Changes of Forests In Czechoslovakia

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In the territory of Central Europe, and, consequently, in Czechoslovakia, there has occurred in the last two centuries a substantial change in the species composition of the forests. This change was caused by an economic-historical situation in this country. In the areas of relatively dense population the timber consumption increased proportionally with the development of industry, so that the timber resources in the forests were successively reduced. Artificial regeneration was not regulated, and natural regeneration was, in those times, hindered to a great degree by grazing.

Timber scarcity and the unfavorable state of forests were such that various ways for the improvement of forestry were sought, in order to ensure a sufficient quantity of timber. One of those ways was, especially at the close of the 18th and in the 19th century, the establishment of pure stands of Norway spruce (*Picea excelsa* L.) and Scotch pine (*Pinus sylvestris* L.). In Central Europe the Norway spruce is a native species in mountain ranges, while the Scotch pine is a species of the lowlands, growing there as an autochthonous species in the oak zone in relatively poor and dry sites. Regarding climate, both species are, to a great degree, indifferent to it, thus enabling them to be grown outside of their natural range.

In the pure stands, the Scotch pine was grown first of all at low altitudes, later, in the oak stand zone (up to 600 meters above sea level), and finally, instead of in the oak forests, was mixed with the following species: *Quercus, Carpinus, Fagus, Ulmus,* etc. In the beech zone, ranging in Czechoslovakia at altitudes from 400 to 1,000 meters above sea level, mixed stands formed by the species *Fagus silvatica* L., *Abies alba* Mill., *Picea excelsa* L., *Acer pseudoplatanus* L., etc., were changed to pure stands of Norway spruce.

The pure stands of *Pinus sylvestris* L., and especially of *Picea excelsa* L., which were most favorable from the economic point of view, successively extended and took over more and more areas, from which the autochthonous tree species were removed. In regeneration, a radical method—clear-cutting, together with artificial regeneration by sowing and planting—was used, and in this way the original ecotypes suitable from the site point of view were destroyed. This management method caused the establishment of pure, even-aged stands, characterized by their regularity of cut areas and compartments. In the history of Central European forests, this was the first and, to a great degree, accomplished planning, which ensured a space arrangement in the forests and established a simplicity and greater possibility in their management. However, this method involved a number of errors, because it did not take into consideration the biological requirements of individual tree species.

A substantial change of tree species composition occurred in the territory of Bohemia, situated, from the phytogeographical point of view, in the Hercynian range. At the present time, the Norway spruce here covers over 62,5%, and the Scotch pine over 19,7% of the total high forest area. The broadleaved species cover only 13,2% of the area. In the eastern part of Czechoslovakia, i.e., in Slovakia, which belongs to the Carpathian range, and where industry was not developed to such a great extent as in Bohemia and timber consumption was less important, no substantial change of species composition occurred. Here, high forests are composed primarily of broadleaved species (54,8%), whereas conifers occupy only 45,2% of the area. The present tree species composition here corresponds roughly to the natural conditions. On the other hand, in the western part of Czechoslovakia, i.e., in Bohemia, a great part of the spruce stands is situated in unsuitable sites. The comparison of actual tree species representation in Bohemia with the ideal species composition corresponding to site conditions is given in the following table:

	(Cover of the total area (in %)	
Species	**Actual**	**Ideal (corresponding to site conditions)**
Picea excelsa L.	62,5	24,7
Pinus sylvestris L.	19,7	15,7
Abies alba Mill.	2,8	10,0
Larix decidua Mill.	1,6	4,1
Other conifers	0,2	—
Fagus silvatica L.	5,0	18,1
Quercus robur L.	3,8	11,5
Fraxinus, Acer, Ulmus	1,1	4,7
Other hard broadleaved	2,1	2,1
Other soft broadleaved	1,2	9,1
Total coniferous	86,8	54,5
Total broadleaved	13,2	45,5

It is clear that in Bohemia a large area of spruce stands is situated on unsuitable sites, so that an important problem arises here, viz, in which ways those pure stands may be replaced by mixed ones composed of species corresponding to the respective site conditions. The fact that the spruce and pine stands in Bohemia occupy unsuitable sites may be illustrated by a rough comparison with the site qualities of the stands situated in the eastern part of the Republic, i.e., in Slovakia, where the spruce and pine stands grow on much more favorable sites. The mean site qualities (by Schwappach's method) of Norway spruce and Scotch pine in Bohemia are 2,6 and 2,8 respectively, and 1,4 and 2,2 in Slovakia. The same differences may be found in regard to the mean annual increment of coniferous and broadleaved tree species, averaging 3,4 cubic meters and 2,5 cubic meters in Bohemia, and 4,9 cubic meters and 3,1 cubic meters in Slovakia, respectively.

The large-scale establishment of pure stands, especially of Norway spruce, which was extended even to unsuitable sites in Bohemia, brought about not only a decrease in timber production, but also a series of other unfavorable features accompanying the pure stand management over the whole of Central Europe.

The pure stands suffered heavily from various disasters caused by both abiotic and biotic agents. The most dangerous abiotic factors were storm and snow. So, e.g., a great deal of timber, equaling two annual calculated cuts, was damaged by gales in 1929, and by snow and rime in the years 1930 to 1933. The last gales in 1955 destroyed one-third of the annual calculated cut. The pure spruce stands growing outside of their natural range suffered in 1947 from drought, causing enormous financial losses. In spite of the fact that forest management in Bohemia has aimed at protecting the pure stands from storms and snow by various silvicultural measures (outer and inner space arrangement, sequence of regeneration operations, tending of stands), at present, 11,5% of the total forest area is menaced by wind, 12,4% by snow, and 5,9% by drought.

The disasters in pure stands caused by abiotic agents affected outbreaks of harmful insects, inducing again further biotic calamities. Of the great group of insects which attack the pure stands of Norway spruce, bark beetles (*Ips typographus* L., *Polygraphus polygraphus* L., and *Pityogenes chalcographus* L.) are the most dangerous species, causing, in the years 1945-1947, timber destruction equalling ¼ of the annual calculated cut. A very dangerous insect enemy of pure spruce and pine stands is the nun moth (*Lymantria monacha* L.) which attacked the forests of Bohemia several times. The most destructive outbreak of this pest was in 1917-1919, when it attacked the pure stands of Bohemia and Moravia, causing compulsory logging on 4% of the total forest area. The establishment of pure stands also caused considerable damage in game management, especially in game suffering from diminished nutrition possibilities. The lack of suitable food caused the game to damage the stands heavily, including the new young plantations.

A further unfavorable consequence of pure stands was the deterioration of soil properties—soil degradation. The acid humus, which is formed in pure stands of Norway spruce and Scotch pine, causes in the soil profile leaching of nutrients from the upper horizons, this being sometimes accompanied by the formation of secondary hard pans, which diminish the physiological soil depth. At the present time, the pure stands have caused 4,86% of forest soils in Bohemia to become degraded, and 2% heavily degraded (soil sickness), where the further existence of the forests is endangered.

The species composition of the stands, which does not correspond to site conditions, as well as the clear-cutting system, with all its unfavorable consequences, have caused the hydrological conditions of the landscape in many parts of Czechoslovakia to become considerably deteriorated. At the present time, only 11% of the forests are fully active from the hydrological point of view. In the residual forest area, the retention capacity of forest soils deteriorated 1-9 times. In view of the fact that a majority of Central European rivers rise in the territory of Czechoslovakia, this situation is very unsatisfactory.

The above-mentioned unfavorable effects of pure stands accompanied by rough regeneration methods caused forest science and practice to start, as early as at the close of the 19th century and in the early 20th century, to solve the problem of pure stands. Even at the present time, a great deal of attention is devoted to the change of pure stands in Czechoslovakia, both in research and in practice.

In Central Europe the spruce and pine pure stands cover various geologic substrata and various soil types, and occur in various climatic conditions. The difference between the given site conditions and those of the natural range of Norway spruce and Scotch pine forms, together with the economic conditions (growth, quality, resistance of stands), the main criteria for the extent of changes. Taking into account these points of view, the pure stands are divided into those with complete, prevailing, and partial changes. Because the greater part of Bohemian forests consists of managed forests (96%), the changes are not performed with the purpose of forming the natural associations of tree species which should replace the present pure stands, but in order to form economically profitable stands. In such forests the economically important species, including the Norway spruce and Scotch pine, must be represented to a maximum degree. However, the site conditions (especially the soil conditions) and the safety of the forests must not be unfavorably influenced.

In order to determine the optimum species composition and the silvicultural treatment aiming at the changes, it is necessary to take into account the diversity of natural conditions, and, therefore, forest typology is largely applied. Based upon the analysis of environmental factors, of historical research results, and of economic considerations, the determined typological units make it possible to find not only the required species composition, but also the techniques of changes (regeneration methods).

In the given natural conditions, the technique of changes requires special silvicultural measures elaborated with respect to the biological and ecological properties of both logged and regenerated tree species. A number of methods for changes were elaborated and tested in Czechoslovakia. One of the best and most-used methods of changing the pure stands is the regeneration method by Gayer (1886). Gayer's regeneration method of gap-cutting was elaborated in Czechoslovakia with respect to the changes of pure spruce and pine stands. In this connection, the problems of the preparation of pure stands to changes, inner space arrangement of pure stands, establishment of regeneration elements, development of regeneration, etc., were solved.

The most important measure in changing the pure stands may be considered the inner space arrangement of stands. It was elaborated in various natural conditions, whereby special attention has been drawn to the extensive accessibility of the stands, to the resistance to climatic factors (especially to storms), and to the utilization of regeneration cuts regarding their favorable climatic effects.

The goal of changes is also the improvement of growth conditions, especially of soil properties. In changing the pure stands, the amelioration measures are also largely applied. The highest emphasis is placed upon biological amelioration, i.e., introduction of different broadleaved species with ameliorative effects into the stands, e.g., *Fagus silvatica* L., *Carpinus betulus* L., *Tilia europaea* L., etc. This biological amelioration, which is of long-term character, is usually combined with mechanical or chemical amelioration (fertilization).

In Czechoslovakia, the technique of changes is being further elaborated and tested under various natural conditions. The results obtained in establishing the pure stands and their changes may be used both in the countries where the natural stands are replaced by pure stands, and in the countries where the pure stands situated on unsuitable sites are to be replaced by stands in harmony with the natural conditions. This was proved also in the FAO Forestry Study Tour in Czechoslovakia in 1956.

RESUMES

Changements dans les forêts en Tchécoslovaquie

Au cours des deux derniers siècles, l'ensemble du territoire de l'Europe Centrale, y compris la Tchécoslovaquie, a été l'objet de changements importants dans la composition des essences dans les forêts, à la suite de la culture de peuplements purs épicéa (*Picea excelsa* L.), et de pin sylvestre (*Pinus sylvestris* L.)

Dans le cas des peuplements purs, l'épicéa était cultivé aux basses altitudes de la région du chêne, tandis que le pin sylvestre était cultivé dans la région du hêtre. L'etablissement de peuplements purs équiennes a été accompagné par une méthode de régénération radicale—la coupe à blanc. Les résultats de cette méthode d'exploitation ne sont pas favorables du point de vue des conditions de la station, et de la composition des essences cultivées dans les peuplements, qui sont parfois attaquées par des agents nuisibles. Une autre conséquence défavorable des peuplements purs est la détérioration des propriétés du sol—la dégradation du sol. En Bohême, les peuplements purs ont causé une dégradation de 4,86%, et une forte dégradation (maladie du sol) de 2%, de la zone forestière.

A l'heure actuelle la Tchécoslovaquie met en oeuvre un programme intensif de modifications dans la culture du sapin et des peuplements de pin purs, notamment dans les emplacements peu favorables à la culture des essences mentionnées. Ce programme est basé sur la typologie forestière qui permet de déterminer non seulement la composition d'essences désirée, mais encore les techniques de modifications. D'après les résultats des recherches typologiques obtenus, on suppose que les zones plantées d'épicéas et de pins sylvestres seront réduites de 62.5% à 24,7% et de 19,7% à 15,7% respectivement.

En Tchécoslovaquie, une attention soutenue est accordée au travail des techniques de modifications dans des conditions naturelles diverses. Sous ce rapport un certain nombre de problèmes forestiers relatifs à la transformation des peuplements purs ont déjà été résolus, notamment l'entretien des peuplements purs, leur disposition interne, la mise au point d'éléments de régénération, le développement de la régénération, etc. On accorde également une attention toute spéciale à l'amélioration biologique des sols par la culture d'essences feuillues. Les résultats obtenus en rapport avec la solution de cette question ont été communiqués aux membres de la FAO lors de leur voyage d'études forestières effectué en 1956.

Cambios de los Bosques de Checoeslovaquia

Durante los últimos dos siglos en el territorio de toda la Europa Central, inclusive en el de Checoeslovaquia, se registraron cambios sustanciales en la composición de las especies de árboles de los bosques cuando se establecieron los rodales puros de pino del norte (*Picea excelsa* L.) y de pino de Escocia (*Pinus sylvestris* L.).

En los rodales puros el pino del norte se cultivó a bajas altitudes, en la zona correspondiente a los robles, mientras que el pino de Escocia se plantó en la de las hayas. Al plantarse estos rodales regulares se empleó también el método de renovación radical con tala a mata rasa. Este tipo de administración no ha dado resultados en lo que respecta a las condiciones del sitio y las especies de composition de los rodales, que suelen ser atacados algunas veces por agents abióticos y bióticos. Otra mala consecuencia de los rodales puros es el deterioro de las propiedades del suelo, su degradación. En Bohemia 4,86% de las tierras forestales están degradadas y un 2% sumamente degradadas (enfermas).

Actualmente, en Checoeslovaquia, se lleva a cabo un trabajo intensivo para cambiar los rodales de píceas y pinos, especialmente en los lugares no adecuados para las especies mencionadas. Este trabajo se basa en los principios de tipología forestal, mediante los cuales es posible determinar no sólo la composición de especies requerida, sino también los métodos de cambio. De acuerdo con los resultados de estas investigaciónes tipológicas, se supone que las areas de pino del norte sean reducidas del 62,5% a un 24,7% y las de pino de Escocia, del 19,7% a un 15,7%.

En Checoeslovaquia, está dedicándoseles gran atención a los trabajos relacionados con los cambios en las distintas condiciones naturales. En este respecto se han resuelto algunos problemas de silvicultura concernientes a los cambios de los rodales puros, como son, su cuidado, el espaciamiento interior, el establecimiento de los elementos reproductivos, el desarrollo de la reproducción, etc. También se está poniendo atención al mejoramiento biológico de los suelos, mediante el cultivo de especies de hoja ancha. Los miembros del grupo de Estudios de Silvicultura de la FAO que estuvieron en Checoeslovaquia en 1956 informaron sobre los resultados obtenidos en la solución de este problema.

"Orchard" Versus "Naturalistic" Silviculture

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In the early days, foresters mainly dealt with timber and fuelwood, but with advances in civilization, foresters were called upon to develop a variety of species for varied uses of man. In days of old, mostly slow-grown hardwood timber species were raised. The rotation was necessarily long. On the other hand, the species raised in forests in the recent past include fast-growing timber or fuelwood species as well as tree species raised for other products, such as bark, fruits, etc. Short rotation crops are, in fact, becoming more common. The pattern of silviculture adopted at present naturally varies considerably from the earlier pattern.

Forestry no longer contents itself with the pickings obtained from whatever nature gave to man in the primeval forest. Forestry is now assiduously engaged in planting, tending, harvesting and replanting not merely timber species but trees of economic value for purposes other than timber. Even when the artificial establishment of plantations of timber species became a regular feature, the practice of silviculture, which in early times was mainly concerned with the tending and manipulation of existing forests, gave place to methods akin to those of agriculture. By "silviculture" should be meant "more or less the same thing in relation to the forest, as is meant by agriculture in relation to the fields" says H. Cotta. Of late, with the growing of tree species other than those of timber value, the concepts of silvicultural practice have undergone many changes; ideas pertaining to horticulture have set in, and, gradually, the concept of "orchard silviculture" has evolved as distinct from "naturalistic silviculture."

