto obtenida después del empleo de este método contiene en el segundo ciclo gran cantidad de árboles de teca. Los claros que queden se llenarán con plantíos de teca en fosos.

Puesto que la teca cultivada en estas condiciones no es uniforme ni en densidad ni en vigor, se ha adoptado un sistema de cultivo llamado de Silvicultura de Tallo Individual mediante el cual se seleccionan los retoños de teca más prometedores y se les dá el óptimo espacio de crecimiento.

Los resultados han sido altamente halagadores. El rendimiento ha aumentado en el segundo ciclo y los bosques aumentan constantemente en valor.

Con el tiempo, en el tercer ciclo, se proyecta convertir estos árboles de distintos tamaños en bosques uniformes, siguiendo el método llamado de *balivage intensif,* para lograr obtener así un bosque normal de teca, con tamaños uniformes de crecimiento, desde los más pequeños hasta los más grandes, en zonas similares.

Forest Management and Working Plans In Japan

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The islands of Japan, located east of the Asiatic continent, have an area of 380 thousand sq. km., 67 percent of which is forest land.

Ancient Japan was covered with dense forests. With the advent of human habitation, forests were exploited, and rural communities were formed. Toward the end of the 16th century, feudalism had its inception, and commodity economy was remarkably developed and with it forestry management made its appearance.

During the Tokugawa era (1603-1868), feudal lords resided in every district in Japan, and governed a greater part as the clan-forests. Many of them prohibited, in their domain, farmers from cutting such valuable trees as Sugi (*Cryptomeria japonica*) and Hinoki (*Chamaecyparis obtusa*), which were important financial resources in the clan economy. These forests were converted to national forests in the Meiji era as a worthy legacy.

Sharing-forest is a system in which the feudal clan, the land-owner, leased the land to farmers under planting contracts. When the forests matured, the yields were shared between the clan and the farmers.

The so-called farm-forest was a forest managed by a consensus of the villagers for collection of their firewood, charcoal, logs, grass, and for grazing. Forest lands in some districts were acquired by private owners, but their areas were not so large.

In 1868, sovereignty was restored to the Emperor, and in 1872, the land reformation policy did away with the feudalistic land ownership. The Meiji Government divided the forest land into national, community, and private forests. (The Imperial Household forest began to be organized in 1885 and, in 1947, was amalgamated with the national forests.) In 1879, the Forestry Bureau in Japan was established, and the management of national forests and the policy towards community and private forests began to display an active development.

It was in 1890 that the first provision for management plans for national forests was enacted, but the first plan was prepared in 1894 by Dr. T. Shiga, who studied at Tharandt Forestry College in Germany. Details of this plan followed the pattern of Germany. In order to decide the period of rotation, the forest-rent theory (Waldreinertragstheorie) was adopted at first, but in 1902, this was replaced by the soil-rent theory (Bodenreinertragstheorie), but actual rotations of high forests were about 100 years or more, and no remarkable change occurred during the Meiji and Taisho periods. A number of methods to determine the amount of allowable cut were employed, including area control, volume control, combined area and volume control methods, Judeich's stand method, several formula methods, etc. As to the silvicultural system, clear cutting, selective cutting, and other systems were practiced. The provision was revised in 1948.

A noteworthy achievement in the private forest policy was the enactment of a forest law in 1897. The law was revised in 1907 and again in 1939, which revisions provided for the management system for private forests, and the forest owners' associations were authorized to prepare and follow the management plans as were members of commercial undertakings.

During the Taisho period (1912-1926), our lumber, paper, and pulp industries made greater progress, and timber imports increased gradually. While in 1914, the domestic timber production was 7,640 thousand cubic meters and imported timber was 326 thousand cubic meters, in 1924, the former was 15,991 thousand cubic meters, and the latter increased to 3,650 thousand cubic meters, and in 1935, the former was 18,817 thousand cubic meters, the latter was 2,220 thousand cubic meters, and the import from overseas colonies was 2,330 thousand cubic meters.

In the Second World War, reckless cutting was resorted to for war purposes. As the result of the increasing demand for forest products during and after the war, it was necessary to cut forest trees much in excess of the annual cut specified in the program, thereby exhausting the forest resources and reducing more and more their productivity. On the other hand, as a result of the release of unreclaimed land for the transformation of forest or wild land into farmland, more than one million hectares were purchased by the Government as of 1950, and a considerable portion has actually been converted into farmland.

These situations called for further revision of the forest law in 1948 and in 1951. The features stipulated in this revised law are the forest planning system, control of cutting, and the forest owners' associations.

The planning is formed and executed in accordance with the following principles: (1) control of the amount of cut, taking into account balances between the growth of forests and the demand for timber throughout the country; (2) prohibition of clear cutting of too young stands and promotion of thinning; (3) reforestation of cleared, cut-over, and unstocked areas and conversion of low productive stands to more productive ones; (4) establishment of forest roads and other matters involved in transportation facilities for forest products; and (5) designation and control of protection forests. In return for these controls, the Government subsidizes private and community forests for their expenses of reforestation and construction of roads, etc.

Details of Forest Planning at Present

Forest planning comprises the national basic plan, the general management plan, the working plan for private and community forests, and the management and working plans for national forests.

The National Basic Plan

Under this plan, the whole country is divided into basic plan regions, totaling 251, each of which covers a main watershed, by each prefecture embracing the whole forest, national as well as private and community forests in each area. The plan is redrawn every five years by the Minister of Agriculture and Forestry, on the basis of results obtained from surveys and matters concerning forest management and the forest economic situation. The chief objective of this plan is systematic execution of the plan by sound management to achieve rational exploitation, utilization, and conservation of the forest resources in each region, and maintenance of the productivity of the forests.

The General Management Plan for the Forest Districts

Every five years, each Prefectural Government revises its general management plan for private and community forests. This is done on the forest districts, totaling 2,096 in the whole country. For each district, a management plan is drawn for the whole area, not for the forest of each private owner. Each plan specifies the allowable limit of cutting and the minimum area to be planted for the working period.

For restriction forests (protection forests, national parks, etc.), the species and the cutting system are specified for each forest, the harvest being restricted to a limit based on the amount of standing timber.

Forests for special use (fruit, leaves, bark, etc.) and forests for home use are designated as such by the Prefectural Government on application by each forest owner. No restriction is placed on cutting in these forests.

The legal provisions of the Ministerial Ordinance require for the ordinary forests (all private and community forests which are not restriction, special-use and home-use forests) that the cutting of standing conifers belonging to the age-classes lower than the limited age-class shall be restricted, unless permission is obtained, and that the amount of the cut shall not exceed the limit expressly specified under the same provisions. With regard to the cutting of standing conifers belonging to an age-class higher than the limited age-class and for all hardwoods, reporting the prospective cutting to the Prefectural Governor concerned is all that the legal provisions require. No restriction is placed on the amount cut from these stands. The limited age-class is determined by the major species which are found in each district subject to forest planning, taking into account the utility and profitability of cut timber and the period of average maximum yields (for example: Sugi 36-60 years; Pine 26-50 years). For people who cannot get permission to cut their stands, the Government helps by making loans with low interest.

The Working Plan for the Working Circles

These plans are prepared annually by the Prefectural Government, on the basis of the forest district management plan for the private and community forests involved therein. They serve as a means of insuring planting by each forest owner of areas in need of reforestation and of restricting the amount cut.

The Management and Working Plans for National Forests

Under the national basic plan, each chief of a regional forestry office (governing national forests), forms a five-year management plan for the national forests. The planning is done by the management plan unit, totaling 106 in the whole country. The regional forester executes the plan approved by the Minister of Agriculture and Forestry. He also prepares and executes the annual working plan for each working unit, totaling 410.

The features of these newly revised provisions for management plans for the national forests are as follows:

1. The unit area for management plans is the management plan unit, which consists of several working units.
2. One management group extends over in the management plan unit, not in each working unit, and it is said not as a unit of regulation of yields, but as that of control management.
3. Rotation is decided for several years before and after the period of average maximum yield, taking into account the utility and profitability of cut timber. Actually, those of high forests are usually 40-60 years.
4. Calculation of allowable cut is set on the basis of growth of the whole area, but it is permitted to cut more then periodic growth, if it is expected to increase future growth.
5. To estimate accurately the growing stock and increment in the whole area, an inventory using the sampling method combined with aerial photogrammetry is put into practice.

Insofar as forest planning in Japan is concerned, great emphasis is placed on economic policy, all on national, community, and private forests. Some plans in these programs seem to have characters somewhat different from those of management plans in other countries. The current forest planning pursues the objective of contributing to the development of the national economy by fulfilling the large demand for timber. For this objective, we should devote unprecedented efforts by fostering the continuous productivity of the forest and the territorial integrity thereof.

After 1949, the reforested area gradually increased and came to exceed the area being cut over, and now we have already accomplished almost all planting for unstocked areas, and plantation after cutting of natural stands is also expanding rapidly, on national, community, and private forests.

Tending and thinning for young stands, protection from diseases and insects, tree breeding, introduction of exotic species, etc., are enforced. Besides, soil surveys are carried out to prepare soil maps, and chemical fertilizing for forest lands is tested.

On the other hand, construction of new forest roads for exploiting inaccessible forests, improvement of railroads, truck roads, and extension of cableways are going on in many parts of the country, and mechanization of logging operations is also progressing.

In my opinion, we must devote much more effort to combine silvicultural and logging techniques with economy, and to contribute to the development of the national economy by fostering the continuous productivity of our forests.

RESUMES

Aménagement des forêts et plans de travail forestier au Japon

Dans ce rapport, l'auteur expose l'histoire, la situation actuelle et les caractéristiques de l'aménagement forestier nippon et de ses plans de travail.

Le premier plan d'aménagement de notre domaine forestier national fut établi en 1894. La loi sur l'aménagement forestier fut promulguée en 1897 et revisée en 1907 et 1939. Ces dernières revisions prévoyaient l'aménagement du domaine forestier privé.

La demande croissante portant sur les produits forestiers causée par la guerre et l'après-guerre a conduit à l'épuisement des ressources sylvestres et à la réduction de la productivité des forêts. La Gouvernement japonais modifia la loi sur l'aménagement forestier en 1948, puis en 1951, y introduisant un système de planification pour la sylviculture. La planification forestière comprend:

1. Le plan national de base, préparé par le Gouvernement sur la base des plans régionaux, et couvrant les forêts domaniales, communales et privées.
2. La plan général d'aménagement pour la Conservation régionale des forêts.
3. Le plan de travail pour la Conservation préfectorale.
4. Le plan d'aménagement pour l'unité d'aménagement et le plan de travail pour le rayon local de travail forestier.

Les points (2) et (3) du plan sont préparés par la Conservation de la Préfecture pour les forêts communales et privées, tandis que les plans du point (4) sont préparés par la Conservation régionale des forêts pour toutes les forêts domaniales de la région. Les différents plans sont établis de manière à s'intégrer harmonieusement les uns avec les autres.