Kostler says that "silviculture is a biologically dependent technique by means of which treatments are so regulated that definite objectives are attained; within the frame work of organised forestry, these for the most part are economic objectives." In the early days, when the demand was mostly for a particular species, silviculture concerned itself either with natural production of the desired species in greater proportion in the natural forest, or, when the need for more concentrated effort arose, it dealt with artificial regeneration techniques, but in keeping with the basic concepts of naturalistic silviculture. The development of silvicultural techniques reached the stage of orchard practices when it was decided that forest lands also could be devoted to growing species other than those of timber value. The naturalistic silviculture in the initial stages naturally dealt with the virgin forests, which originated on the soil without man's assistance, and developed without disturbance by man. Thereafter, to the concept of conservation was gradually added the concept of rehabilitation of the forests which had been adversely interfered with by man.

The concept of naturalistic silviculture confined itself to the dominant aim of developing good timber. The emphasis had always been on the development of clean, well-developed stems in the forest stands, so that they might achieve the maximum production of timber. In orchards, it was the usufruct of the tree that was the concern of the producer, and the emphasis was to develop trees in order to yield maximum usufructs. Even in the case of fast-growing timber species grown under orchard conditions, the concern now is to produce the maximum of wood (cellulose) per hectare rather than the maximum of good timber, as the trend is towards use of pulp or processed wood. Where trees are grown for timber, the development of height is an important consideration. Often in orchards, a spreading crown with excessive branch is deliberately aimed at. A very close espacement with a view to covering the soil as early as possible and its gradual opening with the development of crop is a common practice in naturalistic silviculture, while in orchards, the species are raised at wider or final espacement, and intensive attention is given to the individual plants so that the objective is attained early. The gradual removal of excessive stems by way of thinnings is not economically unsound where the intermediate yield is marketable and when the tree crop is raised at low cost. In the case of species of orchard value, intermediate removal of the stems which had been raised and tended with care and greater cost is a waste of effort and money. Hence, while in naturalistic silvicultural practice, close espacement is the rule, in orchards and forests grown under orchard conditions, wider espacement or the final espacement itself even to start may be resorted to.

As the bearer and sustainer of the forest stands, the forest soil demands the constant attention of the forester, and one of the constant endeavours of the forester is to maintain the productive capacity of the forest soil. As injuries to the soil are much more difficult to rectify than injuries to the forest crop, the forester naturally exercises great caution whenever he has to interfere with the canopy. When clear felling is resorted to, he attempts to replace the vegetal cover without delay. The protection of the forest soil is always considered to be of paramount importance. In the early days, attempt was rarely made towards any curative action in the form of application of fertilizers or manure. But care was always taken to prevent deterioration of the forest site. Once the constitution of the soil had been disturbed, it was found difficult to restore it by natural means to the same condition capable of bearing the original forest growth. The naturalistic silviculture, based on the concept of sustained production of yield, paid attention to the maintenance of the inherent natural capacity of forest soil of the site and did not advocate any silvicultural measure which had a deleterious effect on forest soil. The ideal system for maintaining soil productivity was always considered to be the selection system, and clear felling systems were not in favour. In due course of time, when methods of conversion became essential, complete clearing, followed by reforestation with desired species, was done. The methods adopted in farming slowly came into play in the field of forestry as well: Soil working or preparation of the soil for regeneration activities, burning, as a means to improve the soil condition, measures to eradicate the acidic nature of the detritus, etc., were adopted.

With the development of forest lands for growing economically valuable species and for maximizing the production per unit area of land, attempts specially to prepare the soil for regeneration work had become a part of forestry operations. Over expensive areas, which were once considered difficult if not unsuitable, by adoption of high-powered soil-working machines, planned development of chosen species had taken place on a large scale. In orchard silviculture, the forester is not content merely with taking care of the soil he deals with. In addition to taking precautions necessary for preventing soil deterioration, he makes constant effort to apply deficit elements and also add the trace elements which may be particularly needed for the species. In orchards, the horticulturist does not wait to see the effect of the soil of a particular plot on the yield but begins to apply straightaway to the soil all the needed elements desirable for the species in question, so that the development of the species may be the optimum. Thus, in all cases, irrespective of the soil found in the areas that had been selected to grow the species, optimum achievement is secured. The principle of application of correctives has been extended, in recent days, even in regard to timber stands in some countries. The application of correctives to the forest soils has become a common feature as a result of application of the concept of orchards to silviculture, whereas naturalistic silviculture paid attention mostly to the care of the soil on the spot and sought to prevent any action that would cause deterioration of the forest soil. Whereas the status quo of the virgin forest soil was sought to be maintained with all care in the old concept, the modern trend is to get the optimum development of the species on all sites by resorting to corrective methods or curative action.

The development of the orchard concept in silviculture had made many a marginal forest land come into full productivity. Lands, which in the past were considered not worthwhile for being developed into timber stands, etc., are now taken for raising tree species of economic value. The varied needs of man for different kinds of products has made the forester grow varied kinds of species of economic value for purposes other than of timber. As the produce obtained from growing of such species are economically more valuable than timber, it has now become possible to resort to more intensive preparation of the site than in the past. Intensive preparation of the site at a great cost had led the investor to expect quick returns, and the traditional forms of raising forest species, commencing from a large number of seeds ultimately giving few distributed number of stems, had given place to organised planting work in which a well-developed seedling is planted at a regular espacement and the development of each of the planted seedlings claims the attention of the forester. Main attention is devoted to make all the planted seedlings achieve their full productive capacity at an early date.

Intensive forest management for quick returns will, in future, have to resort to the application of fertilizers on an increasing scale as is now being done in orchards. The development of radio tracers has proved the relatively greater efficiency of applying fertilizers in liquid form than by the old method of fertilizing the roots. Tests with P 32 have shown that the foliar method is 95% efficient, as against a score of about 10% by root feeding. In the case of forest species, the application of fertilizers by root-feeding methods will also invigorate the other unwanted ground flora in the forest, whereas the application of fertilizers by the foliar method would be useful as an economic method for application of the solution to the planted species only.

The utilisation of lands for growing species valuable for purposes other than timber is better confined to such lands which do not naturally support timber stands. It would not be advisable to convert timberland to growing of other species of economic importance. It is only in regard to the lands where the forests have degraded that the forester is finding it increasingly difficult to resist the demand of the public for converting them to agricultural farms. If more intensive methods are adopted by foresters in such degraded forest areas and in the marginal lands by preparation of the soil, using high-powered tractors and by application of fertilizers, there is the possibility of retaining them as forest lands. If the forester sticks to basic naturalistic silvicultural concepts, many such areas will inevitably be transformed into agricultural lands.

In Madras State, many of the degraded forest lands have been devoted to growing cashews (*Anacardium occidentale*), and steps are being taken to manage them as orchards. In case of other unproductive forests, but with better soil conditions on the hills, leases of lands for growing of plantains and oranges have been given in the hill tracts of South India. Some of the chestnut forests in Southern France, which played a great part in the hill economy, are in poor shape, due either to neglect or to attack by chestnut blight. Those chestnut forests which are not in good productive state are being grouped in such a manner as to have regular orchards of chestnut where conditions are favourable, and to convert other unproductive chestnut forests into productive timber stands. The role which the old chestnut forests played as a multiple use of land in the field of agriculture, animal husbandry, and forestry is being changed into a more intensive form of single utilization of land by having chestnut orchards confined to more suitable locations.

The modern concept of orchard silviculture seeks to attain maximum utilization of lands by bringing into the field of forestry the tools of the farmer and the recent advances made in agriculture and horticulture. In the past, the forester was content in selecting seeds of good origin from chosen mother trees for the development of the desired species. The modern development of genetics has helped to create disease-resistant or fast-growing or high-yielding varieties, more potent than even the parent species. The production of superior varieties has also become possible by radiation methods, as a result of progress of atomic science in the field of plant genetics. In course of time, superior strains of many timber species will be evolved as a result of application of orchard silviculture. In all cases, where species of economic value are grown, it has already become a regular feature to resort to a particular strain in order to get the maximum productivity. In Switzerland, care is taken to plant only chosen strains of poplars. The progeny from trees of satisfactory performance are given specific numbers in order to identify the parentage. In the case of chestnuts in Southern France, hybrid varieties from *Castanea sativa* and *Castanea crenata* have been developed. The use of hormones to stimulate growth and of antibiotics to protect plants against diseases are some of the orchard practices that will find increasing use in future forestry.

Water is an indispensable constituent of all living organisms. The consumption of water (soil moisture) varies with the species. According to the water supply from the soil—limited or adequate or abundant—different types of plants, namely, xerophytes, mesophytes, hygrophytes, tropophytes, etc., inhabit different tracts. The forester takes into account the moisture requirements of different species, and according to the extent of rainfall or local soil moisture conditions, he decides on the species to be raised. With the growing of species of high economic value or of short rotation, it had become possible for him to regulate the moisture conditions of the site by having recourse to aids like flood irrigation, hand watering or sprinkler irrigation. Growing forests under orchard conditions, the forester now employs various methods of water supply, and as the moisture needs of the species is met to an adequate degree, tree species which could otherwise not be grown in a particular site are raised now. For instance, in otherwise dry tracts of coastal Madras, casuarina has been grown successfully by hand watering, and mulberry and sissoo under irrigated conditions in the arid zone of the Punjab. Sprinkler irrigation is used in some forest nurseries of European countries, and where it is practicable, the method is likely to be extended to forest areas as well, in future. The economics of watering will depend on the availability of water in the vicinity and the value of the species grown.

In areas where excessive moisture precluded the growing of valuable species in the past, attempts have now been made to grow trees either as tree belts or plantations by the draining of marshes or swampy tracts. The planting of shelter belts in the Orbe Plains of Switzerland, and the reclamation of marshes in Del Fueino, Delta Pedanna in Italy are some of the cases where land not carrying vegetal growth had been brought under either agricultural crop or tree crop (orchard or poplar shelter belts). In one of the erstwhile marshy areas of Ferranna (Italy), the reclaimed land now carries a large number of orchards (peaches). Tractor ploughing and placement of fertilizers is done to get maximum production of the fruit crop. Poplars are being increasingly planted by agriculturists in some places in Italy and Switzerland in view of the increased demand for wood by the wood industries of the region. The growing of fast-grown timber under orchard conditions is made possible in view of the economic importance of the species. The concept of orchard silviculture has developed even as the economics of growing fast-grown wood came to compare favourably with traditional farming.

In naturalistic silviculture, great importance was paid to biological control of pests. Where the forester was called upon to regulate the composition of natural stands by suitable tending to yield the desired species, the regulation of the various species that helped as alternative hosts was possible. Where forest plantations are established after complete eradication of all other vegetal growth and making elaborate soil preparation, it is difficult to depend upon alternate host plants for biological control of pests. Under orchard silviculture conditions, increasing importance is therefore paid to the role of chemical insecticides and herbicides. Chemical control by way of application of chemicals either by dusting the powder or by spraying the solution has become more common.

In naturalistic silviculture, by a series of tending operations, the forester builds up gradually, spread over a long span of time, a forest most suited to the locality. Under orchard silviculture conditions, attention is paid mainly to the commercial or productive aspect. Attention is paid to the rapid development of the species by application of methods adopted by farmers and horticulturists in order to get the maximum production in the shortest time. The concept of natural regeneration formed the first basis of silviculture. The early foresters tended, exploited, and regenerated the forests by resorting to natural methods which would give abundant natural regeneration to replace what had been taken out. Sowing and planting methods, which were in use for a long time in agriculture, came in only subsequently when artificial regeneration was adopted in the field of silviculture. With the development of economic species, intensive methods have come to play; and many measures of the agriculturists and horticulturists are being used in modern forestry also. In any case, whether naturalistic silviculture or orchard silviculture is adopted, it has to be remembered that the objective is the creation of a forest. Whether it is the ideal selection forest, where naturalistic silviculture principles can continue unviolated, or a commercial forest raised under orchard conditions, the fact should always be kept in mind that the forest is a living entity which should be in harmony with nature. The basic principles of silviculture remain the same whether the traditional or modern methods are adopted to *regenerate* the forest, and once the forest has been established, it should be managed with a long-range view and with a full understanding of the function of the forest, its economic objective, and its contribution to human welfare. Even if modern methods aim at maximizing production, forest management should continue to be on the basic principle of sustention—the guiding force of silviculture at all times.

RESUMES

La sylviculture "en verger" par opposition à la sylviculture "naturaliste"

L'orientation de la sylviculture a varié au cours des temps en raison des objectifs différents qui ont régi la culture des essences forestières. A l'origine, les forestiers s'occupaient surtout de bois d'oeuvre et de chauffage; depuis quelque temps, certaines essences sont cultivées en vue de la production de cellulose

plutôt que de bois d'oeuvre, et, tout récemment, a commencé la culture d'essences recherchées pour leur écorce ou leurs fruits. La sylviculture d'aujourd'hui se consacre à la plantation, à l'entretien, à la récolte et au reboisement, et ne se contente plus d'exploiter les ressources des forêts vierges. Depuis que l'on cultive d'autres essences que celles qui produisent, après une longue période de croissance, du bois d'oeuvre, les notions de base de la sylviculture ont subi des modifications importantes. Des idées relevant de l'agriculture et de l'horticulture se sont implantées, et la théorie de la sylviculture "en verger", que l'on distingue de la sylviculture naturaliste, s'est développée.

A ses débuts, la sylviculture s'est occupée de la régénération naturelle des essences désirées, et même lorsque le besoin de régénération artificielle intensive s'est fait sentir, les notions fondamentales propres à la sylviculture naturaliste ont été respectées. La remise en état des forêts dégradées et la culture d'essences nouvelles ne donnant pas de bois de sciage, ont forcé le sylviculteur à emprunter les outils de l'agriculteur et de l'horticulteur. Alors qu'autrefois tous les efforts visaient à la production de troncs droits et bien développés pour en faire du bois de sciage, le forestier en est arrivé à rechercher la plus grande quantité de bois (cellulose) que peuvent rendre les essences à croissance rapide, ou encore les fruits d'autres essences. En sylviculture naturaliste, la règle consiste à planter serré et à éclaircir ensuite graduellement, alors qu'en sylviculture en verger on a recours à une méthode de plantation plus ouverte, voire même respectant l'espacement définitif des arbres.

La sylviculture naturaliste limitait ses efforts à l'entretien du potentiel de production du sol forestier tel qu'il se trouvait dans la forêt vierge, alors que la sylviculture en verger a eu recours à des méthodes de prévention et de correction, en utilisant des engrais, naturels et artificiels, et des oligo-éléments de manière à obtenir un production maximum sur toutes les stations. Le travail du sol forestier au moyen de puissants engins de terrassement, et l'application d'engrais sont des caractéristiques courantes de la sylviculture en verger. L'acceptation de la notion de sylviculture en verger a permis à de nombreuses forêts marginales de devenir pleinement productives. L'irrigation des terres arides, le drainage des sols détrempés et des marécages, l'utilisation d'hormones facilitant la croissance, et la lutte contre les parasites au moyen de produits chimiques efficaces, sont les outils utilisés dans le cadre de la sylviculture, à la suite des progrès réalisés en agriculture et en horticulture. En sylviculture naturaliste, le contrôle biologique des parasites pouvait aisément être effectué en raison des nombreuses essences qui poussaient dans les forêts vierges, alors qu'en sylviculture en verger le contrôle chimique est, pour ainsi dire, le seul utilisé.

Dans le contexte de la sylviculture naturaliste, la forêt la mieux adaptée au site est aménagée après une série d'opérations d'entretien qui s'étalent sur un long laps de temps. Par contre, avec les méthodes de sylviculture en verger, la forêt commerciale est soignée de manière à produire dans les plus courts délais. Les principes fondamentaux de la sylviculture restent inchangés, qu'ils s'appliquent à une forêt à sélection idéale obtenue grâce à la sylviculture naturaliste, ou à une forêt commerciale cultivée dans un but précis selon les méthodes de sylviculture en vergers. Lorsqu'une forêt a été aménagée de manière à rendre sa productivité maximum, que ce soit par l'une ou par l'autre de ces deux méthodes, il importe qu'elle soit gérée suivant le principe de la sustentation et en pleine connaissance du rôle des forêts dans le bien-être de l'humanité.

La Silvicultura de "Huerto" y la "Naturalista"

La situación de la silvicultura ha cambiado con el tiempo. debido a los diversos objetivos del cultivo do las especies en las especies en las áreas forestales. En un principio los silvicultores se ocupaban principalmente de la madera de construcción y de combustible. Hoy se cultivan las especies con miras a obtener más bien madera para celulosa y, aparte de esto, las tierras forestales se utilizan ahora también para cultivar especies valiosas por su corteza, sus frutas, etc. Actualmente la silvicultura da más preferencia a las labores de plantación, cuidado, corta y repoblación que a la explotación de lo que ofrecen los bosques vírgenes. Con el cultivo do las especies de rápido crecimiento han cambiado los conceptos de la silvicultura. Se han implantado ideas propias de la agricultura y la horticultura y se ha desarrollado un concepto de la silvicultura de huerto, distinto del concepto de la silvicultura naturalista.

Al principio, la silvicultura se limitó a la regeneración natural de las especies deseadas y aun cuando surgió la necesidad de implantar la regeneración artificial concentrada, los conceptos básicos naturalistas continuaron en uso. Las tareas de rehabilitación de bosques degradados y el crecimiento de especies de otras maderas no destinadas necesariamente para fines maderables, puso al servicio de la silvicultura los implementos del agricultor y el horticultor. Asi como los esfuerzos se dirigían anteriormente a la producción de troncos bien desarrollados para madera, en el caso de las especies de rápido crecimiento el silvicultor concentró sus esfuerzos en la producción máxima de madera para celulosa y en el caso de otras especies, para productos derivados. En la práctica la silvicultura naturalista suele plantarse a corto espacio y el aclareo es gradual, mientras que en la silvicultura de huerto las plantas se espacian más desde un principio o como norma definitiva.

La silvicultura naturalista se limita a mantener la capacidad productiva del suelo forestal, tal como se encuentra en los bosques naturales, mientras que la silvicultura de huerto se vale de la acción curativa o de los métodos correctivos mediante la aplicación de fertilizantes, estiércol o elementos de indicio, a fin de lograr la producción máxima en todas partes. La preparación del suelo forestal mediante maquinaria de gran potencia y la aplicación de fertilizantes son procedimientos comunes de la silvicultura de huerto. El desarrollo del concepto del sistema de huerto en la silvicultura hizo que muchas tierras forestales de poco rendimiento, pasaran a ser muy productivas. La irrigación en terrenos áridos, el drenaje de áreas cenagosas y pantanos, el uso de especies mejoradas y la aplicación de hormonas para estimular el crecimiento, así como el eficiente control químico de las plagas, son medidas que vienen aplicándose progresivamente en la silvicultura de huerto como resultado de los adelantos logrados en los campos de la agricultura y la horticultura. El control biológico de las plagas puede ensayarse con facilidad en la silvicultura naturalista debido a la variedad de especies disponibles en los bosques naturales, mientras que en la silvicultura de huerto se recurre mayormente al control químico.

En la silvicultura naturalista el silvicultor sigue una serie de tendencias, en proceso lento, y cultiva el bosque en la localidad más adecuada al mismo, mientras que la silvicultura de huerto cultiva el bosque, con criterio comercial, a la mayor brevedad posible. Bien sea la selección ideal del bosque, segun la silvicultura naturalista, o el bosque con fines comerciales cultivado con un determinado propósito, segun la silvicultura de huerto, los principios básicos de la silvicultura prevalecen, y una vez que el bosque ha desarrollado su máxima productividad por cualquiera de los dos métodos, éste debe regirse por el principio cardinal de pleno sostenimiento, con el completo entendimiento de las funciones que ha desempeñar el bosque para el bienestar humano.

Creation of Mixed Stands as a Method for Raising the Productivity of Forests

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On creating mixed stands, it is essential to choose tree species which exert a beneficial effect on one another, or at least attenuate sharpness of competition, especially the competition of the secondary species in respect to the chief species. If the selected species meet the environmental conditions and have been properly combined, it is possible to attain a rise in productivity, resistance of the stands to injurious influences and, in a number of cases, an improvement in the quality of the wood; the important point, however, is that all this is attained without any additional investment of capital or expenditure of labour.

To accentuate the essential features of the method of raising productivity, specifically for forestry, dealt with in this report, let us compare it with agronomic methods. The use of organic and mineral fertilizers and the complex measures of modern intensive preparation of the soil and care of plants, considerably raise the cost of the crops. Among the measures in question we may include sideration, bean-cereal crop mixtures and, especially, grass mixtures in meadow management. In these cases, use is made primarily of the fertilizing effect of leguminous plants, which provide fixed nitrogen for non-leguminous plants.

The method of mixed forest plantation is similar to that of crop rotation, widely practised by agronomists, which leads to considerable increase in productivity as compared with one crop planting over long periods (according to Williams—as much as 50 per cent yield increase in cereal grains).

Crop rotation may also be effective in forestry. Russian forest and soil scientists have found the soil-improving role of birch and aspen stands, arising from natural seeding after a clear cut of spruce stands. The researches of many German, Swedish, Czech, and Polish scientists have shown the necessity of planting deciduous trees—especially, beech—after soil-deteriorating spruce.

Deciduous trees are known to neutralize in these cases the high acidity caused by spruce, to accumulate considerable reserves of mild humus, lime, nitrogen, phosphorus, potassium, and magnesium in the surface soil, and to accelerate metabolism between trees and soil with the aid of the attendant diversified and numerous soil microflora and mesofauna. Most active and beneficial for accelerating the rotation of matter among the mesofauna are the earthworms.

Agronomic crop rotation is similar to the mixed plantation of foresters with the sole essential difference that, in the former case, the effect of agricultural plants on one another is one-sided, without interaction, since the preceding crop *a* affects the succeeding *b*; whereas *b* cannot possibly affect *a*. In mixed forest and other plantations, species *a, b,* etc., are planted together and simultaneously, and all the components, therefore, mutually affect one another.

It follows from the foregoing that forestry has at its disposal broader prospects than agronomy for utilizing the relations between plants for elevating their productivity; in addition, forestry is more interested than agronomy in the proper choice and the adaptation of its perennial plants to the environment, among other reasons, because forest stands are planted once for a long time. Under these conditions, mistakes made at the beginning will have their repercussions after several decades, whereas in the case of annual or biennial crops, the agronomist's error is recognized and corrected within the next few years.

The best object for research on the problem involved is that of artificial forest seeding and plantation. The Ukraine has abundant experimental material of this kind. The total area of forest plantations in our republic amounts to 2.357.000 hectares, which constitutes 31 per cent of all its forests. The plantations are located in various thermal and hydroclimatic zones—from the semi-desert banks of the Sivash to the boggy plains of Polesye and the highland forest zone in the Carpathians. The edaphical conditions are just as diversified.

Mixed plantations, consisting of 2, 3, 4, and more species, not infrequently involving shrubs as well, are created on fertile soils occupying over 50 per cent of the plantations. The age of the plantations varies from 1 to 150 years. There are sections with mature stands of the second generation, created like the first by human hands. The number of forest tree species cultivated in the Ukraine is considerable—about 40 aboriginal and over 110 introduced tree and shrub species. The most diversified methods of spatial alternation of species are encountered.

The introduction of the principle of the proper choice of arboreal species for a given site has greatly raised the productivity, quality and resistance of our plantations. Selection of "types of forest plantations" to correspond to types of site has been applied in practice, the classification of sites having been developed on the basis of data on natural woods. Its basis is the ordination system—an "edaphical network" reflecting the quantitative gradations of soil fertility from A to D and soil humidity from 0 to 5 obtained by utilising plant indicators.

During the last century forest stands planted in the steppe consisted of relatively hygrophilous elm trees;

they withered in the course of 15-25 years from drought and insect invasions. Oak plantations proved hardy in steppes, surviving to 60 and, in some localities, to 100 years.

The types of plantations for deciduous forests of the forest-steppe and forest zones of the Ukraine correspond to natural stands in respect to species. The plantations created in conformity with the new system differ favourably from those of the last century.

Many new species of trees have been introduced into the plantations. In the steppe zone of the Ukraine black and honey locusts have been extensively planted; in the forest-steppe zone many walnut species (*Juglans*), hickory, dark conifers (spruce, fir), Douglas-fir, larch, red oak, the Amur cork-tree and others, frequently as additions to local trees.

Of particular interest are the combinations of tree species yielding a pronounced rise in productivity and recommended for extensive use. We shall dwell briefly on two examples.

1. Plantation of common ash (*Fraxinus excelsior* L.) and larch (*Larix sibirica* Ledeb.) on soil of medium and high fertility (C and D) and medium moisture (2 and 3). This mixture is not encountered in our natural forests and was considered unpromising, since both varieties require a great deal of light. It was used accidentally in a number of places in the Ukraine at the close of the last century. Ash grows well and within 50-60 years suppresses the larch, which has by that time attained a height of 30 metres.

In 60 years the ash attains the same height and diameter as it does in natural stands on the same soils in 100 years; the larch produces 400-500, and the ash 250-300 cubic metres of wood per hectare, which is twice the yield of normal natural stands of the same age under the same conditions of site.

The explanation of the success of this combination was found in the domain of metabolism. The ash, as was shown by vegetational experiments, is a nitro-phosphorophil. The larch furnishes fertilizer for the ash in the decomposition products of its litter, which is rich in phosphorus and potassium. In addition, it sets up the best microbiological conditions for the nitrogen exchange of the soil (nitrogen fixation, ammonification, nitrification) and yields other advantages on which we are unable to dwell in a brief report.

2. Mixed plantation of poplar and alder (*Alnus glutinosa* Gaertn.). This record-breaking productive combination of tree species was discovered by my pupil, G. I. Redko, in 1955.

He did not find any mature mixed plantations of poplar and alder and studied the mutual effect of these species at the points of contact of pure stands. It has been shown that alder effectively influences the growth of poplar (*Populus canadensis* Moench., *P. nigra* L.).

At a young age the highest growth of h and d was revealed by the second row of poplars from the alder, since the first row was shaded by the older and taller alder. The second and succeeding rows of poplar, not subjected to light suppression, were better able to utilize the advantages created by alder in the soil. It was the interrelationships in the soil sphere that were the chief cause of the record-breaking rise in poplar productivity under the influence of alder: the increase in height at a young age (up to 10 years) was as much as 100 per cent; at old age—up to 20 per cent; the increase in diameter at a young age—up to 200-250 per cent, at old age—up to 30-70 percent; the increase in reserve at a mature age—up to 100-150 per cent.

Excavations showed that the horizontal roots of the poplar grew chiefly in the direction of the alder, overcoming a distance of 10-20 metres. On reaching the alder zone they are densely ramified. G. I. Redko found numerous cases when the small roots of the poplar penetrated into the large nodules on the alder roots. He established by means of chemical analysis that the poplar absorbs nitrogen compounds from the alder nodules. Here we have a typical case of one component benefiting the other, the latter effectively taking advantage of the opportunity offered to increase its growth.

We whole-heartedly recommend combined plantations of poplar and alder, particularly on sites B and C, where the poplar cannot yield an average annual accretion of 8 cubic metres without recourse to fertilizers. The common alder (*Alnus glutinosa* Gaertn.) grows best on sites of the 3rd and 4th rank of humidity; in the second rank of humidity, less hygrophilous alder species should be employed—*A. incana* Moench and *A. viridis* DC.

The favourable mutual influence of forest trees may be reflected not solely in the mobilization or transfer of deficient elements of soil nutrition, but also in removing excess of some element. Thus, in pure black locust stands an excess of nitrogen accumulates in the soil, which may be absorbed by nitrophilous plants, especially by elder (*Sambucus*) undergrowth. By decreasing soil nitrogen, the elder makes the N: P: K ratio more favourable for black locust.

The interaction of arboreal species may take place in various spheres. Direct chemical action is not unfrequently encountered, bearing the character of so-called "allelopathy." More comprehensive and involved interaction is of greater frequency, being effected through a long chain of intermediate links, the interrelationship of the plants and the ecological environment being of conclusive importance. Thus, the beneficial effect of hornbeam, maples, *Rhus cotinus* L., spruces on neighbouring species is particularly effective on soils rich in lime and on alkaline soils, inasmuch as the litter of these species promotes soil acidification. The soil-alkalinizing deciduous plants, especially elder and other shrubs (the acidity of water infiltrated through their forest litter having a pH of up to 9.5), are able to neutralize acid podsolized soils rapidly and effectively. Tree species whose litter is choice food for earthworms (shrubs, maples, limes, etc.) are able to raise soil fertility and productivity of the stands in a short time.

Since the interaction of arboreal species with the environment and with each other is greatly diversified and alters with time (antagonistic relations in youth, for instance, may give way to beneficial relations in old age), special experiments conducted with the aim of finding effective combinations are of great value. We suggest the universal application of poly-chessboard plantations, which permit testing on a relatively small area all possible combinations of species. Poly-chessboard plantations should be founded in each forest ranger district.

The idea of these plantations is the following. To test all combinations of tree species cultivated in the given locality, not only must their binary combinations *n* by *n* be planted, but at least four different vectorial meetings must be secured for each pair of species. In other words, species *a* should meet with species *b* on the south, north, east and west, since this condition affects in lighting regime and may substantially alter the course of interaction between the species. In the elementary case of a simple bi-chessboard system, if one of its sides is aligned with the meridian, the black and the white squares meet in the four above-mentioned vectorial combinations.

Row plantations do not satisfy our requirements; first, because it is necessary to use for the experiments a large area of homogenous land. Secondly—and even more important—on mixing species in solitary rows, an early and sudden termination of the experiment may occur when one species suppresses the other at a young age, because one of them is backward in development due to weather conditions, pests and other accidental factors. It is better to make use of a chessboard combination of species in squares (10 x 10 m. or larger), each of which contains a seeding or planting of only one species. In this case, the course of interaction of the species may be observed at the points of contact over a fairly long period—25-50 years—since the depth of the front of their meeting is great (in the example given, 10 m. or more), The control of the growth of each species is the height of the trees in the centre of the square.

The bi-chessboard principle is suitable only for combinations of two species. The poly-chessboard system proposed by the author enables us to conduct experiments with many species. Take, for example, a poly-chessboard system for ten species on an area of one hectare. Each species meets each of the other species four times in accordance with the four-vector requirement mentioned above. Each species is diffusely scattered over the section, which enables us to control the homogeneity of soil conditions by the average height of the trees in the centre of the square. The mathematical principle of arrangement, the methods of calculation and organisation of the experiments have been previously described.