Certains de ces plans sont établis en liaison avec des plans économiques, et tous ont certaines caractéristiques uniques si on les compare avec des plans de même nature établis dans d'autres pays.

Administración y Planes Activos Forestales en el Japón

En este trabajo, el autor describe la historia, situación y características de la administración y planes de trabajos forestales en Japón. Fue en 1894, cuando se preparó el primer plan administrativo de nuestros bosques nacionales en el Japón. La ley forestal fue aprobada en 1897 y enmendada en 1907 y 1939, por la que se proveía el sistema administrativo para bosques de propiedad particular.

Como resultado de la creciente demanda de productos forestales durante la guerra y después de ella se extingieron los recursos forestales y se redujo su productividad.

El Gobierno japonés enmendó la ley forestal en 1948, y después en 1951, y sus puntos principales dieron origen al sistema de planes forestales. Los planes forestales comprenden:

1. El plan básico nacional, preparado por el gobierno nacional para regiones de plan básico, inclusive bosques nacionales, colectivos y particulares.
2. El plan general de administración para cada distrito forestal.
3. El plan de trabajo para los círculos de trabajo.
4. El plan administrativo para las unidades de plan administrativo, y el plan de trabajo para las unidades en funcionamiento.

(2) y (3) fueron preparados por el gobierno prefectural para las comunidades y los bosques de propiedad particular, y (4) fue preparado por la oficina regional de bosques, dependiente de la nacional. Todos los planes se formularon coordinándolos entre sí.

Algunos planes siguen cierta dirección económica, y todos tienen rasgos excepcionales en comparación con planes de otros países.

Determination of the Current Accretion of Stands By the Lateral Surface of Trees

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Raising the productivity of forests is one of the most important tasks of forestry. To accomplish this task requires an individual approach to the different plantations and a consideration of the peculiarities of their growth. The intensity of forestry is characterized by the amount of the so-called current accretion. In view of this, it must be concluded that the solution of the problem of raising the productivity of forests is connected with the consideration of the amount of the current accretion of the plantations. The current accretion is a quantity by which the given valuation index (diameter, height, volume, etc.) changes during a definite time in the life of the tree or the plantation, for example, during the past year. It is found as the difference in the value of the particular valuation index at the given moment and a year before.

The change in the valuation indices of a tree of plantation taking place in the course of one year is hard to calculate because it is negligible, and the valuation measurements are not very accurate. For this reason the current accretion is, more often than not, determined by the differences in the valuation indices not for one year, but for 5, 10, and more years. For example, the current annual accretion in size is taken as equal to the difference in the sizes of the tree observed at the given time and 10 years previously, divided by 10.

Instead of the current accretion, such determination yields the average annual accretion observed during the past 10 years in the life of a tree. Thus, the theoretical idea of the current accretion is somewhat different from the actually established accretion.

In forest organization it is the average accretion determined by dividing the arboreal stocks by the age of the plantations that is most frequently taken into account. However, the average accretion offers a clearly erroneous

idea of the real productivity of the little cultivated northern and northeastern forests (the forests of the European North, Siberia, and the Far East).

The greater part of these forests consists of ripe and overripe massifs. The actual accretion in these forests has, therefore, either completely stopped or is very insignificant. But in determining the average accretion by means of dividing the available wood stocks by the age of the plantations in all cases (however high the age of the plantations), the accretion turns out to be a positive quantity. Thus, this positive quantity does not reflect the real productivity of the forests—their real accretion. Considering this, when taking stock in the northern and northeastern forests, it is necessary to determine the current, rather than the average, accretion of the plantations.

The question of calculating the current accretion is not new. Over a period of many decades a number of methods have been elaborated, these methods making it possible to determine the current accretion in individual trees and whole plantations. However, the essential shortcoming of these methods is the extensive labour-consuming nature of the operations, as a result of which the current accretion is found, but the results obtained are inaccurate.

Finding new methods and further improvement of the existing methods of determining the current accretion of the plantations constitute an urgent problem.

The present article is on the method worked out by the author for determining the current accretion of the trees by the average thickness of the annual layers and the area of the lateral surface of the trunks forming the plantation.

As is well known, the growth of a tree is the result of the activity of the cambium which annually deposits a ring of wood. In connection with this, when the amount of the accretion is being established it is necessary, in the first place, to find out the area of the cambium which produces the wood. The cambium is a thin layer of living cells that separates the wood proper from the layer of bark and thus covers the entire lateral surface of the trunk. Correspondingly, the area of the cambium which produces the wood equals the area of the lateral surface of the trunk, taken without the bark. In view of this, when searching for ways and means of determining the current accretion, it is, first of all, necessary to find out the area of the cambium or the area of the lateral surface of the trunks.

Our task includes the elaboration of a method for determining the accretion, not of an individual tree, but of a plantation taken as a whole. With such a task it is necessary to determine the area of the lateral surface of the aggregate of trees forming the plantation.

The average sizes of trees and their number on a unit of area can be found in tables showing the course of growth of plantations based on considerable experimental material. The tables showing the course of growth for the plantations with a 10-year age interval give the diameter ($D_{1,3}$), height (H), and species number (f) of the average tree. On the basis of these data it is possible to determine the area of the lateral surface of the trunk (S).

By multiplying this quantity (S) by the number of trees (N) per hectare, provided by the tables showing the course of growth of the plantations, we find the area of the lateral surface of all the trunks (ΣS) forming a normal plantation.

$$\Sigma S = S \cdot N \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

When determining the lateral surface of the trunks, we find in the tables showing the course of growth their average diameters breast high in the bark. We therefore reduce them by a double thickness of the bark (2t):

$$D_{1,3} - 2t = D'_{1,3} \text{ (without the bark)} \quad \ldots\ldots\ldots (2)$$

As a result of this operation, we get the diameter of the average tree, breast high without the bark.

With the aid of the table of specific numbers drawn up by M. Tkachenko, by the height of the average tree and specific number taken from the tables showing the course of growth of plantations, we find the coefficient of the trunk shape (q_2).

As the basis of our calculations we took the tables showing the course of growth of plantations, drawn up by Vargas-de-Bedemar for the forests of the Leningrad Region. Since these tables lacked the data on specific numbers, the latter were obtained by dividing the table stocks (M) into the product of the sum of the areas of cross-sections by the average height (ΣgH). It follows that the specific number was found by the formula:

$$f = \frac{M}{\Sigma gH} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

By multiplying the breast-high diameter of the average tree with the bark ($D'_{1,3}$) by the coefficient of the shape (q_2) we get the diameter of the trunk without the bark at the middle of its length:

$$d_{av} = D'_{1,3} \cdot q_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

We multiply the average diameter without the bark by "π" and find the length of the circumference at half the height of the trunk:

$$l = \pi \cdot d_{av} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

By multiplying the length of the circumference by the average height of the trunk we get the area of its lateral surface:

$$S = l \cdot H \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

As stated before, the lateral surface of the trunks of all trees forming a plantation is found by multiplying the area of the lateral surface of the trunk (S) of average size by the number of trees (N) per hectare in a full normal plantation, provided by the tables showing the course of growth of plantations. Such calculations determining the areas of the lateral surface of the trunks were made applicable to Vargas-de-Bedemar's tables for all ages and all classes of bonitation. They are shown in Table 1.

An analysis of the figures in Table 1 warrants the conclusion that the area of the lateral surface, or the area of the cambium, of trees forming a plantation during a period of about 100 years remains almost constant.

During various decades it changes by 300-400 square metres or not more than 5 per cent of the total area of the lateral surface of the trunks. Such discrepancy in the area of the lateral surface of the trunks is within the limits of accuracy of the calculations accepted in drawing up the tables showing the course of growth of plantations.

The area of the lateral surface of the trunks for the main arboreal species was found as a result of much

Table 1. Lateral surface of the trunks in pine plantations, established on the basis of Vargas-de-Bedemar's tables showing the course of growth of plantations per hectare.

Bonitation class	Age of plantations, in years											
	40	50	60	70	80	90	100	110	120	130	140	Average
	Lateral surface (ΣS), in 1,000 m.²											
I	8,0	7,3	8,1	7,7	7,7	7,8	7,7	7,5	7,7	7,7	7,7	7,7
II	6,6	7,1	7,5	7,5	7,2	7,3	7,6	7,6	7,6	7,6	7,6	7,5
III	5,9	6,5	7,0	7,4	6,9	6,9	6,8	6,8	6,9	6,8	6,9	6,8
IV	5,6	5,8	5,9	6,5	6,3	6,2	5,8	5,9	5,8	5,6	—	5,9
V	4,3	4,9	5,2	5,1	5,3	5,1	—	—	—	—	—	5,1

labour-consuming research. At the same time, it was shown that the above-mentioned regularity, manifesting itself in the constancy of area of the lateral surface of the trunks which form the plantation, is typical of all the species studied—pine, fir, birch, aspen and black alder.

Owing to this, we have come to the conclusion that in determining the current accretion of middle-aged, maturing, and mature plantations, we may, without great error, accept the area of the cambium or the lateral surface of the trunks as a constant. The following are the calculations made in pine plantations applicable to the tables of the course of growth of plantations drawn up by Vargas-de-Bedemar:

Bonitation class	I	II	III	IV	V
Area of the lateral surface of the trunks, in 1,000 m.²	7,7	7,5	6,8	5,9	5,1

The lateral surface of the trunks (ΣS) forming a plantation is a peculiar "sown area" in which the wood "grows" or, in other words, layers of wood are annually deposited.

The constancy of the lateral surface of the trunks (ΣS-Const) preserved in coniferous plantations for 100 years and in deciduous species for 50-70 years at first sight appear to be at variance with the laws of forest growth since, with an increase in the age of the trees, their sizes invariably also increase and, at the same time, the total stock of wood likewise increases. Everything else being equal, the larger trees with the greater wood stock must also have a larger lateral surface.

However, the development and growth of a plantation differ from those of an individual tree. While a tree annually, to the end of its life, increases in volume by depositing annual rings of wood, two processes simultaneously operate in a plantation composed of an aggregate of trees: the greater number of trees deposit annual layers and thus increase their volume, whereas some trees cease to grow, dry up, are felled by the wind, or are cut down during the forest maintenance cuttings.

Thus the growth of trees, on the one hand, and the self-rarefication, on the other hand, change the lateral surface of the trunks, forming the plantation, in different directions. The growth of the trees increases the area of the lateral surface of the trunks, while the self-rarefication of the plantation reduces the area of the lateral surface of the trunks.