The practice of poly-chessboard plantations demonstrates their high scientific informativeness. A comparison of the heights of tree species: (1) at the line of contact; and (2) in the centre of the squares, answers the question of the interaction of two neighbouring species. There are cases when one species rapidly surpasses some neighbouring species in growth at a young age, which is to be expected when combining rapidly growing and slowly growing species. In this case, the research value of the combination may be raised by somewhat complicating the experiment, which permits assaying the obscure aspect of root competition between the pair of species. The trunks of the rapidly growing trees are cut at the level of the top of their slowly growing neighbours. The subsequent difference in the growth of this pair of species may, to a great extent, reflect their interrelationships in the soil environment. The cutting is carried out on an area of ¼ of a square adjoining the species that is lagging in growth.

Our practice includes a poly-chessboard plantation of 28 species which is ten years old. The first investigation of five- to 7-year-old sections has been published, valuable indications being obtained on favourable and unfavourable species combinations.

Poly-chessboard plantations are recommended for international application.

The results will be of great scientific and practical interest—especially communications on productive combinations of the type mentioned in the foregoing—ash and larch, poplar and alder and others. It is essential to indicate the types of site on which the results were obtained.

RESUMES

Création de peuplements melangés pour accroitre la productivité des forêts

Ayant étudié les nombreuses associations d'essences se trouvant dans les peuplements mélangés, l'auteur et ses collaborateurs ont trouvé des combinaisons d'essences sylvestres qui accroissent de façon considérable la productivité forestière grâce à l'effet salutaire des essences les unes sur les autres. Ainsi, dans les conditions de climat et du sol spécifiquement indiqués dans le rapport, certaines essences qui emmagasinent de l'azote, notamment l'aune glutineux (*Alnus glutinosa* Gaertn.) ont pour effet de doubler, et parfois même de tripler l'accroissement des essences nitrophiles voisines. On a découvert par exemple que les radicelles du peuplier pénétrent dans les nodules des racines de l'aune et en tirent un supplément d'azote. Dans des peuplements de robiniers (*Robinia pseudoacacia* L.), l'excès néfaste de nitrates du sol, mis en réserve par cette essence, est absorbé par des essences nitrophiles, notamment le Sambucus, ce qui a pour effet d'augmenter la croissance du robinier.

Il a été possible d'établir et d'étudier une augmentation de croissance chez le frêne (*Fraxinus excelsior* L.) sous l'influence du mélèze (*Larix sibirica* Lebed.) qui ameliore les conditions générales de nutrition du sol.

L'auteur propose le système de damiers pour des plantations expérimentales ayant pour objet de découvrir des combinaisons productives d'essences pour des peuplements mélangés. Chaque essence est semée ou plantée dans des carrés de 10 mètres de côté au moins; les carrés sont disposés de façon géométrique, ce qui fait que toutes les essences se rencontrent quatre fois: au nord, au sud, à l'est et à l'ouest. Les résultats de l'action réciproque des essences sont étudiés à la ligne de contact. Cette expérience a l'avantage de ne pas nécessiter une grande surface de sol homogène et de permettre la plantation dans des carrés de grandes dimensions. Elle permet également d'étudier l'action réciproque des essences au cours de longues périodes. Les premiers résultats de ce système de plantation en damiers ont été publiés.

Nous recommandons, pour l'estimation du site, un arrangement basé sur deux facteurs—fertilité et humidité du sol (réseau édaphique de sites).

Creación de Arbolados Mixtos como Método para Elevar la Productividad de los Bosques

A base del estudio de numerosas combinaciones de árboles en bosques mixtos, el autor y los colaboradores han encontrado algunas combinaciones de especies arbóreas que permiten un considerable aumento en la productividad, debido a los efectos beneficiosos de una especie sobre otra. Así, en determinadas condiciones de clima y suelo, según se indica en el informe, las especies que conservan nitrógeno particularmente el *Alnus glutinosa* Gaertn., aumenta dos o tres veces más el crecimiento de las especies vecinas nitrofilosas. Se descubrió que los extremos de la raiz del álamo habían penetrado en los nudillos de las raíces del aliso, utilizándolo como fuente suplementaria de nitrógeno. En arbolados de *Robinia pseudoacacia* L. el exceso dañino de nitrógeno del suelo, almacenado por esta especie, es absorbido por las especies nitrofílicas, particularmente el *Sambucus,* y esto aumenta el crecimiento del algarrobo.

El aumento de crecimiento se estableció y se estudió en la especie *Fraxinus excelsior* L. bajo la influencia de *Larix sibirica* Ledeb., que mejora las condiciones generales de nutrición del suelo.

El autor propone el método de tablero de ajedrez para las plantaciones experimentales, con el fin de descubrir combinaciones de especies productivas para rodales mixtos. Cada especie es sembrada o plantada en espacios de 10 metros cuadrados (o mayores) y los cuadrados se trazan en orden geométrico de modo que todas las especies encuentren a las demás cuatro veces: al norte, sur, este y oeste. Los resultados de la acción mutua de las especies se estudian en las líneas de contacto. La ventaja de este experimento es que no requiere una gran área de suelo homogéneo; esta plantación en grandes cuadrados, permite estudiar las interrelaciones de las especies por largos períodos de tiempo. Los primeros resultados de las plantaciones en forma de tablero de ajedrez han sido ya publicados.

Para fines de estimación del sitio es recomendable que la ordenación considere la fertilidad y humedad de los suelos.

El Método Mexicano de Ordenación de Montes

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Desde hace treinta y cinco años las leyes forestales del país, con un sentido altamente proteccionista en beneficio de la colectividad, se han promulgado para que su jurisdicción se extienda sobre todos los regímenes de propiedad (particular, ejidal, comunal y nacional), impidiendo la aplicación de métodos de tratamiento (matarrasa y sus variantes) que tienden a la obtención de montes regulares, y obligan, para permitir explotaciones, que en forma previa se presente ante el Servicio Forestal Federal, quien los supervisa, estudio de los bosques por aprovechar formulado por técnicos en la rama con ejercicio de postulancia autorizado.

Por los accidentados sistemas orográficos y la diversificación de climas, exposiciones y suelos en los que tienen asiento, los bosques mexicanos, tanto coníferos como hojosos ofrecen extrema irregularidad: en edades, diámetros, alturas, crecimientos y desarrollos, asociación de géneros y especies, cubierta herbácea, etc.

Tomando en cuenta la circunstancia real de nuestra deficiente experiencia, que las condiciones estacionales y los elementos de protección disponibles generalmente no garantizan el seguro establecimiento del repoblado en grandes áreas descubiertas, y dadas las condiciones sociales de nuestro medio no preparado aún para admitir cortas intensas; no tenemos ni hemos tenido los forestales mexicanos, otra alternativa que la de seguir métodos de tratamiento (de selección principalmente) que producen bosques irregulares.

Pero si desde su origen el manejo de bosques de tipo irregular es impuesto por la naturaleza misma, a mi entender, de 1926 a 1945 esta necesidad no fué bien comprendida porque para la determinación del *cuanto* volumétrico de las cortas, los técnicos postulantes y los del Servicio Forestal Federal aplicaron procedimientos propuestos por la escuela europea, entre otros el de Cabida, Von Mantell, Heyer, Suizo y Francés, todos ellos derivados de bosques regulares o irregulares sensiblemente normalizados en los que la edad tiene significación como parámetro ordenador, y por lo mismo, fundamentalmente distintos de las masas arboladas de México, repito, altamente irregulares y de edades múltiples confusamente mezcladas; lo que se demuestra conocido el origen de deducción de las expresiones de los métodos europeos citados, en las que si VC = volumen de corta anual; S = superficie del bosque; T = turno; v = volumen real por unidad superficial; V = volumen total; VN = volumen normal total; i = incremento volumétrico anual; y X = años para que V = VN, tenemos:

Cabida: $$VC = \frac{S}{T}v \qquad \dots\dots\dots\dots(1)$$

Von Mantell: $$VC = \frac{2V}{T} \qquad \dots\dots\dots\dots(2)$$

Heyer: $$VC = i + \frac{V\text{-}VN}{X} \qquad \dots\dots\dots\dots(3)$$

Francés: $$VC = \frac{2.25V}{T} \qquad \dots\dots\dots\dots(4)$$

Suizo: $$VC = \frac{Y+Z}{cc};$$

$$cc = \frac{Y+Z}{Xi+Yi} \qquad \dots\dots\dots\dots(5)$$

en las que: Y y Z = volúmenes de las clases diamétricas sobre el diámetro límite, y extracortable; cc = ciclo de corta; Xi e Yi = incrementos anuales de las clases bajo el diámetro límite e Y.

La inadaptabilidad de los métodos anteriores a los montes mexicanos la pone de manifiesto el hecho comprobado de que después de mas de veinte años de aplicación ningún bosque ni remotamente sostuvo el volumen del aprovechamiento anual que en ellos calculaban, y porque los mismos bosques no se encuentran siquiera en mediano bosquejo de ordenación al no saberse cuándo permitirán una nueva corta por cantidad parecida a la originalmente explotada.

Ante esta situación varios técnicos forestales mexicanos, deseosos de dar a nuestros bosques un tratamiento acorde con sus realidades, propusieron en 1944 y han venido mejorándolo gradualmente, un sistema de cálculo del *cuanto* de la cosecha que efectivamente producen las masas arboladas, en función de sus existencias antes y después de las cortas y del incremento corriente en volumen antes de ellas, y que permite además determinar el ciclo y la intensidad de corta, aunque para ésto debe prefijarse uno cualquiera de los dos valores para definir el otro.

La teoría relativa a que los crecimientos anuales volumétricos de un árbol se acumulan siguiendo la ley del interés compuesto, la hizo extensiva a las masas forestales este método, que por no tener semejanza con otros conocidos y al complementársele con instrucciones para la fijación del *donde, cuando* y *como* de la ordenación forestal se le ha venido llamando Método Mexicano de Ordenación de Montes, siendo sus expresiones matemáticas las siguientes:

$$PC = \frac{VC}{cc} \qquad \dots\dots\dots\dots (6)$$

$$ER = VP \times 1.0p^{cc} \qquad \dots\dots\dots\dots (7)$$

$$cc = \frac{\log.ER - \log.VP}{\log 1.0p} \qquad \dots\dots\dots\dots (8)$$

$$IC = \left(1 - \frac{1}{1.0p^{cc}}\right) \times 100 \qquad \dots\dots\dots\dots (9)$$

en las que: PC = posibilidad de corta anual.
ER = existencias reales antes de la corta.
VP = volumen en pié después de la explotación.
VC = volumen de la corta, por definición ER—VP, de donde VP=ER—VC.
p = porciento de incremento corriente en volumen, observado al hacer el inventario de ER.
cc = ciclo de corta en años.
IC = intensidad de corta = (VC/ER) × 100.

Obsérvese por (7) que el método forja como tendencia la reposición de *VC* para volver a obtener *ER* original partiendo de *VP,* lo que se logra durante *cc* si los crecimientos volumétricos anuales del mismo *VP* se acumulan siguiendo su tasa *p* la ley del interés compuesto.

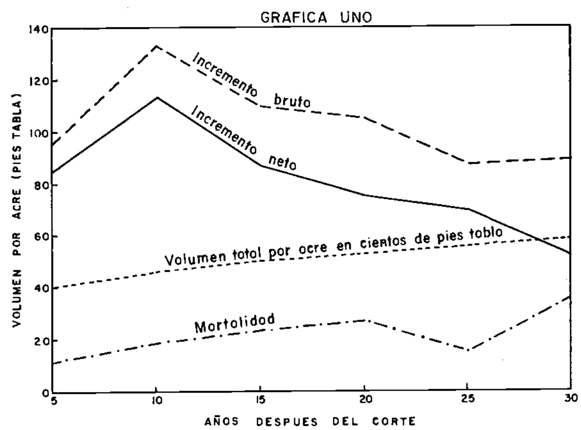
Es de hacer notar especialmente que para *cc* fijo, *IC* solo es función de *p,* por lo que para cada predio o rodal, si tienen crecimientos diferentes, lo que generalmente sucede, deben calcularse intensidades de corta también diferentes según les correspondan. Esto es lo que se hace en la práctica porque el ciclo de corta debe permanecer contante, y se determina haciendo variar la IC general entre el 35 y 50% de ER, eligiendo la que concilie: 1°.- la economía del aprovechamiento con 2°. las necesidades dasonómicas.

Los límites anteriores se mantienen aunque las IC individuales (de predios o rodales) resulten menores o mayores por el cálculo, atendiendo precisamente en el primer caso a la referida economía porque intensidades mas bajas impiden o hacen poco costeable la explotación, y en el segundo a razones de conservación y cultivo silvícola.

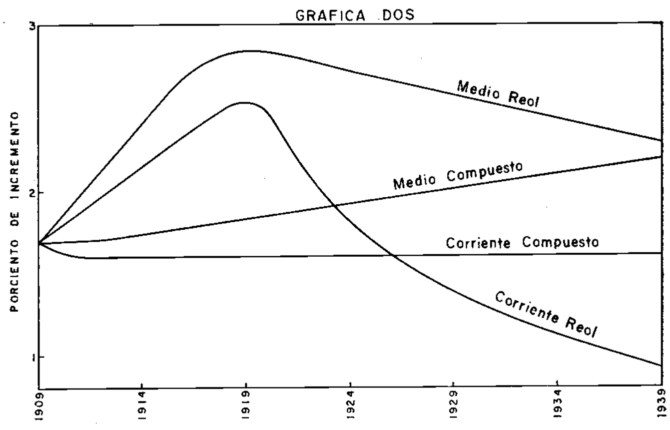
Apréciese por lo expuesto, y este concepto debe quedar perfectamente claro, que con el Método Mexicano se programan cortas según sus crecimientos, con intensidades variables en cada predio o en cada rodal de los comprendidos por la extensión boscosa sujeta a ordenación, espaciadas a un número de años (ciclo de corta) fijo, durante el cual las masas reponen con sus respectivos incrementos (del arbolado dejado en pié y del renuevo) el volumen cortado; estableciéndose rotación de explotaciones que en teoría tienden a repetirse indefinidamente.

La variación de las intensidades de corta individual es se comprende porque para un mismo período de recuperación (ciclo de corta), un monte que tenga mayores crecimientos podrá reponer mayor volumen cortado que otro que los tiene inferiores, en el que por comparación, deberá ser también menos su aprovechamiento.

Por su reciente enunciación carecemos de experiencia propia sobre la aplicación de este Método en bosques nativos, y para juzgar de la ley de acumulación de crecimientos en masas cortadas consultamos los resultados obtenidos en montes de P. Ponderosa durante treinta años (1909 a 1939) de observaciones controladas mediante la parcela S-3 de investigación permanente con 456 acres (185.5 Has. aproximadamente) de extensión, de la Estación Experimental Forestal de Fort Valley, Arizona, publicados por United States Department of Agriculture, Forest Service, en la Monografía N°. 6 intitulada *Management of Ponderosa Pine in the Southwest.*



Gráfica 1. Sitio permanente de experimentación S3 de Southwestern Forest and Range Experiment Station



Gráfica 2. Curso de las tasas volumétricas de incrementación corriente y media reales y corriente y media según la ley del interés compuesto (Interpretación del autor)

La Gráfica y Tabla Uno corresponden a los resultados que reporta la Monografía; la Tabla Dos corresponde a la Tabla Uno con interpretaciones de factores y coeficientes de conversión, y las Tablas Tres a Cinco se deriban de la Tabla Dos también según interpretaciones del suscrito, haciendo hincapié en que la Tabla Tres se tomó p = 1.07 y VP = 63.378 m3. Finalmente la Gráfica Dos expresa el curso de las tasas de los diversos incrementos anuales deducidos en las Tablas Tres a Cinco.