Given the lateral surface of the trunks, to determine the current accretion by volume, it is necessary to find only the average thickness of the annual layer (t). By multiplying the area of the lateral surface of the trunks (ΣS) by the thickness of the annual layer, we find the current accretion of the plantation by volume or by stock:

$$Z = \Sigma S \cdot t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

According to this formula, the current accretion in full or normal pine plantations of different bonitation classes is as follows:

$$Z_I = 7{,}7 \cdot t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$
$$Z_{II} = 7{,}5 \cdot t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$
$$Z_{III} = 6{,}8 \cdot t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$
$$Z_{IV} = 5{,}9 \cdot t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11)$$
$$Z_V = 5{,}1 \cdot t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

The amount of the current accretion depends on the fullness of the plantations. In connection with this, the final formula determining the current accretion will be as follows:

$$F = \Sigma S \cdot t \cdot P \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (13)$$

where P is the fullness of the plantation.

The thickness of the annual layers is usually measured in mm. In the foregoing formulas the mm. are likened to m., in other words, the average thickness of the annual layer is increased 1,000-fold. Corresponding to this increase, the area of the lateral surface of the trunks (ΣS) is reduced 1,000-fold.

As a result of multiplying the area of the lateral surface of the trunks (ΣS), reduced 1,000-fold, by the thickness of the annual layer (t), increased 1,000-fold, we get the current accretion by volume of stock in cubic metres per hectare of plantation.

In growing trees, the thickness of the annual layers is usually found with the aid of Pressler's perforator.

Experience shows that the width of the annual layers in trees differs on different sides of the light. Bearing this in mind, it is necessary to drill the cylinders of wood with the idea that about an equal number of cylinders may be drilled on the northern, eastern, southern, and western sides.

Within the limits of a homogeneous plantation, the choice of trees to take samples for accretion should be made purely mechanically. For example, along the course of the valuator, value samples of accretion may be taken from every 20th tree, 30th tree, etc.

To simplify the method of determining the current accretion of plantations, we have transferred the solution of the problem from the sphere of algebra to that of geometry. For this purpose, applicable to the formula

determining the current accretion, we have built a special nomogram* (Figure 1).

The points showing the thickness (in mm.) of the last 10 annual layers for pine trees of all five bonitation classes are found on the left-hand scales of this nomogram. The scales on the right-hand side of the nomogram show the fullness of the plantation also for all five bonitation classes. In the middle of the nomogram there is a scale determining the current accretion of the plantations per hectare in cubic metres.

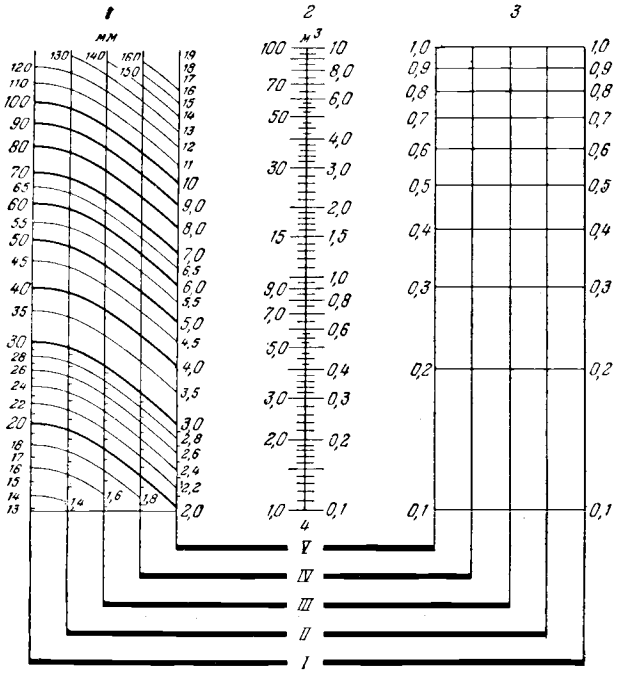


Figure 1. Nomogram to determine the current growth accretion of pine plantations.

1—Width of the last 10-year strata; 2—Accretion; 3—Thickness; 4—Classes of bonitation.

The method for using the nomogram is illustrated with an example.

Let us assume we are valuating a pine plantation of the II bonitation with an 0.7 fullness. The width of the last 10 annual layers of the trees forming the given plantation turned out to be 9 mm.

In the left-hand part of the nomogram, on the second axis, we find a point of intersection of this axis with a curve marked "90-9." To the right of the second axis in the right-hand part of the nomogram we find a point at which the second axis crosses a horizontal line marked "0,7-0,7."

We apply the edge of the ruler to these two points. In this case, the ruler will cut off point "4,75" on the middle scale. This means that in the plantation being valuated the current accretion equals 4,75 cubic metres.

To facilitate the reading by the nomogram after finding one point, the tip of a pencil should be placed on this point and the edge of a ruler applied to the tip of the pencil. Using the tip of the pencil as a fulcrum, we turn the ruler around it with the idea of crossing the other requisite point with the edge of the ruler. After this, we find the result sought for on the middle scale.

The foregoing method simplifies the calculations aimed at establishing the amount of the current accretion of the plantation.

However, this simplified method also requires cylinders of wood to be drilled out of the trees in order to establish the thickness of the annual layers.

For this purpose, we have proposed an accretion probe which is inserted into the wood by a percussive method. The construction of this tool is shown in Figure 2.

The cylinders of wood removed by the probe show lesser deformation than those drilled out by the accretion perforator.

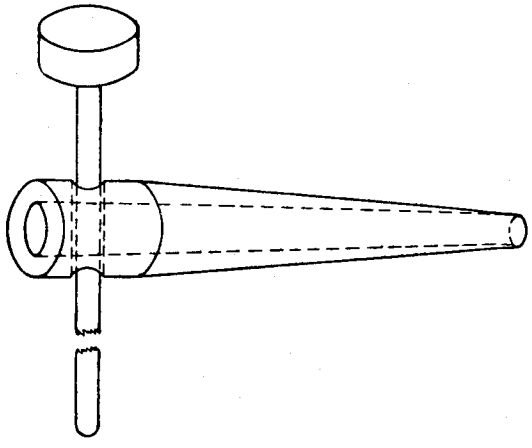


Figure 2. Accretion probe.

* The purely mathematical methods and calculations used in building the nomogram are not considered.

RESUMES

Comment déterminer le taux d'accroissement des peuplements par la superficie laterale des arbres

La croissance d'un arbre est le résultat de l'activité du cambium, qui constitue chaque année un nouveau cerne, ou accroissement annuel. Le cambium est une mince couche de cellules génératrices comprise entre le bois et le liber. La superficie du cambium est égale à celle de la surface latérale du tronc, considéré sans l'écorce. Pour déterminer le taux d'accroissement, il faut donc établir d'abord la superficie latérale du tronc.

Dans toute forêt de conifères de plus de 100 ans, la superficie de la surface latérale des arbres qui constituent le peuplement demeure à peu près constante pendant une centaine d'années. Ce principe étant admis, il est maintenant plus simple de trouver le taux d'accroissement courant. On multiplie la superficie constante de la surface latérale des arbres, établie pour des peuplements dans chaque classe de qualité, par l'épaisseur moyenne des cernes annuels et ensuite par le nombre d'arbres composant le peuplement. Le chiffre trouvé est égal au volume de l'accroissement courant pour le peuplement considéré. On détermine l'épaisseur des couches annuelles en découpant, à l'aide d'une perforatrice spéciale, de petits cylindres-échantillons dans le tronc d'un arbre sur 20 ou 30.

Notre nomographie permet de calculer le taux de l'accroissement courant en utilisant l'épaisseur moyenne de dix cernes annuels, le nombre d'arbres composant le peuplement et la classe de qualité.

Determinación del Incremento de las Plantaciones por la Superficie Lateral de los Arboles

El crecimiento de un árbol es el resultado de la actividad del cambium, que anualmente deposita un anillo de madera. El cambium es una delgada capa de células vivas que separan la madera propiamente dicha de la capa de corteza. La zona del cambium iguala a la zona de la superficie lateral del tronco, tomado sin corteza. Por tanto, para determinar el incremento actual es necesario hallar primero la zona del cambium o la de la superficie lateral del tronco.

En todo bosque de coníferas de más de 100 años la zona de la superficie lateral de los árboles que forman el rodal permanece casi constante durante un período de 100 años. Basándose en esta ley es mucho más fácil determinar el incremento actual. La zona constante de la superficie lateral de los árboles, establecida para rodales en cada clase de "medio estacional" se multiplica por el espesor medio de los anillos anuales y después por el conjunto del rodal. El resultado iguala al volumen del incremento actual del rodal. Cilindros se extraen con taladro de 20 a 30 árboles para determinar el espesor de las capas anuales.

Nuestra fórmula permite calcular el incremento actual empleando el espesor medio de 10 anillos anuales, el conjunto del rodal y la clase de medio estacional.

General Regularities In the Growth of Oak Plantations

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The total area of the state stock of oak forests constitutes 8,511,000 hectares, 40 per cent of these having high-trunk trees (with high felling ages) and 60 per cent having low-trunk trees (with lowered felling ages).

The average age of the high-trunk oak forests is 50 years and that of the low-trunk forests is 35 years. Being located in the zone of most intensive forestry, the oak forests have half the average age compared with all the other Soviet forests. The average stock per hectare of oak forests constitutes 84 cubic metres, whereas the average stock of all Soviet forests is 110 cubic metres per hectare.

The most favourable conditions for oak growing are found in the Ukrainian and Byelorussian Republics and in the central chernozem regions of the RSFSR, where the productivity of the plantations is characterized by the highest bonitations (I-III). Less productive plantations (III-IV bonitations) are growing in the foothills of the Urals and the Caucasus and in the Far East.

In the total forest stock of the USSR the area covered by oak groves is rather small (about 1.5 per cent). But the importance of the oak groves, as a source of valuable wood, a landscape element, and a powerful natural defense factor, in the country's national economy is enormous. In part, this finds its expression in the great attention devoted to the oak in forest research. The fruit-bearing, the processes of natural renewal by seed and shoots, the agrotechnique of plants, selection, maintenance measures, methods and ages of felling, and a complex of other forestry and biological questions have long since been subjects of profound study. During the last ten years, as a result of collective works of forest research and experimental institutions and higher educational establishments, capital monographs devoted to the oak groves of various large forest-growing areas in the USSR have been published.

However, insufficient attention was devoted in the past to the growth and productivity of the oak groves. In part, so far only tables showing the course of growth of shoot oak forests, drawn up by B. Shustov, have been published, while there have been absolutely no generalized investigations of the growth of seed oak groves.

The experimental tables, showing the course of growth and representing in figures, as it were, the material history of the plantation, arm the forester in his practical activity. The availability of such tables, showing the growth of the plantations under certain, long-acting conditions of growth, facilitate forest stocktaking and at the same time make it possible to find out to what extent and in what direction the growth of the actual forest being studied deviated from the "norm." The tables also make it possible to appraise the results of the particular forestry measures carried out, to note the influence of the transient factors, and to arrive at corresponding conclusions. Usually drawn up for forests of optimum density, the tables serve as criteria for evaluating the actual state of the forest stock and offer grounds for planning measures aimed at raising the productivity of the forests.