Estación Experimental Forestal de Fort Valley, Arizona, EEUU.
Pinus ponderosa
Crecimiento Total, Mortandad y Crecimiento Neto
Sitio Permanente de Experimentación No. S-3

TABLA NUMERO UNO

AÑO	ARBOLES POR ACRE DN en pulgadas		VOLUMEN PIES TABLA Por acre	PIES TABLA x ACRE x AÑO		
	4-11″	12″ ó más	12″ ó más	Total	Mortandad	Neto
1909	6.38	11.71	3,521	—	—	—
1914	—	—	3,946	96	11	85
1919	4.70	13.07	4,518	134	19	115
1924	—	—	4,951	110	24	86
1929	3.77	13.56	5,333	103	27	76
1934	—	—	5,676	85	16	69
1939	14.41	13.75	5,939	88	36	52
PROMEDIOS DE 30 AÑOS (1909-1939):				103	22	81

Los datos subrayados se interpolaron de la Gráfica Uno.

TABLA NUMERO DOS

AÑO	ARBOLES POR HA. DN en metros		VOLUMEN M3. ROLLO/Ha.	PROMEDIOS M3. ROLLO x HA. x AÑO		
	.10 a .275	.30 ó más	0.30 m. ó más	Total	Mortandad	Neto
1909	15.77	28.94	63.378	—	—	—
1914	—	—	71.028	1.728	0.198	1.530
1919	11.61	32.30	81.324	2.412	.342	2.070
1924	—	—	89.118	1.980	.432	1.548
1929	9.32	33.51	95.994	1.854	.486	1.368
1934	—	—	102.168	1.530	.288	1.242
1939	35.61	33.93	106.902	1.584	.648	.936
PROMEDIOS DE 30 AÑOS (1909-1939):				1.854	0.396	1.458

DATOS Y NOTAS: Volumen antes de la corta .... 218 M3.
Volumen después de ella .... 63 M3.
Intensidad de corta 71%

M3. ROLLO TOTALES POR HECTAREA:
(0.00246 x 2.47104 x BF)/(.50 x .65) = 0.018 x BF.
0.00236 = factor de conversión de pies a M3.
2.47104 = factor de conversión de acres a Has.
0.50 = coeficiente de asierre.
0.65 = proporción de fustes en el volumen total por árbol.

Del análisis de las gráficas y tablas anteriores tenemos dos conclusiones básicas:

Primera. Que como consecuencia de los aclareos y del arbolado generalmente mas joven dejado por las cortas, en la masa remanente se produce una "aceleración" en el crecimiento de rápido ascenso con culminación aproximadamente a los diez años, decreciendo después con mayor celeridad. Esto fué comprobado en un pinar del Estado de Jalisco, México, que antes de la explotación en 1947 de 5,700 m3. con intensidad del 37% de *ER* (15,400 m3.) incrementaba 6.2%, y en 1957 con *ER* de 22,400 m3. su tasa era del 12.6%, y

Segunda. Que el Método Mexicano al calcular la recuperación del volumen cortado partiendo de *VP* y de *p* antes de la corta, resulta conservador durante unos

Estación Experimental Forestal de Fort Valley, Arizona, EEUU.
Pinus ponderosa
Sitio Permanente de Experimentación No. S-3.

TABLA NUMERO TRES

AÑO	PORCENTAJES: Total	Mortandad	Neto	OBSERVACIONES
1909	1.90	—	1.70	Deducido
1914	2.43	0.28	2.15	Observado
1919	2.97	0.42	2.55	”
1924	2.22	0.48	1.74	”
1929	1.94	0.51	1.43	”
1934	1.50	0.28	1.22	”
1939	1.48	0.61	0.87	”
PROMS:	2.93	0.63	2.30	

TABLA NUMERO CUATRO
VARIACION REAL DE LA TASA DE INCREMENTO MEDIO

AÑO	n	EXISTENCIAS REALES M3. ROLLO/HA.	I. MEDIO/AÑO M3.	%
1909	0	63.378	—	1.70
1914	5	71.028	1.530	2.41
1919	10	81.324	1.795	2.83
1924	15	89.118	1.716	2.71
1929	20	95.994	1.631	2.57
1934	25	102.168	1.552	2.45
1939	30	106.902	1.451	2.29

TABLA NUMERO CINCO
VARIACION DE LAS TASAS DE INCREMENTO CORRIENTE Y MEDIO CONFORME A LA LEY DEL INTERES COMPUESTO

AÑO	n	$1.0p^n$	ER M3.	I. CORRIENTE/AÑO M3.	%	I. MEDIO/AÑO M3.	%
1909	0	—	63.378	—	1.70	—	1.70
1914	5	1.088	68.955	1.115	1.62	1.115	1.76
1919	10	1.184	75.040	1.217	1.62	1.166	1.84
1924	15	1.288	81.631	1.318	1.61	1.217	1.92
1929	20	1.401	88.793	1.432	1.61	1.271	2.01
1934	25	1.524	96.588	1.559	1.61	1.328	2.10
1939	30	1.658	105.081	1.699	1.61	1.390	2.19

FORMULA APLICADA: $ER = VP \times 1.0p^n$ .... (3)

veinte años después de la explotación; caso general porque los ciclos de corta elegidos raras veces son mayores. Esto es conveniente para prevenir bajas por incendios y plagas, lo que no motivará se deje de comprobar cuál es la verdadera reacción del monte y procedamos en concordancia.

Las extensiones boscosas que proporcionan el volumen de corta por año se localizan y delimitan en el plano de predios y rodales integrando cada una las llamadas Areas de Corta Anual, cuyo número es igual al de años que comprende el ciclo de corta, con lo que se define el *donde;* a cada una de estas áreas se les asigna un orden de explotación, con lo que se tiene el *cuando;* la intensidad de corta y el método de tratamiento de selección o cortas de jardinería constituye el *como,* quedando así resueltas las cuatro condiciones fundamentales que pide todo sistema ordenatorio.

Sin embargo no esperamos que la primera intervención de este método o la primera corta gobernada con él ordene los bosques mexicanos. Será necesario que se repita varias veces hasta que en una área de corta dada se establezcan tres o cuatro clases de edad diferentes, y el conjunto de estas áreas o cuartel de ordenación, tenga tantas clases de edad como años el *turno* obtenido para poder aplicar, entonces sí, uno de los métodos europeos de ordenación que mejor encaje en el tipo de masas irregulares semicontínuas producidas.

Por lo dicho, no es propiamente el Método Mexicano un método de ordenación, sino que cuando más aspira a ser preparatorio de ella. Pero si con él o con otra idea mejor logramos persistencia en los volúmenes de aprovechamiento, podremos considerar los forestales mexicanos, el cumplimiento de la misión que en la época que nos ha tocado vivir nos corresponde.

El ingente deseo y nuestro alto sentido de responsabilidad por dar a los bosques de México el tratamiento técnico que merecen, mantienen abiertas las puertas para recibir con beneplácito, la capacitada colaboración que para resolver el problema que afrontamos nos hagan los honorables miembros de este magno Congreso.

RESUMES

The Mexican Method of Forest Management

The European forest management systems, such as the Cabida, Von Mantell, Heyer, Swiss, French or Melard, and other similar methods, have been considered unsuitable for the forests of Mexico, because these methods have been developed from normal forests where *age* and *rotation* act as managing parameters. Such is not the case in Mexico, where there is a lack of regularity in ages, diameters, heights, and growth, as well as a mixture of generic and specific associations and, in general, all other aspects of the individuals comprising the native stands of Mexico.

To approach the technical problem that these forests present, the first cutting operations are designed to prepare the forests for management, properly speaking, by reducing their extreme irregularity and maintaining a constant annual yield.

The estimate of the measurable annual yield and the cycle and intensity of the cutting is determined by the law of the accumulation of compound interest, as follows:

$$PC = \frac{VC}{cc}$$

$$AS = VC \times 1.0p^{cc}$$

$$cc = \frac{\log. AS - \log. VC}{\log 1.0p}$$

$$IC = (1 - \frac{1}{1.0p^{cc}}) \times 100$$

Explanation of symbols:

PC = Possibility of annual cut.
AS = Actual stocks before cutting.
VS = Volume still standing after cutting = AS -VC.
VC = Volume of cut = AS - VS.
IC = Intensity of the cut = (VC/AS) x 100.

This method, which has been suggested by Mexican technologists, with added proposals for determining the *where, when* and *how* of forestry management, has come to be known as the Mexican System of Forest Management.

An earnest interest in providing the forests of Mexico with the treatment that they deserve has led me to present the described method for the consideration of the distinguished delegates. We gladly accept any aid which will help us to solve our problem.

La méthode mexicaine d'aménagement des forêts

On a estimé que les méthodes de Cabida, de Van Mantell, de Heyer, la méthode suisse, la méthode française, celle de Mélard et autres méthodes européennes d'aménagement forestier ne pouvaient être appliquées aux forêts du Mexique, parce qu'elles avaient pour point de départ des forêts considérablement normalisées, pour lesquelles l'*âge* et la *rotation* jouent le rôle de paramètres ordonnateurs; il n'en va pas de même pour les forêts mexicaines, vu la grande irrégularité que l'on y constate quant à l'âge, au diamètre, á la hauteur, à l'accroissement, aux mélanges de genres et d'espèces, et, en général, en tout ce qui relève du mesurage des sujet composant les massifs indigènes mexicains.

Pour s'attaquer au problème technique que posent ces forêts, on y pratique tout d'abord des coupes ayant pour objet de les préparer à l'aménagement proprement dit, en atténuant l'extrême irrégularité et en maintenant à un niveau constant le volume de leurs accroissements annuels.

Voici, calculée selon la loi d'accumulation de l'intérêt composé, la formule exprimant le *"combien"* de l'accroissement annuel, ainsi que le cycle et l'intensité de la coupe:

$$PC = \frac{VC}{cc}$$

$$RE = VP \times 1.0p^{cc}$$

$$cc = \frac{\log. RE - \log. VP}{\log. 1.0p}$$

$$IC = (1 - \frac{1}{1.0p^{cc}}) \times 100$$

étant entendu que:

PC = potentiel de coupe annuelle.
RE = réserves effectives avant la coupe.
VP = volume sur pied après l'abattage = RE - VC.
VC = volume de la coupe = RE - VP.
IC = intensité de la coupe = (VC/RE) x 100.

Proposée par les techniciens de notre pays, cette méthode, une fois complétée par des indications permettant de fixer les *"ou, quand* et *comment"* de l'aménagement forestier, a été baptisée "Méthode mexicaine de l'aménagement des forêts".

Mûs par le grand désir de donner aux forêts mexicaines le traitement qu'elles méritent, nous soumettons à l'examen des éminents congressistes la méthode exposée ci-dessus, le meilleur accueil étant assuré à toute offre de collaboration qui nous permettrait de résoudre nos problèmes.

Working Plans In Great Britain

D. R. JOHNSTON

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The Forestry Commission of Great Britain has recently produced a Working Plans Code which introduces a form of working plan and a system of planning and management designed to meet the needs of a young and expanding forest estate in a period of rapid economic and technological change. The Forestry Commission was established in 1919 and inherited a number of old Crown forests, but 1,000,000 acres of the present planted area of 1,200,000 acres are less than thirty years old, and 700,000 acres are less than twelve years old. Management planning in the early establishment phase was achieved with simple, short-term plans for individual operations such as planting, weeding, cleaning, and thinning, but as forests reached the production stage, the need was felt for a more comprehensive form of plan; particularly as it is our policy to maintain a permanent labour force in each forest. A number of working plans have been written in recent years both for old Crown woods and also for younger forests entering the production stage. These plans, which were based upon the traditional pattern developed in Europe and India in the nineteenth century, were found to be quite unsuitable for our purposes, since they were evolved to meet the needs of a non-expanding forest estate having well-established markets in a relatively stable world. They invariably became out of date in a few years and, because a plan is invested with a certain amount of authority, any prescriptions contained in it became more of a hindrance than a help to management, as soon as they became obsolete. In addition, lacking an effective working plans code, there was no uniformity in the form and presentation of plans, so that officers who moved from one district to another found it easier to write a new plan than to try to operate the old one. The various procedures for short-term planning, financial estimating, and record keeping, were developed quite independently of the working plan, which, if it existed, was regarded as a rather impracticable ornament to management.

The Code introduces a system of planning and management which is quite new to Great Britain, and some aspects of it may be of interest to other countries with similar problems. The Code not only introduces a form of working plan but also deals with the organisation necessary to carry out field surveys, and with the writing, maintenance, and implementation of the plan. It defines the responsibilities of the various grades towards working plans and ensures that the routine management of each forest is intimately linked to the working plan procedures.

Some of the more important aspects of a working plan, as set out in the Code, are discussed below:

The Purpose of the Working Plan

The purposes of a working plan are summarised in the Code as follows:

(a) To ensure that national forest policy is made effective at all levels of forest management.

(b) To ensure the orderly and economic development of the forest within this framework of policy and to prevent unco-ordinated *ad hoc* management decisions being taken without regard to their wider implications.

(c) To ensure that the aims of management are clearly defined and that the methods of achieving them are realistic and are the result of a careful study of all relevant factors.

(d) To ensure that all supervisory staff concerned with the forest are aware of its intended future development and thereby to achieve continuity of management when there are changes in staff.

(e) To bring together in a readily accessible form such information as is necessary for the efficient management of the forest.

The Working Plan Period

The plan is not written for a fixed period of years but is regarded as having an indefinite life. It is revised and adjusted once a year, before the detailed annual financial estimates are prepared; but since it would be impracticable to keep a plan completely up to date in this way, it is throughly reviewed every ten years.

Planning Procedures

Planning, which is achieved in three stages, is highly flexible. One might say that plans come sharply into focus for the year immediately ahead but become progressively less detailed as one looks further into the future.

Long-term planning takes the form of a statement of local policy which is written under the traditional title of "Objects of Management." This defines, for example, the type of forest to be produced; whether broadleaved or coniferous, selection or evenaged and, if possible, gives some idea of the size of final crop tree and rotation length. Although the Objects of Management may not be altered without high authority, it is intended that they should be rewritten if changing circumstances make them unrealistic. An alteration to the Objects of Management might well involve a complete review of the whole working plan.

Medium-term planning is expressed in five-year forecasts of quantities, which are revised and extended by one year every July. These forecasts deal only with quantities of work, not with location, and they are prepared by an analytical rather than a synthetic process. The requirements and potential production of the forest as a whole are considered and, in the light of changing circumstances, the district officer, who is responsible for the forecasting, decides what quantities of work by operations (e.g., acres of planting, acres and volumes of thinning and felling, miles of ditching and road making) are required for each of the ensuing five years. He takes account not only of the requirements, but also of the resources likely to be available and reconciles all the forecasts with the likely resources for each year of the five-year period. These forecasts are not regarded as prescriptions, and at the annual revision, the district officer is able to revise any forecasts which have become unrealistic. The forecasting process is particularly valuable in balancing the labour force with the requirements of the forest and, although no cumulative record of departures from earlier forecasts is maintained, it is possible from a critical examination of a series of forecasts to detect any changes in the tempo of work either in the forest as a whole or in any particular operation.

Short-term planning is the most detailed and normally extends for only one year ahead. Annual programmes of work are prepared for each operation. These state not only the quantity, but also the location of work, by compartments or subcompartments. They are regarded as quantitative prescriptions, and the total of each programme equals the total for the first year of the corresponding forecast. If, for example, the planting forecast were as follows,

1960	1961	1962	1963	1964
497 acres	450 acres	400 acres	350 acres	350 acres

the planting programme for 1960 would list a number of compartments or subcompartments whose total area came to 497 acres. The programmes thus become the foresters' working instructions for the year, the basic document of record and control, and also form the basis of the annual financial estimates. If it proves impossible to complete a programme, the programme total is not amended, but is retained as the basis for working plan control. The quantity of work actually completed is recorded on the programme and forecast at the end of the year, and any discrepancy is taken into account when preparing forecasts and programmes the following year.