Of late, it has become evident that, for forest organization and timber production, the usual experimental tables showing the course of growth are no longer adequate and must be supplemented by a comprehensive assortment structure of the stocks. Knowledge of the dynamics of the change of the forest assortment with age offers a clue to the solution of a number of most important forestry problems (determination of the technical maturity of the forest stands, assorting the standing timber, planning the distribution of the wood-cutting areas, etc.).

Table 1. Distribution of oak forests according to age (in per cent).

Forests	Age groups					
	Under-growth	Middle age	Maturing	Mature	Over-ripe	Total
High-trunk	40	25	15	15	15	100
Low-trunk	29	32	13	16	10	100
Total for all oak forests	33	29	14	16	8	100

In drawing up the general plan for the development of forestry in the Ukrainian Republic and in organizing the oak groves in the central chernozem regions of the RSFSR (1953-1957), the forest planners and students of the Voronezh Institute of Forestry, under our general super-

Table 2. Course of growth in height of seed oak gro ves of the II bonitation according to experimental tables.

Authors of Tables	Age of oak groves, in years										
	20	30	40	50	60	70	80	90	100	110	120
	Height (in metres)										
Naumenko	7,1	10,4	13,5	16,2	18,6	20,6	22,3	23,8	25,2	26,3	27,3
Davidov	7,5	11,1	14,0	16,6	18,9	20,9	22,6	24,1	25,5	26,6	27,5
Moiseyenko	—	10,0	13,1	15,8	18,2	20,3	22,1	23,6	25,3	26,2	27,1
Wimmenauer (II-III bonitation)	6,5	9,8	13,1	15,9	18,3	20,3	22,0	23,5	24,9	26,1	27,2
Average	7,0	10,3	13,4	16,1	18,5	20,5	22,3	23,8	25,2	26,3	27,2
Deviation from average heights according to Naumenko (metres)	0,1	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,0

vision, laid out more than 350 trial plots (with felling of more than 2,000 samples) for studying the growth and assortment of the stock of seed and shoot oak plantations. The tests characterize oak plantations mainly of even surface conditions of growth. These data, as well as the published materials of other investigators, have made it possible to draw up tables showing the course of growth and marketable structure of the dense seed (Ia-III bonitations) and shoot (I-IV bonitations) oak plantations.

An analysis of the material gathered enabled us to establish that the Ia and I bonitations correspond to the type complex of forest of the humid maple-linden oak grove, the II bonitation to the fresh sedge oak grove and humid cudubrava, the III bonitation to the dry sedge oak grove, and the IV bonitation to the very dry oak grove on saline soils.

Independent of our work, experimental tables showing the course of growth were drawn up at the same time on other material by M. Davidov for the seed and shoot plantations of the Ukrainian Republic, by F. Moiseyenko for seed plantations of I-III bonitations of the Byelorussian Republic, and by G. Nechistik for the oak groves of artificial origin in the northern forest-steppe (I-II bonitations).

Of the small number of tables showing the course of oak growth in Western Europe, the experimental tables showing the course of growth of the seed plantations in Central Germany and drawn up by Wimmenauer have become the most widespread. Until very recently, these tables were also used in our forest organization practice and were published in various forestry manuals.

Capital research into the growth and productivity of Rumanian oak groves was published in 1957 by a group of Rumanian foresters. A. Tyurin familiarized the Soviet people with the content of the experimental tables showing the course of growth of the shoot oak forests in the USA, published by G. Shnur.

The material accumulated by the investigations of the growth of oak forests is of considerable interest for comparative studies aimed at finding the similarities and differences in the development of the plantations of various forest-covered areas, states, and continents.

Let us trace, in the first place, the course of growth of seed plantations using the II bonitation as an illustration. According to Wimmenauer, our II bonitation corresponds to something between the II and III bonitations. At 120 years, the seed plantations in this bonitation have an average height of 27.2 m., with variations, according to the date of various authors, ranging within 27.1 and 27.5 m.

How, then, is the development of these forests in height represented for all the preceding years? We find the answer to this question in Table 2. It turns out that the seed oak forests which have equal heights at 120 years, in the past grew in height perfectly equally. During each decade the amplitude of variations in average heights is usually found within the limits of 0.5 m., and in very rare cases reaches 1 m. We have found the same proposition to hold when comparing the growth in height in the other bonitations as well.

We observe an almost complete coincidence of the growth in diameter in the tables drawn up by I. Naumenko, F. Moiseyenko and K. Wimmenauer. Parallel with them, but higher (1-2 cm.), is shown the growth of diameters in the tables drawn up by M. Davidov (Table 3).

As is well known, the plantation stock is most closely

Table 3. Course of growth in diameter of seed oak groves of the II bonitation according to experimental tables.

Authors of Tables	Age of oak groves, in years										
	20	30	40	50	60	70	80	90	100	110	120
	Diameters (in cm.)										
Naumenko	4,3	8,0	11,7	15,5	19,2	22,8	26,2	29,6	32,8	36,0	39,0
Moiseyenko	—	8,9	11,9	15,6	19,3	23,0	26,3	29,2	32,0	35,1	38,0
Wimmenauer	4,5	8,0	11,7	15,7	19,2	22,6	26,0	29,2	32,4	35,5	38,1
Average	4,4	8,3	11,8	15,6	19,2	22,8	26,2	29,3	32,4	35,5	38,5
Davidov	6,1	9,7	13,5	17,3	21,1	24,9	28,6	32,3	35,9	39,4	42,9

connected with its height. On the basis of this we show the correlation between the stocks and heights within the limits of the II bonitation according to Naumenko, Davidov, and Moiseyenko. In using Wimmenauer's tables, we excluded from the total stock (trunk wood and twigs) the volume of the twigs, taking it to equal 12 percent of the total stock. In F. Moiseyenko's tables, the total stock is shown together with the part that falls away, while in all the other tables the stock pertains to the main part of the plantation. For purposes of comparison, we excluded from the total stocks in Moiseyenko's tables the volume of the part that falls away, i.e., that accumulates during the preceding decade. We therefore made use of the corresponding average data from Naumenko's and Davidov's tables.

Comparison of the stocks shows complete identity of their connection in the various tables with the heights, on the one hand, and the proximity of the stocks at the same heights, on the other hand. For example, the heights of 15, 20 and 25 m. correspond to the stocks:

Authors of tables	Heights (in metres)		
	15	20	25
	Stocks (in cubic metres)		
Naumenko	190	285	390
Moiseyenko	175	275	380
Davidov	170	270	380
Wimmenauer	175	275	395
Average	178	276	386

Thus, the difference in the stocks at the same height in the tables of the different authors does not usually exceed 5-6 per cent.

The data showing the general productivity also turn out to be relatively close. For example at 70, 90, and 120 years it constitutes:

Authors of tables	Age (in years)		
	70	90	120
	General productivity (in cubic metres)		
Naumenko	434	556	709
Davidov	391	521	689
Wimmenauer	395	525	705
Average	407	534	701

The comparison made by us warrants the assertion that there are general regularities in the development of seed oak forests of the RSFSR and the Ukrainian and Byelorussian republics. A result of this is an identity and great similarity in the change of the various valuation elements in the qualitatively homogeneous conditions of growth. In particular, the plantations, which at the age of maturity have the same heights, develop along the same line, revealing a similarity and closeness of the main valuation elements (heights, diameters, and stocks).

Here we are in no position to cite in a similarly detailed manner material showing comparisons of growth of shoot oak forests. By way of illustration we shall use here, too, the data for the II bonitation (after G. Shnur). These are plantations which at 100 years have a height of 70 feet (26.2 m.). The growth of the shoot oak groves in height almost fully coincides in the tables of I. Naumenko, M. Davidov, and G. Shnur. The same thing is characteristic of the other bonitations. The development of the oak plantations also proceeds parallel with this, according to V. Shustov, but with a lag of about half of a bonitation class.

With age, the changes in the plantation stock reveal the following peculiarities: in the tables of I. Naumenko and M. Davidov the stocks are very close in volume, whereas in G. Shnur's tables they are 10-15 per cent lower. At the same time, the nature of the change in the stocks of the U.S. oak groves with age is identical to that in the USSR. In other words, there are reasons to believe that G. Shnur's tables reflect the growth of the plantations incompletely (0.85-0.90). This is also confirmed by the correlation between the sums of the areas of the cross-sections: with the same heights, the latter are 10-15 per cent lower in G. Shnur's tables than in the tables of I. Naumenko and M. Davidov.

Thus, the analysis of available experimental tables showing the course of growth of the seed oak plantations has made it possible to establish a similarity in the development of the oak groves in the European part of the USSR and Central Germany. On the basis of this, by treating diagrammatically and mathematically the close values shown in the experimental tables of the different authors it is possible to draw up general tables showing the course of growth of seed oak groves. We propose to do this in the nearest future. The task of generalizing the growth of the shoot oak forests is feasible in similar measure, although here it is desirable to supplement the material beforehand by extending the field of studying the growth of oak forests.

RESUMES

Regularities générales dans la croissance des plantations de chênes

L'analyse des comptes-rendus d'espériences présentés sous forme de tableaux et montrant l'évolution de la croissance des futaies de chênes a permis d'établir une similitude dans le développement des forêts de chênes de la région européenne de l'URSS et en Allemagne centrale. En se fondant sur cette découverte, il est possible de procéder à des représentations graphiques et mathématiques des valeurs proches indiquées sur ces tableaux et d'établir des tableaux généraux montrant la croissance des futaies de chênes. C'est ce que nous nous proposons de faire dans un avenir proche. La généralisation de la croissance dans les taillis de chênes semble possible dans une mesure identique, bien qu'il soit souhaitable de compléter les données dont on dispose par une étude plus approfondie de la croissance des forêts de chênes sur le terrain.

Regularidades Generales en el Crecimiento de Plantaciones de Robles

El análisis de gráficas experimentales disponibles que indican el índice de crecimiento de montes altos de roble, permite establecer una comparación entre el desarrollo de las rodales de roble en la zona europea de la U.R.S.S. y las de la Alemania Central. Sobre esta base, y utilizando gráfica y matemáticamente los valores aproximados que se indican en las tablas experimentales de diversos autores, es posible preparar gráficas generales que indican el índice de crecimiento de montes altos de robles.

Nuestra intención es abreviar esto. La tarea de generalizar el índice de crecimiento de los montes bajos de robles es posible de manera similar, aunque aquí es conveniente complementar el material de antemano, ampliando el estudio sobre el crecimiento de los bosques de robles.

Specialization of Forest Growing by Regions

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As an independent branch of the economy, forestry has as the objective of all its activities the satisfaction of the demands of all branches of material production of the country for timber and other forest products.

As bigger supplies of machinery flow into the national economy of the U.S.S.R., forestry establishments receive more technical equipment. For this reason, particularly topical are questions of increasing productivity and a fuller utilization of the natural resources.

By decision of government bodies, the U.S.S.R. is to do a great deal to raise the productivity of the forests and to develop forestry.

The present state of the development of forest science and practice permits effecting a purposeful influence on forest growth, of ensuring higher productivity, and of improving the quality. In ultimate effectiveness, the forestry measures which are capable of altering the productivity of the forests differ.

Some improve essentially the factors of the environment and in this way considerably raise the productivity of the forest tree stands (melioration, fertilizers). Other measures, for example, the introduction of fast-growing types, do not essentially change the forest-growing conditions, but promote a more effective utilization of the potential fertility of the soil. Finally, there are measures that help improve the qualitative state of the forests (for instance, maintenance cutting) without perceptibly raising the general productivity of the tree stands.

Such measures as fire-control, prophylactic work to prevent the build-up of pest foci, and pest control are not directly related to raising the productivity of the forests, but are important as measures aimed at eliminating the causes that reduce possible forest productivity.

The different forestry intensity level in different parts of the country and the different natural conditions determine the degree of differentiation of forestry measures, their system, and the practical possibility of effecting them.

The type of forest and the interrelations of the species under specific conditions of their habitat determine the techniques employed in forest management, but the degree of activity in carrying out a given forest measure is determined by the level of development of the forest management.

This is why Soviet forest science and practice has posed and elaborated the problem of the specialization of forestry measures by regions. These measures are directed towards forest growth, with account taken of the natural and economic conditions of the separate regions of the country.

Underlying the specialization of forestry measures is the forest-growing and the forest-exploiting division of the forests of the country into regions.

Specialization of forest measures is carried out according to the type of forest, and permits, more fully, to determine the peculiarities of forest management, to account for the specificity of growth and formation of tree stands and regeneration processes in them, and, consequently, it makes for a more effective influence on raising the forest productivity.

For each forest-exploitation region, established on the basis of forest-growing demarcation into regions, with account taken of the division of forests into groups according to their economic importance and level of development of forestry techniques, there are elaborated the principal trends of forest development and a system of consecutively carried-out forestry measures.

The level of development of the forestry determines the number of forestry regions into which the area is divided. If the work is conducted on an intensive scale, a forest-growing region may embrace several forest-exploiting regions, and, on the contrary, when the work is conducted on an extensive scale, several forest-growing regions may be united into a single forest-exploiting region.

The system of forestry measures depends upon the possibilities in a given forest-exploiting region. In the intensive regions, the system of forest measures envisages the entire complex of influencing factors (artificial regeneration, the introduction of fast-growing species, the selection of an assortment of species that ensure the most effective utilization of the forest-growing conditions, maintenance felling, prophylactic measures for pest fighting, etc.).

In regions with underdeveloped forest areas with extensive forest management, minimum forestry measures may be envisaged, ensuring only regeneration of the forest—at times, even with replacement of the species. In regions of extensive forest management, more attention is paid to organizational-prophylactic measures, for example, fire-fighting, and the like.

The principal requirement in working out a system of forestry measures on a region-by-region scale is the consecutiveness of execution of the entire sequence of interrelated jobs, which determine the effectiveness of regenerative measures, since if any one of the measures is missed the result will be an unjustified expense as far as the remaining jobs are concerned.

In order to elaborate scientifically substantiated proposals in the specialization of forest-regeneration measures it is necessary to have materials that characterize the process of regeneration of species of trees at felling areas

in different types of forest, the role and significance of new growth, and the trend in the replacement of tree species.

The data below characterizes the peculiarity of the regeneration process and the character of replacement of tree species in pine and fir forests of a subzone of the southern taiga.

In pine groves of Pinetum cladinosum and Pinetum callunosum, the natural regeneration of the pine takes place, as a rule, without replacement of the species, if there is a new young growth on the felling area.

Cultivation of the soil produces a good effect only on freshly felled areas, if it is carried out in the fruiting year of the pine trees, or if the cultivation of the soil is accompanied by the planting of seed. Soil cultivation on old felling areas does not produce good results.

In felling areas in these types of forest it is best to make use of artificial regeneration; and in forestries of medium and high intensiveness, the production of forest cultures is absolutely necessary.

In pine forests of Pinetum vacciniosum, soil cultivation on freshly felled areas ensures good regeneration if there is new young growth and retained sowing material. On old felling areas (over two years of age), one must, as a rule, sow or plant pine trees. In pine forests of Pinetum myrtillosum, soil cultivation on freshly felled areas (in the case of available sowing material and in years of high yields) sometimes produces a good effect, but in the case of intensive exploitation it is best to employ artificial regeneration.

In pine forests of Pinetum polytrichosum, one can count on natural regeneration of the pine without replacement of species if the felling area has a new growth of pine. In the absence of a young growth, soil cultivation does not produce good results. Due to the fact that the productivity of tree stands in pine forests of Pinetum polytrichosum is comparatively low, they do not serve as a basis for growing valuable stands of pine. For this reason, in the case of low-intensive exploitation there are no grounds for special concern about artificial regeneration. But in intensive forestation work the productivity of these pine forests can be increased by a class of quality by means of the very simplest drainage work—the digging of furrows to 30-35-cm. depth. Therefore, in regions of more intensive forestation work, artificial regeneration may be employed on felling areas in pine forests of Pinetum polytrichosum by combining it with the digging of furrows, the crests of which should be used for sowing or planting pine trees. For the majority of forestries, these jobs are not urgent, and their execution depends upon the facilities of the forestry.

Pine forests of Pinetum sphagnosum are low-productive tree stands if radical drainage melioration is not effected. For this reason, it is meaningless to conduct reforestation work here.

Pine forests of Pinetum oxalidosum are, productively, one of the most valuable of tree stands. Natural regeneration in them most often proceeds by means of replacement of the pine with birch and aspen with an admixture of fir and pine. Soil cultivation on felling areas does not produce good results. Here, it is always necessary to resort to artificial regeneration of the pine.

The same methods of regeneration must be applied to pine forests of Pinetum compositum and Pinetum herbosum.

Soil cultivation on felling areas in fir forests can be carried out only in fir groves of Piceetum vacciniosum and Piceetum hylacomiosum, and only on freshly felled areas if sowing material is present.

In other fir groves, it is necessary, as a rule, to conduct artificial regeneration, with the exception of fir groves of Piceetum polytrichosum, where this is not advisable without drainage.

Specialization of forestry work by regions, in accordance with the foregoing principles, has been organized, at present, on a considerable forest area in the U.S.S.R. To date, this work has been completed in all the forests of the Ukrainian SSR, in a subzone of the southern taiga, and in the subzone of coniferous-broad-leaved forests in the European part of the U.S.S.R., in the forests of the Urals, and in the Far East.

At the present time, work is being completed on the forest-growing and forest-exploiting demarcation into regions of the Siberian forests, and an elaboration (by region) of the specialization of forestry work in these forests.

The drawing up of overall plans for the development of forestry in the U.S.S.R., which plans are directed to raising the productivity of the forests, is conducted with account taken of region-by-region specialization of forestry work.

This specialization, which is based on the materials of a typological study of forests and investigations into the regenerative process on felling areas with different types of forests, introduces essential changes into the trend of forestation work. For example, the region-by-region specialization of forestation work in one of the central regions of the European part of the U.S.S.R. (Yaroslavskaya Region) has shown that the forestation policies of this region need to be altered radically.

It was established that, given the present typological composition of the forests, it is necessary to sharply increase the volume of artificial regeneration, since the measures aimed at natural regeneration have not produced positive results here. It was also found that the volume and technique of maintenance felling that had been carried out in young growths, without taking into account the type of forest, does not ensure the formation of young growth with allowance made for valuable coniferous species. It has been proven that the money and labour now being spent on work to promote the natural regeneration in types of forest where they cannot produce positive results could be more effectively switched to maintenance felling in young growth.

In addition, regional specialization of forest work according to types of forest has made it possible to determine the extent of forest drainage work and its effect.

For measures established on the basis of regional specialization of forest-growing to be realistic for the present level of development of forestry, it is necessary to give an analysis of the structure of the process of forestry work as to labour expenditure (this method is E. Ya. Sudachkov's) and the introduction, on the basis of such an analysis, of amendments to the system of measures.

The experience in regional specialization of forest-growing that has been gained during recent years in the

U.S.S.R. permits us to state that only a system of regeneration work established for the separate forest-exploitation regions and, within their limits, according to type groups of forests, can ensure a rise in forest productivity, making for more effective use of the money spent on forest-regeneration measures.

Regional specialization in forest-growing creates a new qualitative basis both for planning forest-regeneration and forest-exploitation work and for forest management on a scientific basis.

Forest practice and forest science in the U.S.S.R. now possess sufficient material to substantiate the effectiveness of individual measures in different types of forest, and they enable us to recommend both the organization and techniques for carrying out work on a region-by-region scale and according to types of forest.

Regional specialization in forest-growing enables us to solve more correctly a series of organizational problems in regulating the utilization of forest raw materials, and it determines the trend in the mechanization of labour processes.

RESUMES

Spécialisation régionale de la croissance forestière

L'état actuel du développement des sciences et pratiques forestières permet d'exercer une influence délibérée sur la croissance forestière, de manière à assurer une productivité accrue.

Les niveaux différents de densité sylvestre dans les différentes régions du pays, et les conditions naturelles différentes de chaque région déterminent le degré de variation entre les mesures à prendre, leurs caractéristiques et les possibilités pratiques de leur réalisation. Le genre de forêt et les relations entre les essences dans certaines conditions spécifiques d'habitat déterminent les techniques à utiliser dans l'aménagement de la forêt; mais le degré d'activité à déployer dans l'application d'une certaine mesure forestière dépend du niveau atteint par l'aménagement forestier.

C'est pour cela que la science et les pratiques forestières soviétiques ont posé et résolu le problème de la spécialisation régionale des mesures de croissance forestière, tenant compte toutefois des conditions naturelles et économiques des différentes régions du pays.

A la base de cette spécialisation des mesures forestières se trouve la division en régions des travaux de sylviculture et d'exploitation.

La spécialisation des mesures forestières est effectuée selon le genre de forêt, et permet de déterminer plus amplement les particularités de l'aménagement forestier, tenant particulièrement compte de la croissance et de la formation du peuplement et du processus régénérateur qui y a lieu. En conséquence, ceci permet d'exercer une influence plus efficace sur l'élévation de la productivité sylvestre.

Un système de mesures forestières, exécutées consécutivement et tenant compte des tendances principales de développement forestier, est établi pour chaque région d'exploitation forestière. Ces régions sont établies sur la base des régimes de croissance des forêts.