Allocation of Responsibilities

There is often a tendency for the responsibilities of different grades within a forest service to be imperfectly defined. The new code defines responsibilities in some detail. Broadly speaking, the ranks from district officer to conservator (professional grades) are responsible for local planning, and the forester (technical grade) is responsible for carrying out these plans. More specifically, the conservator (there are thirteen territorial conservators in Great Britain) is responsible for writing the Objects of Management, while the district officer (who will usually have several working plan areas in his charge) is responsible for writing the working plan, keeping it up to date, and for revising and extending the five yearly forecasts each year. He is also responsible, with the help of the forester, for preparing the programmes and annual financial estimates. The forester is responsible for planning and supervising the year's work in the forest. It is recognised that the district officer and forester rarely have either the time or the necessary technical experience to undertake the topographic surveys, forest inventories, and soil surveys required for a working plan. The district officer writing the plan can therefore call upon the services of specialist working plan survey teams, who work under the technical control of a central Working Plans organization. The Objects of Management, together with a summary of proposals for achieving them, have to be approved by the Director of each country (England, Scotland, and Wales) and finally by the Director General of the Forestry Commission, but the details of each working plan need only be approved by the conservator.

Contents of the Working Plan

The layout of the plan is conventional, with a descriptive Part I, followed by Objects of Management, and a prescriptive Part II. It is bound on a loose-leaf system to facilitate revision and amendment, and includes forecasts, programmes, compartment records, inventory data, record and control forms, and maps.

The plan is regarded as a planning document, not as a manual of instructions and qualitative prescriptions are kept to a minimum. Since well trained foresters are available to implement the plans, only exceptions from normal forest practice are prescribed in detail.

Application of the Working Plan

It will take a number of years to complete the necessary surveys and inventories and to write plans for all forests, but as from 1960, all planning, financial estimating, records, and control in the Forestry Commission is being done in accordance with the procedures defined in the Working Plans Code, and all existing procedures which do not fit into this scheme are being abolished. There is therefore no longer any fundamental distinction between a forest managed according to a working plan and one without a plan. The preparation of a plan, however, involves the careful collection of data and a critical evaluation of the factors affecting management. As a result, planning and management will be based upon a surer foundation than if no working plan existed.

RESUMES

Plans d'exploitation en Grande-Bretagne

L'auteur fournit les raisons pour lesquelles des plans d'exploitation ont été adoptée par la Forestry Commission en Grande-Bretagne. Il décrit le type de plans utilisé et donne un bref exposé des objectifs que ces plans doivent réaliser. Il indique les méthodes adoptées pour l'élaboration des plans et les responsabilités des différents gardes forestiers à tous les échelons à l'égard de ces plans. Il fait ressortir que le rassemblement des renseignements et le contrôle des opérations sur les bases établies pour le plan d'exploitation peuvent être introduits dans le plan d'aménagement d'une forêt avant que le plan soit complètement prêt. Le parachèvement des plans d'exploitation pour l'ensemble des forêts de la Forestry Commission doit nécessairement s'échelonner sur un certain temps.

Planes de Trabajo de la Gran Bretaña

Se dan las razones que indujeron a la Comisión Forestal a establecer el sistema de planes de trabajo en los bosques de la Gran Bretaña. Se describe el tipo de plan que va a usarse y se esbozan brevemente los propósitos que éste ha de servir. Se

explican los procedimientos seguidos en la preparación de los planes y se enumeran los responsabilidades de los diversos miembros del personal forestal en el desarrollo de los citados planes de trabajo. Se señala, también, que la compilación de datos y la regulación de las operaciones sobre las bases establecidas para cada plan pueden comenzarse en el bosque antes de que dicho plan esté completamente preparado. Por necesidad, la terminación de los planes de trabajo que la Comisión Forestal tiene para todos sus bosques tendrá que extenderse por período razonable de tiempo.

The Introduction of the Check System Into Scottish Woodland Management

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In 1878, Gurnaud in France devised a method of management which he called the *Méthode du Contrôle* and which is generally known in the English language as the Check Method. Its development in practice was largely due to Biolley in Switzerland, where he applied it to mixed uneven-aged forests in the Val de Travers.

The application of the method requires the following:

a. Division of the forest into permanent compartments.
b. The diameter or girth measurement at breast height of all the trees in each compartment which are above a certain minimum size. The point of measurement is marked on the tree so that remeasurement can take place at the same point. This measurement is done once during each cycle or management period.
c. The computation of the standing volume of all the measured trees, using a volume table where the conventional unit of the silve is employed.
d. Any trees to be utilised are measured in silves before they are felled.
e. The calculation of the increment by subtracting the volume at the beginning of the period from the volume at the end of the period, taking into account the yield and the recruitment into the lowest size-class.

Under the direction of Professor M. L. Anderson, the Check Method is being used in the management of certain Scottish woodlands. These studies, undertaken by the Department of Forestry of the University of Edinburgh, are concerned with some half-dozen woodlands where one of the objects is to manage them as irregular forests by the Check Method. At the beginning of these management studies the woodlands ranged from those composed mostly of leaf-trees to one entirely made up of conifers. Some of the woodlands are more or less fully stocked and to some extent are already of an irregular group structure. Even-aged stands occur in the coniferous forest. Some of the woodlands contain large areas of bare ground. Two of the woodlands will be described below.

The application of the Check Method to these Scottish woodlands follows the same lines as the classic examples of the Val de Travers, with one or two modifications. Instead of enumerating the whole forest once during the period, say every 6th year, one block is enumerated annually. In fact, all the operations take place in the current block with the proviso that at half-cycle a block may be re-entered for silvicultural reasons.

The size-class interval is 1½ in. Q.G., beginning with class (O) with a mid-Q.G. of 4½ in. The unit of standing volume measurement is the hoppus silve. The conventional volume table is used for all species and is based on that employed in the Val de Travers but related to quarter-girth measurement. Conversion factors are calculated for the various species by equating the volume of the outturn of felled trees in hoppus feet against their corresponding volume in hoppus silves.

The cycle of operations is 6 years for some of the woodlands and 8 years for those where growth is slower. As yet, insufficient data are available to draw other than tentative curves for the ideal growing-stock, but in a year or two it should be possible to construct curves of equilibrium and to have reliable increment data for some of the forests now being managed by the Check Method.

Dalmeny Woods are situated in the county of West Lothian and comprise 448 acres. The greater part of the growing-stock consists of leaf-trees (oak, beech, sycamore, elm, and ash), but there are some patches of pure conifers (pine and larch). The stands show a rather irregular structure and, in general, there is an excess of the over-mature size-classes. The woodlands form part of the Dalmeny Estate. They range in altitude from mean sea level to 387 feet. They are interspersed among farm land.

Through the carboniferous strata intrude basaltic outcrops which appear on the hilltops and ridges. The soils are base rich and variable in depth. They range from heavy marls to light sandy soils.

The annual rainfall is about 30 in., of which a little under half falls during the growing season of 190 days. Humidity is high, and frost occurs on 25-50 days. The mean minimum temperature is 36°F., and the range of temperature, 25°F.

The objects of management provide for the maximum production in perpetuity, for protection, for amenity, and for research purposes. It is considered that the principal objects can best be achieved by managing the woodlands on a group-selection system by the Check Method.

It is anticipated that when the woods have been brought up to full production the increment should be 2 per cent per annum. Taking this as a guide, the prescribed cycle of operations is 6 years.

The 448 acres have been divided into six blocks, one being treated each year. The ultimate management unit is the compartment, of which there are about seven per block, averaging 10½ acres each. Existing boundaries have been used to demarcate the compartments.

The operations carried out by compartments in the current block are:

a. Complete callipering of the growing-stock.
b. Lay-out of regeneration group openings, marking and callipering the trees to be felled.
c. Yield marking and its enumeration.
d. Selection of species for planting groups.
e. Felling and tending.
f. Planting.

The above sequence begins towards the end of the growing season in October and ends some six months later.

The management volumes of the stand and of the yield are calculated in hoppus silves from the enumeration figures. After felling, the outturn of the yield is measured in hoppus feet, and thus the conversion factors can be computed by species if necessary. So far, this has worked out to be about 0.55 for the leaf-trees. Such a low figure is due to the greater part of the yield being made up of short boled, large girthed, big crowned leaf-trees—a relic of lack of management. No great improvement on this figure may be expected for some years until the majority of the mis-shapen trees have been removed.

The management volume for the growing-stock on the 221.5 acres enumerated to date gives an average of 4,100 hoppus silves per acre, and for the yield, 521 hoppus silves per acre. This represents an exploitation per cent of 12.7, which is near enough to the 12 per cent considered normal by the management planner.

Until the first cycle has been completed and the entire growing-stock enumerated, no real attempt will be made to construct a curve of equilibrium. Current statistics show, as expected, that there is a dearth of trees in the younger size-classes. They also show from the extended range of size-classes that there are many trees which, from a management point of view, must be considered as overmature.

As the group-selection system has been adopted, no rotation has been prescribed, but from increment investigations and because ash and sycamore will be grown on relatively short rotations, an appropriate average exploitable age for all species has been taken as 90 years.

The area to be regenerated each year is the total area divided by the exploitable age, 448 ÷ 90, i.e., 5 acres. Artificial regeneration by planting is being used at present because squirrels, rabbits, hares, and game birds make natural regeneration difficult or uncertain, except for ash and sycamore, and because it is desirable to introduce some pioneer species on certain sites.

A planting group of 1⅓ chains x 1 chain (0.133 acre) has been chosen, and in it 300 young trees are planted. Thus, 38 groups are planted each year to give the required 5 acres.

After 90 years, that is after 15 cycles, the woods should be fully constituted so that each block will consist of a series of age-classes at 6-year intervals.

The second example forms a part of Glentress Forest which is situated in the county of Peebles. By agreement with the British Forestry Commission, a high elevation experimental area of 306 acres is being managed by the Forestry Department of the University of Edinburgh with the object of creating and maintaining in perpetuity a forest of irregular structure which will function primarily in a protective capacity.

The experimental area is situated on two diverging spurs at an altitude of from 800 to 1,831 feet, with most of it above 1,250 feet. It is exposed to winds from the south-west and west. The annual rainfall is more than the 37½ inches, recorded at Peebles, 3 miles away and at 600 feet altitude, and there are 206 rainy days a year. Snow lies for at least 20 days, and frost occurs on over 100 nights. The relative humidity is 75 to 80 per cent, and the mean annual temperature 45°F.

Hard greywackes outcrop on the ridges. There is a heavy glacial till on the lower slopes. The soil is mostly a brown earth, being slightly leached at the higher elevations.

The growing-stock is entirely coniferous, being mainly pine, larch, Norway and Sitka spruce, and Douglas-fir. The existing stands have been artificially created. There are some relics of Scots pine and European larch dating from 1903-06, and the other stands were planted after 1920 when the Forestry Commission acquired Glentress Forest. Thus, the stands have a regular structure.

The principles involved in the management of such an experimental area are:

a. The stand must have a composition and structure best adapted to the environment and must be able to maintain and increase soil fertility to the greatest possible extent.
b. The growing-stock must be so constituted that it will give the highest value production and the highest possible increment in respect of volume and quality.
c. To determine the optimum amount and composition of the growing-stock for the provision in perpetuity of a sustained yield while maintaining the soil permanently overshaded.
d. To obtain experience and information that will provide the means of assessing the effect of the proposed treatment and the progress towards the desired objective.

Bearing these principles in mind, it is prescribed that the treatment will have as its objective the ultimate establishment of a main crop of climax species of irregular structure and composition, in particular Norway spruce, silver fir, and beech, and that management will be by the Check Method.

Treatment began in 1952-53. The 306 acres were divided into six blocks, more or less of equal area, and the existing Forestry Commission compartments were retained. One block is treated each year. The conversion period has been taken as 60 years, and as the cycle is 6 years, one-tenth of the annual block is planted. Regeneration groups are either 1 ch. x ½ ch. or ½ ch. x ½ ch. and containing, in general, 200 and 100 plants respectively. In the later cycles of this conversion period, it is likely that a smaller area will be planted annually because of the retention of parts of stands created before the introduction of the present treatment. At the end of the tenth cycle the growing-stock in the experimental area should have a group-selection structure and should contain an age-class distribution of 0-90 years.

The blocks are treated in sequence, and the operations carried out in the current block are along the same lines as those described for Dalmeny Woods.

The enumerations and calculations resulting from the application of the Check Method will provide the means of assessing the effect of the treatment proposed and the progress being made towards the desired objective. In such a conversion scheme the treatment must necessarily be flexible and it will be modified from time to time on the basis of the results obtained. Observations and records will provide the means of assessing the results of the silvicultural treatment, and the application of the Check Method of management will furnish statistics on increment, production, ideal stocking, and the development of the stands towards the objective of a group-selection structure.

As the experiment is in its eighth year, two sets of statistics are available for Blocks A and B. These are for immature stands and therefore in many respects abnormal. The upper size-classes are unrepresented. However, the statistics do provide a check on exploitation against production. Exploitation for the 6-year period came to 35 per cent of the production in Block A, where Douglas-fir, representing the larger sized trees, was responsible for 63 per cent of the fellings, and to 15 per cent in Block B. These are reasonable figures at the moment, considering the composition of the growing-stock and the aim to create a proper distribution of size-classes.

The application of the Check Method to Scottish forestry is still in its infancy, but it is considered that it has a definite place in Scottish woodland management. Associated as it is with irrigular forests, it has the following merits:

a. It ensures a continuity of annual operations which can maintain a small and efficient labour force in proper employment.
b. It provides an annual source of forest produce which is very desirable in estate management.
c. No extremes of periodic expenditure and financial returns are experienced, but rather a regular annual outlay which should be more than covered by the annual income.
d. Individual stands are treated according to their requirements.
e. The evolution and equilibrium of the stands can be followed by statistical and graphical means.
f. The proper application of the method should ensure the maintenance of site fertility, the maintenance of stand productivity, and the maximum value production at the minimum cost per unit area.
g. The elasticity allowed by the method and the provision for the proper collection and recording of data and the ease of making comparisons make this method ideal for research purposes.

RESUMES

L'introduction du système du contrôle dans l'aménagement des forêts écossaises

La Méthode du Contrôle est utilisée par l'Ecole de Sylviculture de l'Université d'Edimbourg dans l'aménagement d'une demi-douzaine de forêts écossaises. L'auteur présente des variantes de l'application classique de la méthode. Il décrit ensuite l'application à deux forêts de la méthode du contrôle, et énumère quelques-uns des avantages de cette forme d'aménagement.

Introducción del Método de Control en el Manejo de los Bosques de Escocia

El Departamento de Silvicultura de la Universidad de Edimburgo emplea el Método de Control en el manejo de seis bosques escoceses. En este estudio se indican modificaciones a la aplicación clásica del método, se explica su uso en dos bosques y se mencionan algunas de las ventajas de esta forma de manejo.

The Role of Exotic Species In Forest Improvement

T. Achaya

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Generally speaking, there has been some apathy among Indian foresters regarding the introduction of exotic tree species in forest areas. The main reason for this feeling against exotics was a tendency to expect the exotic to thrive under conditions where indigenous species had failed. When the exotic also failed, all exotics and experiments with them were discredited. In India, an exotic which will yield fuel is always a favourite, as it finds a ready market since the majority of the population depend on wood fuel to meet their daily needs. On the other hand, an exotic which has a good timber value in its natural habitat would rarely find a market here, as this country produces extremely well-known indigenous timbers such as teak and rosewood. The selection of a suitable exotic requires the application of prolonged and systematic research. As such, exotics have not been given the fair trial that they deserve. Much has been achieved, however, in the introduction and large-scale adoption of exotics.