Le niveau de développement forestier détermine le nombre de régions forestières dans lesquelles la région est divisée. Le système de mesures forestières dépend des possibilités dans chaque région d'exploitation forestière donnée. Dans les régions d'exploitation intensive, le système de mesures doit prendre en considération l'ensemble des facteurs qui entrent en jeu.

Dans des régions de forêts sous-développées mais pourvues d'aménagements forestiers étendus, un minimum de mesures forestières peut être envisagé de manière à régénérer la forêt. Ceci peut inclure, parfois, même le remplacement de certaines espèces.

L'élément principal nécessaire à l'élaboration d'un système de mesures forestières sur une base régionale est l'exécution consécutive de la séquence complète des travaux qui sont étroitement liés entre eux, qui déterminent l'efficacité des mesures régénératives. Si l'une des mesures est omise, le résultat en sera un accroissement injustifié des dépenses afférentes aux travaux restant á effectuer.

Cette spécialisation, basée sur les résultats d'une étude typologique des forêts et l'investigation des processus régénératifs dans les zones d'abattage, introduit des changements essentiels dans les tendances des travaux de boisement.

La spécialisation régionale en matière de croissance forestière crée une nouvelle base qualitative aussi bien pour la planification des travaux de régénération que pour ceux d'exploitation et d'aménagement forestier sur une base scientifique.

Especialización Regional del Crecimiento Forestal

El estado actual del desarrollo de la ciencia y práctica forestales permite ejercer cierta influencia, con determinados propósitos, sobre el crecimiento forestal para conseguir un aumento de producción.

Los varios niveles en que se desarrolla la silvicultura intensiva en diferentes partes del país y las diversas condiciones naturales existentes determinan el grado de diferenciación de las medidades forestales, del sistema y de las posibilidades prácticas de ponerlas en efecto.

El tipo de bosque y la correlación de especies bajo las condiciones específicas del ambiente son los factores que determinan los métodos técnicos que han de emplearse en la administración forestal, pero el grado de actividad en la consecución de las medidas proyectadas lo determina, a su vez, el estado de desarrollo en que se encuentre dicha administración.

Es por esto que la ciencia y la práctica de la silvicultura soviética ha estudiado y examinado el problema de la especialización de las medidas forestales por regiones. Dichas medidas, encaminadas a desarrollar el crecimiento de los bosques, se han tomado teniendo en cuenta las condiciones naturales y económicas de las diferentes regiones del país.

Como base de esta especialización de las medidas forestales, se han dividido en regiones el crecimiento y la explotación de los bosques del país.

La especialización de los métodos forestales se realiza de acuerdo con el tipo de bosque y esto permit determinar más plenamente las peculiaridades del manejo forestal, dar cuenta y razón específicamente del crecimiento y formación de los rodales y de sus procesos de regeneración y consiguientemente, dar mayor eficacia a las medidas encaminadas a incrementar la productividad forestal.

En cada región de explotación forestal, establecida a base de una demarcación de crecimiento forestal también regional en carácter, se han determinado las principales tendencias de desarrollo y se ha seguido un sistema consecutivo de medidas forestales.

El grado de desarrollo de la silvicultura determina el número de regiones forestales en las cuales ha de dividirse el area.

El sistema de medidas forestales depende de las posibilidades existentes en una región de explotación. En las regiones de silvicultura intensiva, el sistema de medidas forestales toma en consideración todo el completo de factores influyentes.

En las regiones con areas de bosques subdesarrollados con una administración forestal extensiva, sólo puede contarse con la implantación de un mínimo de medidas forestales que aseguren solamente la regeneración del bosque, a veces, mediante el reemplazo de las especies.

El principal requisito al adoptar un sistema de métodos forestales, región por región, es la ejecución consecutiva de toda la serie de labores recíprocamente relacionadas, que determina la eficacia de las medidas regenerativas, ya que cualquier falla en una de ellas representará una gran cantidad de gastos injustificados en lo que a las labores restantes respecta.

Esta especialización, basada en el estudio tipológico de los bosques y en el examen de los procesos regenerativos de las areas de corta de diferentes tipos de bosques, introduce cambios esenciales en el desarrollo de las labores de forestación.

La especialización regional en el crecimiento forestal crea nuevas bases cualitativas tanto para los planes de regeneración forestal y los trabajos de explotación como para los métodos científicos del manejo forestal.

The Treatment of Hardwood Scrub

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The practice of using a light cover of birch (*Betula verrucosa* Ehrh. and *Betula pubescens* Ehrh.) had, for many years, been known to have some beneficial effects on shade-bearing and frost-tender species such as beech (*Fagus sylvatica* L.) but, in general, all hardwood regrowth of whatever type was, until recent times, regarded as weedgrowth and something to be eliminated before any good use could be made of the ground. However, in the natural forest the young seedling develops under the shade and protection of the older trees, and the practice described below is only the artificial application of this principle in hardwood areas by the careful selection and judicious use of the regrowth, either in the form of coppice or maiden stems, which nature so readily provides. Thus evolved a system which has so many benefits—ecological, sylvicultural, and financial—that an ever-increasing number of forest owners in the most heavily wooded parts of England are adopting it to their own benefit and to the speeding up of their reforestation programmes. What had previously been looked on as useless rubbish to be got rid of in the cheapest way possible has now become one of the most valuable assets of the woodland owner.

Almost all woody species can be used effectively. It is fortunate that the age or size which is the most economic from the revenue point of view is also the easiest to deal with and that which provides the best cover. It may often be wise to leave a young regrowth another few years until it is 15 or 20 feet high or more, rather than cut it young when it can bring in little or no revenue, and after treatment, is incapable of leaving adequate shade. Later, it is often possible to sell the largest poles while leaving the lighter stems to form the overhead cover.

The procedure is to go through the area, clearing out heavy or coarse branched trees of all types, retaining as far as possible all light foliaged species such as birch and ash (*Fraxinus excelsior* L.), while at the same time cleaning out the ground cover and brashing up all stems left to about 6 feet to make it possible for planters to move through without difficulty. Planting is then done at normal spacing, regardless of the overhead crop. It is not possible to suggest any specific number of stems to be left per acre because this varies at every age or height and for different species, and so it is much better to work on the basis of direct light intensity. It is necessary to give only about 30% of direct light for the first one or two growing seasons—to some extent depending on the species to be planted—thereafter opening out at appropriate intervals as described below, according to requirements. After some experience, the correct light intensity can be gauged by eye, or, if necessary, there are photographic appliances which can be used. The heavier the shade-bearing capacity of the species to be planted, the less light intensity it needs and, of course, conversely with the light demander. Thus a considerable measure of judgment is necessary, making the whole operation one of special interest to the forester. To assess the position accurately it is better, if possible, to do the work when the leaves are still on the trees, since this is the time when the light intensity counts. It has to be remembered that, while the young tree is establishing itself, the canopy is also expanding annually and reducing the amount of direct light getting through. A careful watch is therefore needed, particularly in the early years.

The benefits to be obtained by the use of "dappled shade" in this way can be enumerated as follows:

1. Shelter from excessive sun, wind, and frost, thus permitting the use of more frost-tender species on sites otherwise not suitable for them.
2. Humidity is retained at a natural level.
3. The movement of the earth ensures that no tree is wholly shaded or wholly exposed to direct sunlight all the day.
4. There is a gradual breakdown of the litter maintaining suitable conditions for microfauna.
5. It avoids the erosion risks attaching to clear fellings on hillsides.
6. Soils are maintained at a more even temperature by day and by night.
7. It greatly reduces the cracking open of clays in long dry spells.
8. The gradual removal of the overhead cover by fellings over a period of years ensures that the brushwood breaks down slowly into the soil and is not destroyed by preparation fires.
9. It is possible to plant one-year-old and two-year-old seedlings successfully, thus effecting substantial economy.
10. Planting can be safely done later in spring or earlier in autumn than in open ground.
11. As the soil does not so readily freeze, planting can be done when conditions make it impossible in open areas. The heavier the shade the more this applies.
12. In comparison with open ground planting, losses are normally much lower. In consequence, beating-up costs are proportionately reduced.
13. Reduction of weeding, weed growth being suppressed by the shade.
14. Bird life is preserved.
15. Sporting values are enhanced.
16. Amenity considerations, which rank so high in many places, are adequately met. Conifer crops can gradually emerge from a hardwood shelter without any sudden change.

Perhaps the most striking visible benefit from this method is the prevention of frost damage under cover, while open areas adjoining are frequently severely cut back by late spring frosts.

Generally, it is found that trees do not make much move in the first season after planting, and if they are allowed a year or two to establish themselves in such very hospitable conditions, without intensive weed competition, they are then ready to grow away with the advent of more light after the first opening up of the shade.

The fellings on each occasion when cover is removed, or partially removed, can, without difficulty, be spread along the lines of the planted trees, leaving at least every other row free for access. In this way every tree is readily accessible on at least one side for weeding, while the volume of brushwood tends to suppress the weed growth on the other side.

Successful planting has been done under the cover of the following species usually in profuse mixture (in addition to birch and ash already mentioned): Common oak (*Quercus robur* L.), durmast oak (*Quercus petraea* Lieb.), sycamore (*Acer pseudoplatanus* L.), Norway maple (*Acer platanoides* L.), sweet chestnut (*Castanea sativa* Mill.), hazel (*Corylus avellana* L.), common maple (*Acer campestre* L.), aspen (*Populus tremula* L.), alder (*Alnus glutinosa* (L) Gaertn.), gean (*Prunus avium* L.), rowan (*Sorbus aucuparia* L.), sallow (*Salix caprea* L.). In using hazel, which is often growing pure and dense, it is necessary to cut off the outside shoots of all stools to prevent them from falling over on the young plants, and this process should be repeated each time the shade is lightened. Hazel makes a very good cover, but owing to its form it is usually essential to remove it rather earlier than more upright species which do not cause physical damage to young plants so soon.

It is desirable to eliminate all shrubs including common privet (*Ligustrum vulgare* L.), dogwood (*Cornus sanguinea* L.), elder (*Sambucus nigra* L.), guelder-rose (*Viburnum opulus* L.), hawthorn (*Crataegus monogyna* Jacq.), holly (*Ilex aquifolium* L.), spindle tree (*Euonymus europaeus* L.) and wayfaring tree (*Viburnum lantana* L.).

The rate of opening out and final removal depends on the species planted as well as the species comprising the overhead cover.

The following trees have been successfully planted by this method: Scots pine (*Pinus sylvestris* L.), Corsican pine (*Pinus nigra* var. *calabrica* (Loud.) Schneid.), European larch (*Larix decidua* Mill.), Japanese larch (*Larix leptolepis* (Sieb. and Zucc.) Gord.), hybrid larch (*Larix x eurolepis* Henry), Norway spruce (*Picea abies* (L) Karst), Douglas-fir (*Pseudotsuga taxifolia* (Poir.) Britton), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), western red cedar (*Thuja plicata* Lambert), Lawson cypress (*Chamaecyparis lawsoniana* (A. Murray) Parlatore), *Abies grandis* Lindley, beech, oak and Norway maple (*Acer platanoides* L.).

The more light-demanding the tree the sooner it needs access to fuller light, and therefore complete removal may be necessary for larches after 3 or 4 years following fairly heavy opening (after the first or second year), whereas beech may retain its cover in ever-decreasing intensity for up to about 12 years, provided there is no mechanical damage. A careful watch needs to be kept for signs of etiolation, small bud formation, thin weak shoots, and drooping needles. All these imply too much shade and indicate urgent attention to be necessary. In practice, it is found suitable to remove 50% of the canopy at each stage, thus preparing the young trees for ultimate complete exposure. Over Norway spruce or Douglas-fir there will be a removal at the second, fourth, and sixth year, the latter being the final. Over beech it is likely to take place at three- or four-year intervals, depending on circumstances. Forest labourers get so well accustomed to the work that they can do it without any marking by a forester.

Over a wide range of sites, covering a period of years, it is now possible to get some idea of the financial benefits to be obtained, although this must, of necessity, be only part of the picture, since much of it cannot be directly assessed in this way.

The use of 2-year seedlings instead of transplants can show a saving of 53% in the initial purchase price of trees. In the case of beech even 1-year seedlings of good quality have been used with complete success, while 2-year seedlings of Douglas-fir and western hemlock have been found satisfactory.

Beating up varies widely, but it is not uncommon to find no appreciable loss at all under cover, with 20 to 25 per cent deaths in adjoining open ground without cover. There is a saving in weeding through the normal period of establishment (particularly prominent in the first year) averaging 28%.

The retention of overhead shade brings about an initial average saving in cutting and burning costs of 32% but, on the other hand, spreading the total removal over a period of years, instead of doing it at one operation, increases the gross cost ultimately. However, figures from sales show that where turnery or pulpwood markets are available, there is nothing to choose financially between the two methods, since poles which were small and unsaleable in the beginning have developed through the years to a useful size, thus increasing the revenue above the figure which would have been attainable to start with. Other benefits due to reduced losses and greater flexibility of time for planting are not easy to assess financially.

Perhaps the hesitation with which this practice was first accepted was due to the fact that it needs a much greater measure of skill than straighforward planting after clearing and burning. However, when the principles are understood there is nothing at all difficult about it, and workmen soon learn to carry out the operation on their own without constant supervision. Woodland owners. who are adopting it in increasing numbers, are not only reaping the evident financial savings but at the same time gaining the many less tangible benefits to amenity and the preservation of game.

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RESUMES

L'aménagement sous-bois de feuilles

Le sous-bois de feuilles qui, jusqu'ici, avait été considéré comme une végétation parasitaire, est maintenant largement accepté comme salutaire et utilisé, après traitement, pour former un couvert permettant de planter sous son abri une grande variété d'essences. Le mémoire mentionne les avantages de ce système du point de vue forestier écologique et financier, et énumère les essences qui peuvent être plantées de cette manière et celles qui peuvent servir d'abri.

La méthode de traitement décrite dans le mémoire est employée régulièrement depuis des années dans les forêts domaniales des parties les plus densément boisées de l'Angleterre et est maintenant adoptée par un nombre constamment croissant de propriétaires privés.

El Tratamiento de los Arbustos

Anteriormente, especies secundarias de hoja ancha estaban consideradas como maleza, pero ahora están generalmente aceptadas como plantas valiosas, y suelen usarse como parte del tratamiento para formar una cubierta adecuada bajo la cual puede plantarse una gran variedad de especies.

En este trabajo se enumeran los beneficios de este sistema silvicultural, ecológico y financiero, se dan las especies que pueden plantarse por este método y las usadas para protección.

El método de tratamiento descrito ha sido práctica corriente por muchos años en los Bosques del Estado en las partes más boscosas de Inglaterra y ahora está siendo adoptado por un creciente número de propietarios particulares.

Principal Problems of Silviculture In Czechoslovakia

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The Czechoslovak Republic is a small country, but natural conditions are uncommonly varied. This variety is conditioned by the meeting of various phytogeographic regions (Central European, Carpathian, Pontico-Panonian), partly by the unusual geomorphologic division, the results of which are pronounced vertical climatic-vegetation zonation and rapid alternation of various ecotypes on small areas. There are aso various economic management factors, notably different management development and degree of influences on forests.

The wide change of forest stand structure is characteristic mainly for the Czech (Hercynian-Sudeten) region: Norway spruce, 60,1 per cent; Scots pine, 21,6 per cent; and leaf-trees, only 12,7 per cent. The Carpathian part of Czechoslovakia has not shown such a pronounced change of tree species composition (52,8 per cent leaf trees, 31,2 per cent beech). The influence of the Saxonian school covered in the Carpathian part only individual estates of German nobility. But the Carpathians show, as the heritage of extensive grazing by stock, considerable areas of eroded, karsted, or otherwise degraded soils. The incidence of damage by grazing is perhaps more dangerous than the unfavourable effect of the pure stand system. It is apparent that both units, Czech and Carpathian (Slovak) regions, involve even different silvicultural problems. As a consequence of primary and secondary forest stand variety, the silviculture of Czechoslovakia is also varied. This is apparent when special attention is paid to the natural conditions and the proper function of the forest.

Natural conditions and proper functions of forests change jointly on small areas. Land use of certain ecotypes includes timber production; other ecotypes show significance as water management factors or as factors of soil conservation or are of indirect significance (forests near cities, national parks, natural parks, etc.). All these multiple uses of forests must be fully respected, whatever silvicultural treatment may be carried out. The attention to the multiple uses of forests is secured in Czechoslovakia by the public ownership of all forests. The public ownership of forests enables, on the one hand, consequential application of new scientific and technical knowledge, but, on the other hand, brings the risk of incorrect measures on large plots. For this reason, the necessity of close connection of research and forestry practice is pointed out, and each scientific research problem comes under wide preliminary testing of practice.

Beginnings of the development of silviculture are to be found far in the past (13th century), but they were limited and isolated and had hardly any important influence on the total further development. First, the developing mining industry (from the 16th century) and with it connected large-scale cuttings and anxiety for timber in some regions contributed to systematic silviculture.

From that time, we know numerous summarizing procedures of more or less legislative character. This is the beginning of the "directed" forest management culminating in Czech regions, under the influence of the Saxonian school (from the 19th century), in an extensive pure stand system with clearcutting, artificial regeneration (notably Norway spruce), and short rotation period. The results of this management are, to the end of the 19th century and at the beginning of the 20th century, more frequent and dangerous natural calamities (wind, snow, drought, insects, etc.). There appeared (mainly in the second generation of stands) phenomena of yield reduction as a result of more or less intensive soil degradation. For this reason, the beginning of the 20th century shows a more pronounced decline from the pure stand system. As a contradiction to the economic base of the Saxonian school about the highest yield of soil, the biological base

of silviculture is pointed out (compare, for example, Konšel 1931). Sometimes this biological side was overstressed and the economic side omitted.

The present state of silviculture could be characterized as the search for a common denominator of biology and economics in silviculture. No doubt it is a difficult task, especially from the standpoint of the long term of the production process and with respect to the obstacles, when calculating the economics of some of the multiple uses of forests. One must point out that public ownership enables the consequential utilisation of all new knowledge of science and techniques in forestry. In this way, there is a new relationship of silviculture to other branches of forestry, notably to forest management. It is apparent that silviculture may not be placed under forest management. Forest management cannot be limited only to the regulation of forest yield. It includes also basic branches such as forestry typology (phytocenology, pedology), historical studies, projects of road systems, etc. This is possible only because the individual management unit does not directly depend on the yield (returns). Owing to the increased cuttings caused by the broad national needs of timber, at present, the care of forests and technical equipment are secured for balanced management. One of the measures serving silviculture directly is the typological study connected with detailed mapping (scale, 1:10.000) which should include the whole area of the Czechoslovak Republic.

The objective of forest typology (which could be called the comparative synecology) is to characterize and define plots which, by their natural conditions and also by yield, are more or less coincident and, to a certain measure, require coincident silvicultural and economic treatment. This aim is nothing new. We know that practical foresters, on the basis of experience, define broad units as pine, spruce, beech, and other sites. Today, typological studies are done by tens of specialized workers, usually under the aegis of the research institutes. In this way, new hypotheses for the development of silviculture are given. Broad silvicultural instructions are established for the individual typologic units. It is natural that nowadays these instructions are, for the most part, based on the evaluation of empirical materials. But the aim is the establishing of a sufficient net of sample plots. This net should show various silvicultural treatments of outstanding ecotypes and give sufficient numerical material. That is even the aim of the so-called "permanent management units" which should include, as far as possible, more or less coincident ecotypes. In general, it means a stage of development of silviculture. It can be designated as an attempt to specify various silvicultural treatments for certain natural units (ecotypes). Since the development of silvicultural techniques is considered as finished (from the standpoint of technological processes, but not from the viewpoint of mechanisation), it may be suggested that this way is a line of further development of silviculture.

Silviculture in Czechoslovakia does not show development of the typical "regional" silviculture as does, for example, Germany (Rebel, K., 1922, 1924; Schaber, 1933; Graser, H., 1928, 1943, etc.) . The reasons are, in a certain measure, because of the uncommon roughness of the terrain and because geomorphologically and vegetationally, larger individual units are not available. Exceptions are the mountain regions with a natural predominance of Norway spruce. In 1857, J. Micklitz carried out general principles of woodland management for the region of the Hrubé Jeseníky Mountains. This work can, by right, be considered as the basis of the regional silviculture. Much of his information is still valuable. Recently, A. Heger, in the Chomutov region, paid attention to the regional silviculture in the Krusné hory mountains (in Saxonian Krusné hory (Erz Gebirge) H. Graser), etc.

The small extent of riverian forests prevents also the development of typical "regional" silviculture in the low lands. But it is of interest to note that several foresters working in these regions have written much in numerous small publications concerning regional silviculture, as it is found in the monographical work of A. Mezera (1956, 1958). This work is also an example of the use of forest typology in silviculture.

In passing, it may be mentioned that a problem recently much discussed is the use of principles of planned selection working. Selection forests, in a narrow sense of the term, are only few in our country, and it is only possible to mention the use of some planned selection working principles (Prof. H. Leibundgut). Certain practical experiences of more years are available (for example, H. Konias in the Opocno estate, Burgan in Slovakia, etc.). Forests have been handled by a kind of specific treatment, but it is incorrect to introduce the term "Czechoslovak type of planned selection working," as this system is usually called in our country. The basic features of the management are more or less coincident with similar attempts in all of Central Europe.