In Madras State particularly, exotics have played a vital role in forest improvement. This was due to some favourable factors locally. The extreme fuel shortage experienced both in the plains and in the hills, which has become more intense with the steady increase of population, necessitated the raising of quick-growing exotic fuel species. Large forest areas were, as a result of past excessive use, rendered completely bare of vegetation and posed a problem requiring quick and efficient rehabilitation with any species that would fill the bill. Exotics therefore enjoyed continued patronage in Madras State, due to compelling circumstances and continued enthusiasm for improving its forest wealth.

Madras State is one of the 13 States of the Indian Union, with a total land area of 50,020 square miles and a forest area of 6,734 square miles. The forest area thus works out to only 17% of the land area, which is far below the accepted world standard. The State occupies the southeast portion of the Indian Peninsula and lies between latitudes 8° and 14° N. and longitudes 76° and 81° E. The State is characterised mainly by a hot and dry summer followed by interrupted monsoon rains, except at higher elevations, where a temperate climate and greater rainfall are experienced. The soils of the State are mostly shallow, red loams.

The forest areas in Madras State and the use of exotics in them, can be broadly dealt with under different elevation groups.

Denuded and Eroded Low Hill and Plains Areas

The type of forest found here is Champion's "Southern Thorn Forest." These forests cover an area of about 3,000 square miles at elevation from sea level to 500′. They are characterised by poor, dry and well-drained soils, low moisture resources and prolonged hot dry weather over 9 months of the year. The temperature ranges from 102° F. to 54° F., the months from March to June being hot and dry, resulting in all vegetation becoming parched. The total annual rainfall is about 22″, the main rainy season being October-November. The other months of the year are extremely dry except for slight drizzles which are instantaneously blotted up by the hot, parched earth. The water table varies from 10′ to 35′, but the supply is poor, especially in rocky areas. These forests are of the open, low type in which thorny, usually hardwood, species predominate, *Acacia* species being characteristic. *Acacia leucophloea, Acacia sundra, Albizia amara, Albizia lebbek, Cassia fistula* and *Anogeissus latifolia* are some of the common species. The trees have short boles and low-branching crowns and rarely exceed 20′-30′ in height. There is a mixture of species, usually few in number. An ill-defined sparse lower storey may also be found consisting of large shrubs, mostly spiny and xerophytic, extending down to low shrub growth of similar character. A thin grass growth may appear during the short moist season, but the soil is more or less bare. Climbers are few, also frequently showing xerophytic adaptations. The soil is shallow red loam with a high pH value.

A majority of these forests are badly degraded owing to past excessive use and are not being worked for wood (fuel) but are still open for grazing. Where these forests are worked for fuel, the simple coppice system is adopted. At the end of the rotation of 30-35 years, the average outturn is only about 1-2 tons per acre.

The coastal areas are saline, sandy and bare of any vegetation. As early as 1930, steps were taken to plant them up with a suitable fuel species, and after trials, *Casuarina equisetifolia* from Australia proved extremely successful and is now grown extensively by both private growers and the Forest Department. The species is raised by transplanting 8- to 12-months-old nursery seedlings in one-foot-cube pits, at 6′ x 6′ or 8½′ x 8½′. The seedlings are watered daily for about eight months till the end of the first summer. No thinnings are carried out. The crop is worked on a 5- to 8-year rotation and yields, at rotation age, from 15 to 25 tons of fuel per acre. This species has thus helped to convert bare wastelands into useful fuel forests, casuarina fuel being the most popular in the State and yielding a high return on a short rotation.

Recently, it has been found that *Eucalyptus camaldulensis* can reach a height of 22′ in three years, with watering daily for six months, and Eucalyptus hybrid from adjacent Mysore State, a height of 42′ in 3 years with similar watering. Both these species can be grown with no watering at all, but the rate of growth would be slower. As these two exotics are faster grown than *Casuarina equisetifolia* and are strong coppicers, they bid fair to replace *Casuarina equisetifolia* in the afforestation of saline coastal soils. Steps are being taken to extend their planting on a large scale.

Another exotic which shows promise in these areas under experimental conditions is *Casuarina junghuniana* from Thailand. Layered cuttings watered daily for six months have reached a height of 52′ in three years, which is a much faster rate of growth than even for the Eucalyptus.

In red, loamy soils, exotics which have shown promise in artificial regeneration work are Eucalyptus hybrid and *Prosopis juliflora.* These are much faster grown than our indigenous species, Eucalyptus hybrid and *Prosopis juliflora* having the added advantage of not being browsed by cattle. Eucalyptus hybrid sometimes suffers from total termite attack at the collar, and control measures using pesticides are being studied. While indigenous fuel species worked on a 30-35-year coppice rotation yield 1-2 tons per acre, Eucalyptus hybrid on a 15-20-year rotation is expected to yield, on a moderate estimate, 15-20 tons per acre. This exotic is thus expected to increase our forest resources four-fold, if not more.

Another useful exotic species that has been introduced successfully is *Anacardium occidentale* from the West Indies, which yields the cashew of commerce and has a good foreign market, both for the edible nut and for cashew-shell oil. It has come into its own on an extensive scale, thanks to its adaptability to grow even on poor soils, its limited moisture requirements, its large crown-spread which makes for an effective soil cover, its immunity against grazing and its industrial uses for nuts and oil. It is raised by dibbling seed at the break of the monsoon in one-foot-cube pits, dug 22′ apart on clean-scraped sites. No watering is done, and full stocking is easily obtained. Better growth is observed if all surrounding vegetation is cleared and the soil worked to a depth of 6″-9″. At the end of five years, a yield of up to 80 lbs. of nuts per acre can be expected.

Low Elevation (500′-2,000′) Tropical Fuel and Timber Forests

The area of forest under this type is approximately 3,000 square miles. The locality factors are almost similar to Type I forests, except for a better annual precipitation of 30″-50″. The upper canopy is usually uneven and not very dense. It is formed by a mixture of trees, practically all of which are deciduous during the dry season, usually for several months, though some for a short period only. The main species found are poor quality *Tectona grandis, Lagerstroemia lanceolata, Terminalia tomentosa,* etc. In areas of higher elevation and better rainfall they stand 50′-75′ tall. The crop is mixed, however, and none of the species is gregarious. The few more or less pure associations can thus be traced to soil peculiarities or human interference. The lower canopy is likewise almost entirely deciduous, and although evergreens or sub-evergreens are present they are inconspicuous and mainly confined to the moister and more sheltered spots. An undergrowth of shrubs and grass is usually present. Bamboos may be present but not luxurious. Climbers are conspicuously few but include large woody species which are locally conspicuous. Epiphytes and ferns are not seen.

These mixed forests are usually worked under a clear-felling system and replanted with teak or semihard-woods (*Ailanthus excelsa*) to improve the stand. The outturn is about 350 cubic feet of teak and 230 cubic feet of non-teak timber per acre. In the drier parts, wherever coppice regeneration is poor, fast-grown exotic fuel species like Eucalyptus are introduced. Experiments are also planned for introducing tropical American pines.

In the timber forests, *Chlorophora excelsa* (African teak) from Uganda, tried experimentally, has put on a mean height of 40′ and a mean girth of 20″ in 15 years, which is better than the adjacent teak plantations raised in the same year. Its future against a local quality timber like teak is, however, very doubtful.

Other exotics that have shown promise in these timber areas are *Aleurites fordii,* (tung-oil tree), *Araucaria cunninghamii* (hoop pine), *Castanospermum australe* (Australian chestnut), *Pericopsis mooniana, Pterocarpus dalbergioides,* (Andaman padauk) and *Swietenia macrophylla* (mahogany).

The matchwood and plywood industries in the country are facing a large shortage of wood, and the State is making efforts to meet this demand partly. Of the exotics tried, *Sterculia companulata,* the Andaman papita, and *Sterculia alata* are found to be fast growing in the moister areas, reaching a height of 30′ and a girth of 8″ in 8 years. Steps to plant these species over larger areas are being taken to augment the supply of indigenous softwoods and feed two important Indian industries.

In *Tectona grandis* (teak) regeneration areas, during the first two to three years the ground is covered with useless weed growth which hampers the growth of young seedlings. *Ocimum kilimandscharicum,* an exotic shrub whose leaves, on distillation, yield the camphor of commerce, has been successfully introduced by both sowings and cuttings as an undergrowth in teak regeneration areas. Thus, a useful exotic shrub has been introduced to replace useless indigenous weeds.

High Altidude (5,000′-8,000′) Temperate Plateau Forests

The mean annual temperature is about 55° F. Frost is common from November to January. These forests are windswept from June to August, and this exposure is important in the development of forests. The total annual rainfall is about 70″. The southwest monsoon gives rain from May onwards, with a maximum in June/July. This is followed by a drier August/September, and then the northeast monsoon sets in, giving a second maximum in October. December to April are the driest months.

These shola-grassland forests consist of tall grass with occasional shrub growth of *Ulex.* Patches of *Gaultheria fragrantissima* and *Hypericum mysorense* are also found. *Rhodendron arboreum* is practically the only tree found very scattered in these areas. Exotics have been successfully established on these grasslands as a result of patience, perseverance and zeal on the part of Madras foresters.

The attempts to clothe these grasslands with tree growth commenced as early as 1843, when *Eucalyptus globulus* (bluegum) was first introduced into the Nilgiri Hills, to supply fuel to the growing towns that had sprung up here in 1840 and depended otherwise on the limited shola growth valuable for its functions of catchment protection. This was selected as the best species to be grown in these areas, after a trial of nearly 35 species. Some of the hardwood eucalypti grown for timber were found to be unsuitable for the purpose, being slow growing and subject to frost cracks. The species is raised by planting one-year-old "messed" seedlings in 1′-cube pits. A small dose of NPK fertilizer is applied to the planting pit to give the seedling an initial boost and raise it above the winter frost level. Smaller seedlings are frost-shaded with bracken fern during the winter months. The species is worked for fuel on a 15-year rotation (under simple coppice) when an outturn of about 100 tons of wood is obtained per acre. After every four coppice rotations, when there is a considerable drop of yield, the area is replanted.

Exotic *Acacias* also played an important role in the improvement of these grasslands. *Acacia melanoxylon* was introduced long ago and today forms a good timber species in these hills. *Acacia decurrens* (green wattle) and *Acacia mollissima* (black wattle) are grown with comparative ease, seed profusely and yield tanbark for processing leather. Incidentally, it may be mentioned that Madras State leads India in the leather industry. The planting technique is almost the same as for bluegum. The wattle will be worked on a 9-year rotation and is expected to yield 5 tons of bark and 20 to 40 tons of fuel per acre. Natural regeneration, which is profuse, will be depended upon during the second rotation.

Thus, these two exotics, bluegum and wattle, have changed the face of the high-level grasslands of Madras State and have contributed significantly towards improving the local wood resources.

Another exotic (*Pinus insignis*)—which was originally introduced for its aesthetic value—has proved to be a good timber for packing cases. This was raised during 1906-15 over about 400 acres on the grasslands and has now reached a height of 80′-100′ and a girth of 24″-36″. The trees, however, failed to produce fertile cones and have commenced to die. They are being extracted, and the felled areas are being replanted with the same species and with *Pinus khasya* from Assam (India).

A number of other exotic species such as *Pinus* species, *Callitris rhomboidea, Bucklandia populnea,* and *Syncarpia laurifolia* have been tried with poor results.

It will thus be seen that while introduction of exotics started merely on an experimental scale, it soon became obvious that great emphasis should be laid on this aspect of forestry. It will not be wrong to say that exotics have played a vital role in forest improvement in Madras State. Some of the introduced species have grown so well and adapted themselves so admirably to our conditions that they have become almost indigenous. They have helped to reclothe areas laid bare by man or left bare by nature, to improve our indigenous forest resources and to feed our forest industries. An indication of the volume of work carried out can be obtained by stating that 191 exotics have been tried so far in the State in our quest towards forest improvement, a quest that will continue in the years to come with all the resources at our command and with the assistance of other nations.

RESUMES

Le rôle des essences exotiques pour l'amélioration de la forêt

Le présent rapport traite du rôle joué par les essences exotiques dans l'amélioration des forêts, et s'inspire de l'expérience acquise jusqu'à présent dans l'état de Madras de l'Union indienne. Cet état pratique depuis 1846 la conservation systématique des forêts. On commença dès 1843 à effectuer des essais avec des essences exotiques, mais ce n'est qu'en 1919, lorsqu'un service de recherche forestière y fut établi, que ceux-ci firent l'objet de plans déterminés. Depuis lors, 191 essences exotiques ont été essayées et certaines d'entre elles se sont si bien acclimatées qu'elles sont devenues presque indigènes. Les essences exotiques ont été très utiles pour le reboisement des régions forestières dégradées, fournissant du bois de chauffage de bonne qualité et à croissance rapide, des bois et produits d'industrie, et contribuant de façon générale à l'amélioration des forêts de cet état. Les essences exotiques suivantes (qui s'y sont bien acclimatées) méritent d'être mentionnées:

1. *Acacia decurrens*
2. *Acacia mollissima*
3. *Anacardium occidentale*
4. *Cassia siamea*
5. *Casuarina equisetifolia*
6. *Eucalyptus camaldulensis*
7. *Eucalyptus globulus*
8. Eucalyptus hybrid
9. *Ochroma lagopus*
10. *Ocimum kilimandscharicum*
11. *Pinus insignis*
12. *Prosopis juliflora*

De nouveaux essais sont actuellement en cours, et l'on travaille également à un projet visant à l'utilisation d'essences exotiques avec les essences indigènes pour les travaux de génétique forestière. Les essences exotiques ont joué—et vont continuer de jouer—un rôle vital dans l'amélioration des forêts de cet Etat.

Papel de Especies Exóticas en el Mejoramiento de Bosques

Este estudio trata del papel de las especies exóticas en el mejoramiento de bosques, a base de la experiencia adquirida hasta la fecha en el Estado de Madras de la India. Este Estado ha conservado sistemáticamente sus bosques desde 1846. Los experimentos con especies exóticas se iniciaron en 1843, pero se les dió base metódica a partir de 1919, con el establecimiento en el Estado de una sucursal de investigación forestal. Desde entonces se han ensayado 119 especies exóticas y algunas de ellas han medrado hasta el punto de convertirse casi en indígenas. Dichas especies exóticas han servido para rehabilitar regiones forestales degeneradas, siendo fuente de madera de leña de superior calidad y de crecimiento rápido, proporcionando materia prima industrial y, en general, contribuyendo al mejoramiento de los bosques estatales. Las siguientes especies exóticas, que se han cultivado con éxito en el Estado, merecen mención especial:

1. *Acacia decurrens*
2. *Acacia mollissima*
3. *Anacardium occidentale*
4. *Cassia siamea*
5. *Casuarina equisetifolia*
6. *Eucalyptus camaldulensis*
7. *Eucalyptus globulus*
8. Eucalyptus hybrid
9. *Ochroma lagopus*
10. *Ocimum kilimandscharicum*
11. *Pinus insignis*
12. *Prosopis juliflora*

Se continúan otros ensayos y se adelantan planes para cruzar especies exóticas con especies indígenas. Las especies exóticas han desempeñado un papel vital en el mejoramiento de los bosques del Estado y seguirán desempeñándolo en el futuro.

Comments

Lester W. Bryan, (U.S.A.):

Hawaii has very few native timber trees. For this reason many exotic species have been introduced and planted under the many different climatic conditions which exist in Hawaii. Introductions began over 150 years ago when, in 1827, *Prosopis juliflora* was brought in. This species at one time covered over 100,000 acres of land. It proved to be a very valuable introduction. The fruit (bean) is an excellent cattle feed; the flowers are outstanding for the production of honey; from the wood we secured charcoal, firewood, and fence posts. It does best in areas too dry for most other species.