We have drafted the main lines of the present state of silviculture in Czechoslovakia. The basic problems of the proper silviculture are similar to the problems of other Central European states with intensive forest management. It differs not only in the form of realising of these or other treatments. In the main, silviculture is motivated by attempts to increase timber volume, always with respect to the improvement of other useful functions of the forest, as mentioned above. Apart from other treatments, the following are among the most important:

1. *Use of all forest area for wood-volume production.* Organisation and legislation ensure that all clear cut areas as a result of calamities (wind, snow, insects, etc.) and of war management may be afforested (with the exception of extreme areas and new clear cuttings from 1959/60). Research and forestry practice have paid attention to this problem. The research work will be concerned mainly with frost holes, karsted soils, devastated pastures, and non-forest land designated for forestry use. Afforestation has been designed with a series of other forestry branches, e.g., seed handling, nursery work, mechanisation of silvicultural work, etc,
2. *Growing of suitable mixtures.* The problem of the Czech regions is to change unsuitable Norway spruce pure stands, whereas in the Carpathians we have been forced here and there to introduce a biological allowable inmixture of so-called economic tree species in broadleaved stands.

The following problems are connected with mixtures:

a. *Provenance problems and seed zonation.* Owing to

the varied nature of topography, our country is rich in various tree species ecotypes. Original ecotypes are only scarcely preserved in natural forest stands (for example, Sudeten larch, Trebon Scots pine, etc.). Plantation work nearly destroyed the ecotypic composition of our forests. The ecotypic composition even disappeared here and there. At present, intensive work is done to select the so-called "Seed Sources" for seed collection and to select elite trees. Seed zonation is established by law and by a series of rules and standards. This is enabled by the fact that all distribution of seeds and plants comes under the Forest Administration. Plant breeding of forest tree species carried out at present is limited to experiments and test practice (e.g., seed orchards) with the exception of poplar breeding (as is shown below).

b. *Problems of use of exotics.* More or less domesticated tree species (for example, *Pseudotsuga taxifolia* (Poir.) Britt., *Pinus strobus* L., *Juglans nigra* L., and *Quercus borealis* var. *maxima* Michx.) are successfully used, and the number of exotics is thus increased.

I class with this problem even the "poplar cultivation action" which is contained in the Government resolution. In the years 1956-1960, 50 million poplars and willows should be planted, 20 million in Czech regions and 30 million in Slovakia, including plantations near cities, industrial enterprises, recultivated plots, etc. A checkup of cultivation showed some failures in 1959, but the programme will be achieved in 1961-65, when an additional 20 million fast-growing trees will be planted.

At present, a proposal has been put forward on zonation of approved cultivars, and, in future, mainly maintainance breeding of them will be the base of the intensive culture. The following groups of poplars are of considerable economic importance in Czechoslovakia:

(1) *Populus deltoides* Marsch. ssp. Monilifera Henry ("monilifera" Zidlochovice, Gabcíkovo, Opocno, Slavicín, Erec, Bodroc, Kunovice).

(2) *Populus euramericana* (Dode) Guinier.
   (a) Cultivar group "serotina" (Kunovice, Cheb, Písek, Stará Boleslav, Veltrusy, Opocno, Hodonín, Tvrdonice, Gabcíkovo, Polárikovo, Levoca, Bernolákovo, Gdyne, Netherland).
   (b) Cultivar group "marilandica" (Opocno, Kunovice, Netherland).
   (c) Cultivar group "regenerata" (Kunovice, Kolín, Opocno, Susice, Netherland).
   (d) Cultivar group "gelrica" (Netherland).
   (e) Cultivar group "robusta" (Jaromerice, Kojice, Kunovice, Gabcíkovo, Leles).

(3) *Populus trichocarpa* Torre et Gray (Hradec).

(4) *Populus* x *berolinensis* Dippel (Praha, Karlovy Vary).

(5) *Populus* x *generosa* Henry (Písnice, Lanzhot, Suciany).

Poplars "x euramericana" play the most important role for increased production. Balsam poplars and their hybrids, (3)-(5), will be used in only fairly limited scope.

3. The next action taken to increase the wood production is the introduction of more productive silvicultural systems. We list the following problems under present conditions:
   a. Changes and conversions of unsuitable pure forest stands (mainly Norway spruce and Scots pine stands).
   b. Changes and conversion of coppices.
   c. Use of some principles of the selection system (change from the coppice system to the selection system).

The first two problems are the topic of a special paper. Here, some points may be made of principles of the selection system which are also in use in the change and conversion of pure stands and coppice stands. The following set of selection definitions according to Prof. H. Leibundgut is in use: (1) in cultivating and logging, the bearer of productivity is the individual tree and not the forest stand (as a collection of individuals); (2) felling is not the master of cultivation, but the means of it (felling shows even breeding effects); and (3) full and permanent use of productivity.

The advantages of these principles are mainly as follows: (1) permanent rising of wood production; (2) maintenance, as far as possible, increase of site productivity, and improvement of some multiple uses of forests; (3) reduction of danger or extensive natural calamities; (4) increase of natural regeneration, maintenance of profitable tree species, diminished by clear cutting system, and lastly, improvement of genetic material of our forests; and (5) forests of selection character are more resistant to temporary overcuttings.

As a matter of fact, not only the system of silviculture aimed at the development of uneven-aged mixed forest stands but also the plantation system is in use in our country. Some fast-growing tree species, mainly poplars, walnut trees, and other tree species, are grown today in plantations. The present state shows that this cultivation system cannot be omitted, though we are well aware of the analogy of "monocultures" (pure stands). The intensification of silvicultural methods requires delimitation of areas suitable for cultivation according to selection principles and those suitable for cultivation of plantations. The role of extreme types will be limited, and transition forms of cultivation will prevail. On all places where the forest is also grown for other uses—for instance, to conserve water and soil, improve climate, etc.—principles of the selection system will be the chief element of silviculture. But actually, the cultivation of plantations may be practised on areas where biological or economic objections do not arise. Plantations should receive cultural and other treatments, i.e., intensive silvitechnique (fertilization, amelioration, etc.). Nevertheless, it is known, of course, that intensive silvitechnique in connection with mechanisation is advantageous also in forests managed according to selection principles.

4. Another way to increase production is site improvement by technical-chemical means. The potential productivity of the site is only scarcely achieved. Most forest stands show more or less lower actual productivity than can be achieved when compared with the potential yield. Much work remains to be done before differences between actual and potential production can be removed. The extent of the difference determines (when no other factors ap-

pear) also the necessity of the amelioration operations. Perfection of site quality can be achieved on many places by biological methods, but other plots require also technical-chemical treatments, i.e., mechanical amelioration (for instance, soils with ortstein) or chemical amelioration (fertilizing) (for instance, works of Dr. A. Nemec). But mostly, combined treatments solve the problem. Some methods are practised in forestry.

5. Lastly, mention must be made of reduction of damage done to forests by other branches of the national economy, notably by industry.

A considerable reduction in growth is caused by such agents as flying ashes and smoke. Silvicultural treatments are not able to prevent damage fully, but suitable tree species composition, and exterior and interior arrangements of forests can partly reduce its size and intensity. For this reason, actual needs of preventive silvicultural and economic treatments, in connection with country and industrial planning, are pointed out at present.

Conclusion

It is natural that this short paper cannot fully cover all problems of silviculture in Czechoslovakia. In most cases, only main lines are drafted. Many of the problems are common for whole regions of Central Europe; on the other hand, other problems—notably, the use of silvicultural principles of the selection system—are specific features of Czechoslovak forestry. It is of interest to note that since forests are in public ownership, silvicultural work is stimulated not only by attempts to increase wood volume production, but also by ensuring other functions of the forest, for instance, water and soil conservation, recreation, aesthetic and social use, etc.

RESUMES

Principaux problèmes de sylviculture en Tchécoslovaquie

Cette communication est un exposé général des problèmes forestiers en Tchécoslovaquie. En passant en revue ces problèmes, on ne doit pas perdre de vue non seulement la question de l'exploitation accrue du bois de construction, mais encore les questions de la conservation des eaux et du sol, ainsi que celles de l'usage des parcs nationaux. Etant donné que les forêts appartiennent au public, il est possible de répondre à ces questions. D'ici peu des forêts situées dans certaines stations seront aménagées du point de vue de la production, tandis que d'autres le seront du point de vue biologique. C'est pour cette raison que l'on délimite les divers peuplements.

Les types extrêmes de cet aménagement sont représentés, d'une part, par les méthodes de plantation, par exemple, les peupliers, les noyers, et, d'autre part, par les forêts aménagées suivant un système de sélection. La délimitation est basée sur l'analyse des conditions naturelles.

Les problèmes actuels de sylviculture en Tchécoslovaquie peuvent être résumés de la manière suivante:

1. Utilisation de toute la surface forestière pour la production de bois, reboisement des vieilles coupes ou des zones excessivement déboisées;
2. Culture des variétés appropriées de peuplements de forêts; "ecotypes", espèces, essences introduites;
3. Introduction de méthodes de sylviculture plus productives, changements et conversion des peuplements purs et des taillis, application des principes du système de sélection;
4. Amélioration technique et chimique, application d'engrais, en général parallèlement à l'amélioration biologique;
5. Traitements sylvicoles préventifs contribuant à réduire les dégâts causés aux forêts par les usines, la fumée, la suie, etc.

Principales Problemas de la Silvicultura en Checoslovaquia

Este trabajo escamina los problemas silviculturales de Checoslovaquia. Al estudiar estos problemas debe tener se presente no solamente el creciente aumento de la producción de madera, sino también la conservación de aguas y suelos y su uso recreativo y social. Dichos problemas pueden re solverse perque los bosques son propiedad pública. En resumen los bosques de unos sitios serán administrados desde el punto de vista de la producción, otros desde el de la biología. Por esta razón es necesario fijar los limites de las diversas divisiones de la administración.

Los tipos extremos de esta administración son los árboles de plantación, por ejemplo, los álamos y los nogales, de una parte, y de otra los bosques administrados por el sistema de selección. La delimitación se basa en el análisis de las condiciones naturales.

Los actuales problemas de la silvicultura de Checoslovaquia pueden reducirse a los siguientes:

1. Empleo de toda el área forestal para la producción de madera en grandes cantidades, repoblación de bosques viejos o cortados completamente a mata rasa.
2. Crecimiento de rodales mixtos adecuados, con ecotipos, razas, especies arbóreas introducidas.
3. Introducción de sistemas silviculturales productivos, cambios y conversion de rodales puros, y montes bajos y uso de los principios del sistema de selección.
4. Mejoramiento técnico-químico, abonos, combinados usualmente con el mejoramiento biológico.
5. Tratamientos silviculturales preventivos que contribuyen a reducir los daños al bosque debidos a la actividad industrial, los causados por el humo, las cenizas, etc.