During the past 50 years over 1,000 species of exotic trees have been introduced for trial. Included in this number are over 100 different species of eucalypti. Many of those introduced have done well and are now being used in our tree-planting program.

Risto Olavi Sarvas, (Finland):

The topic of our discussion underlines a certain controversy between "orchard-like" and "naturalistic" silviculture. It seems to me, however, that there is no great need to emphasize such a controversy. In some instances, at least when working in the North European forests, we feel that by following the natural trends of our forest development we achieve the best economic results. In some other cases again the natural trend can't be followed with economic means, and in such cases we have to choose something that comes more or less near the orchard-like silviculture.

In all cases, however, we have to know the nature of our forests.

I think, therefore, that we shouldn't speak as much of orchard-like silviculture or naturalistic silviculture, as of a silviculture based on the knowledge of the nature and laws governing the development of our forests and based on an economic thinking.

There should be no naturalistic silviculture only, therefore, though the word "naturalistic" is very sympathetic and impressive. If that is done there is a danger that we are practicing a silviculture based on a natural philosophy more than on science.

Valentin Grigoryevich Nesterov, (U.S.S.R.):

The paper, just delivered by Professor Leibundgut, is of considerable value. The problem of which forests are better—those of artificial origin or those which have originated naturally—is a very interesting one.

In connection with a series of failures in reforestation by planting, there is a tendency to give up artificial reforestation and to revert to natural regeneration. It seems to me that such an approach is one-sided. Both artificial reforestation and natural regeneration can result in good forests. The success depends upon proper attention to bioecos, that is, to the relation between the unity of organisms and the environment. By the term "unity" the author means such a concrete complex of biocenos and ecotope that outside of it neither of them can exist.

The success of the undertaking depends on the application of principles within the bioecos, that is, on the degree of correspondence of the complex of organisms and its environment (bios—organisms, oikos—environment). In my idea of nature, I stress the diatopos or bioecoses. They represent the unity of biocenos and ecotope (bioecodiatopes). The contradiction between the biocenos and the ecotope is a fundamental one. Upon this contradiction depends the collision between organisms of the same species, between organisms of different species, within a single organism, within a cell, and so on. Forest cultures do not thrive and may even perish if the principle of the bioecos is disregarded. To guarantee the success of seeding, planting, tending, fire control, and insect and disease control, it is necessary to be guided by the principles of diotopic approach (dia—two-component, topos—unity). This means that it is necessary to coordinate the biocenos and the ecotope.

According to this school of thought, we may obtain high resistance to unfavorable conditions, high productivity and high quality of wood, and vigorous growth, utilizing the cooperative efforts of dendrologists, geneticists, entomologists, phytopathologists, and physiologists on the one hand, and pedologists, site improvement experts, and climatologists on the other hand—all coordinated under the authority of foresters.

The search for the best composition of the biocenos and ecotope in relation to one another and to the environment, while improving both on the basis of the above principles, will ensure good results in both methods of reforestation (artificial and natural reforestation).

My school of thought on the diotopes of nature I have compiled on the basis of facts observed in actual field work.

V. S. Rao, (India):

In the case of the enormous development of human population, the latest term that is now in vogue is "population explosion." To represent a similar condition in the field of modern technology, Professor Leibundgut has coined the very apt term "stormy development."

To the forester, both these developments present features which cause him great concern and anxiety. Whereas "population explosion" tends to militate against the very existence of forest lands, which are demanded more and more for establishment of cities and towns, for mining, for setting up large industrial plants, for creating artificial lakes in connection with hydro-electric projects, for greater agricultural production to feed the growing population, and for rehabilitating the people displaced from submerged lands, the explosive development of technology tends to put too fast a pace on the extraction of timber to feed the constantly growing mills which, in turn, not only cater to the legitimate and essential needs of a growing population but, in the interest of larger sales and consequently larger incomes, try to create new and larger demands, wants, and needs, some of which are artificial and non-essential.

In the very fast pace set by modern technological development, one is likely to forget the biological needs of the forest which, of necessity, is an organism whose maximum of growth is "slow and steady." It is therefore very necessary that warnings are constantly sent from experienced, sober, and philosophic foresters like Professor Leibundgut, to curb the tendency to treat the forests as one would treat a factory or mill. It is essential to remember that here we are dealing with living organisms, rooted to the soil and spread over very large blocks, where treatment of every acre by mechanical means to correct imbalance is a matter of considerable difficulty and expense.

The operations that we try to carry out in the living forests, in our great hurry and impatience, are like surgical operations which, when they do not heal rapidly and we cannot devote attention to them, will tend to remain as festering sores. It is a matter for considerable gratification that a great movement toward a more, if I may be permitted to use the term in this context, humane treatment of forests has been initiated in Europe, the very country which gave rise to the large-scale use of orchard forestry, mainly in the shape of monocultures of conifers in the 18th and 19th centuries, giving rise to strictly regimented forest stands.

I was fortunate in being a member of the Study Tour group arranged by the FAO which went into the question of pine and mixed conifers in Czechoslovakia in 1956. The experience during that tour brought home to many foresters the need to protect and keep in good condition, and for all time, the most important element in the forest capital, namely, the soil.

Pure and even-aged stands of conifers, which are no doubt the delight of the wood-based industries, were certainly not kind to the soil; and even if the deleterious effects were not noticed in the first generation, they were strikingly apparent in the second, or, more definitely, in the third generation. Because of the great and rude disturbance of the totality of the biological environment, it was also noticed that such stands were more susceptible to attack, by insects and disease, while stands maintained on the naturalistic pattern were resistant to disease and epidemic insect attacks.

The point that Professor Leibundgut wants to drive home is, therefore, worthy of serious consideration, namely, that it is far better that the industrial concerns adapt themselves more to the exploitation of forests maintained on the naturalistic pattern than that silviculture should adjust itself to the needs of the industry—which really means that the stable and enduring silvicultural health of the forest crop is sacrificed to short-term economic conditions.

Speaking from my own experiences in India, the replacement of natural mixed stands by artificial means with monocultures, even of broadleaved species, has led to disastrous results, as in the case of *Michelia champaca* plantations which were ravaged by a pentatomid bug *Urostylis punctigera,* or those of *Cedrela toona,* which, for some reason not yet clear, seem to die out early in pure stands, though in the mixed natural forests the species can grow in health to large dimensions.

Professor Leibundgut has also pointed out that although naturalistic silviculture is generally considered to result in low yields, the converse is really the case. "Trees not native to the site," he says, "exhibit better quality and health in naturally managed forests than in plantations, providing, in the long-run, higher yields." This is a point which deserves very serious consideration.

He has not denied the usefulness of orchard forestry in special circumstances, as in the case of raising plantations on new sites. But it is best to remember that silviculture will always remain a biologically based technique, and that in the long run whatever proves to be incorrect biologically will never be economically sound.

I am glad that Professor Leibundgut has sounded a very timely note of warning against the too-mechanical treatment of a highly complex living organism like the forest.

Hans Emil Lamprecht, (Venezuela):

Quiero enfocar brevemente unos puntos del tema en discusión tal como los veo en mi condición de silvicultor que trabaja en y con los bosques tropicales, porque es de mucha actualidad para con los trópicos.

En verdad y salvo contadas excepciones no disponemos en la mencionada zona aún de resultados concretos basados en experiencias suficientemente largas para poder sacar conclusiones definitivas con respecto a las ventajas e inconvenientes ni del manejo de los bosques naturales con métodos silviculturales adecuados ni tampoco de la arboricultura artificial.

A pesar de la falta de experiencia propia me parece posible prever—por lo menos en grandes rasgos—las consecuencias principales de la aplicación de uno u otro de los dos sistemas mencionados en los trópicos, lo que sin duda puede ayudar grandemente a ahorrar tiempo y dinero. Porqué son factibles tales predicciones?

Sencillamente porque las principales leyes naturales que rigen la vida y el potencial productivo de los bosques tienen validez universal, o sea ellas son válidas también en las condiciones tropicales. Lo que hace posible que el silvicultor tropical pueda aprovechar y utilizar—dentro de ciertos limites, por supuesto—muchas de las experiencias hechas en otras zonas climáticas, siempre y cuando se atengan a hechos y fenómenos comparables. Sería deplorable y contraproducente en sumo grado si no aprovechará todas y cada una de tales oportunidades, si prefiriera, pues, hacer él mismo el largo camino de errores, equivocaciones, decepciones, de pérdidas de tiempo y dinero que tuvieron que hacer los forestales de otras zonas antes de alcanzar el alto nivel de la dasonomía que los distingue en la actualidad.

Tal vez unos ejemplos concretos pueden aclarar un poquito mejor lo que quiero decir. No cito sino dos:

1. Es una ley natural universal—pues válida también en los trópicos—que en el bosque climático la vegetación, el clima y el suelo se hallan en un equilibrio biológico estable el cual garantiza *ipso facto* su continuidad por tiempos indefinidos y el cual, por consiguiente, constituye la base de la producción continua o sea del rendimiento sostenido de cada bosque. Huelga insistir en el hecho de que cualquier economía forestal sana y sensata tiene que fundarse invariablemente en el principio del rendimiento sostenido. Ahora bien, al sustituir la vegetación natural por completo y de una manera brusca por otra artificial se destruye necesariamente el mencionado equilibrio natural y con eso las bases naturales de la productividad. Eso—precisamente eso—hacemos con la arboricultura que consiste esencialmente en la implantación de monocultivos completamente artificiales y, a lo mejor, compuestos de una especie exótica.

Como consecuencia inevitable resultarán a largo plazos rodales raquíticos, enfermos con una productividad muy debajo de lo esperado. Todo eso no es teoría especulativa sino se trata de hechos ampliamente comprobados por la experiencia práctica. Me permito citar al respecto unas cifras por las cuales debo las gracias al Prof. Weck, quién me las puso a disposición esta mañana. Alrededor del año 1800 comenzó en Sejonia la transformación directa de los bosques estatales en monocultivos artificiales sobre una superficie de 180.000 ha. En el decenio de 1870 a 1880 terminaron los trabajos de conversión. La llamada estructura normal de las masas en pie que se habia logrado entonces no sufrió ninguna alteración hasta 1930. El incremento medio anual en los 180.000 ha. de arboricultura se desarrolló como sigue:

1840, 4.2 m.^{3}/ha./año.
entre 1870-1880, 6.2 a 6.4 m^3/ha./año.

Pues la arboricultura, una vez establecida dió efectivamente rendimientos muy superiores en comparación con aquel de los bosques originales. Pero del máximo alcanzado de 6.4 m.^{3}, el incremento cayó cada decenio más y más hasta llegar entre 1920 a 1930 a un mínimo de 2.4 m.^{3}/año/ha. Esos en muy grandes rasgos son los resultados del probablemente mayor experimento controlado durante 100 años con exactitud que se ha llevado a cabo en la historia forestal con la arboricultura. Hablan tan claramente que cualquier comentario parece superfluo. Repito que tales experiencias europeas son válidas también en los trópicos o en cualquier otra parte.

Sé que presumiblemente sería posible evitar el mencionado desarrollo desastroso por crear y mantener un equilibrio biótico de producción por medios artificiales de acuerdo con las exigencias del monocultivo en cuestión como lo hace la agricultura.

Pero esto implicaría entre otras cosas:

1. Trabajar los suelos periódicamente.
2. Abonarlos cuando sea necesario.
3. Controlar y combatir en cualquier momento insectos, hongos, virus y cualquier otra plaga que podría surgir.
4. Controlar y regular el abastecimiento adecuado de la arboricultura con agua, etc.

Todo esto y mucho más hay que preveer si se quiere evitar que los cultivos fracasen más temprano o más tarde con seguridad. Pero aún así, queda siempre un cierto riesgo de desastres.

Ahora bien. Disponen los países tropicales, por lo general, hoy en día de la organización, de los medios financieros, de los especialistas, etc., para llevar a cabo tales empresas difíciles, complejas y siempre arriesgadas? Dejo la pregunta sin contestar.

2. El segundo ejemplo: La introducción de nuevas especies en un país cualquiera provoca inevitablemente un proceso severo y alargado de selección dirigido por fenómenos de índole genética, ecológica, climática, edáfica, etc., pues factores los cuales en su gran mayoría no los dominamos o sólo en una escala modesta. Este proceso ocurre no importa ni la especie introducida ni la localidad de su cultivo—pues, tiene lugar también en los trópicos porque también este fenómeno tiene su origen en leyes naturales de validez universal.

A menudo, los efectos selectivos no se manifiestan, sino muchos años después de los primeros cultivos pero a lo largo pueden conducir en casos extremos a la eliminación total de especies exóticas por lo demás prometedores. Recordemos al respecto sólo el caso del *Pinus strobus* en Europa, cuyas existencias fueron literalmente destruidas por un modesto hongo que empezó a seleccionarlos en un momento dado.

Ahora bien. Disponemos hoy día en los trópicos ya sobre los imprescindibles conocimientos genéticos, sabemos lo suficiente sobre las exigencias, necesidades y reacciones de las especies potencialmente utilizables, conocemos suficientemente bien las condiciones ambientales en los lugares donde pensamos cultivarlos para poder reducir en lo posible el riesgo de una selección completamente negativa?

Tampoco quiero contestar estas preguntas sino voy a terminar mi intervención a pesar de que sería facil agregar muchos otros ejemplos simulares a los citados.

Existen hoy en día marcadas tendencias en todas las regiones tropicales hacia la arboricultura. Es fácil de comprender tales tendencias en vista de las enormes dificultades que presenta muy a menudo la dominación y el manejo racional de los bosques naturales. Sin embargo sería falso y sumamente peligroso resignarse y esperar la solución definitiva y completa de las dificultades innatas a la dasonomía tropical de la arboricultura porque a primera vista puede parecer más sencilla y más prometedora que cualquier otro sistema.

Vista a la lux de hechos concretos validos plenamente en las condiciones tropicales resulta al contrario que la arboricultura incluye un enorme complejo de problemas, dificultades y riesgos. Verlos y conocerlos a tiempo puede salvar la silvicultura tropical naciente de menudos errores, pérdidas y decepciones enormes.

Domingo Cozzo, (Argentina):

Una discusión sobre la posible oposición entre los conceptos teóricos y prácticos de la producción de madera por medio de la Silvicultura del bosque espontáneo y la Silvicultura del bosque cultivado, solo puede tener razón de ser en aquellos países ricos en bosques espontáneos de especies comerciales, con rodales uniformes y casi homogéneos o puros; en tales países no tiene sentido el invertir dinero para reemplazar el uno por el otro, o al menos sería en tales lugares donde una posible discusión sobre el tema tendría validez.

Este no es el caso en numerosos otros países del mundo, donde sea por las condiciones productivas, escasas, de sus bosques espontáneos, aún cuando esmeradamente manejados técnicamente (como ocurre en la gran mayoría de las regiones tropicales), sea por las condiciones de creciente déficit en su economía forestal (caso de la Argentina, Uruguay, etc.), o sea por hallarse tales bosques muy alejados o inaccesibles a los centros y mercados de consumo, la cuestión es que el bosque cultivado no solo no se opone al bosque espontáneo, sino que lo complementa y colabora con él. El bosque cultivado utilizando especies de rápido crecimiento, de buena madera, y de gran plasticidad en la adaptación a diferentes tipos de suelos y climas, sean exóticas como indígenas del propio país, es incuestionablemente una medida correcta an aquellos países pobres de bosques espontáneos (Sud Africa, Uruguay), o donde estos bosques se encuentran muy alejados de los centros de consumo (Argentina) cuyos costos de explotación y transporte resultan muy elevados, sin compensación comercial en la competencia con las importaciones. Quizás el verdadero enfrentamiento entre ambos tipos de bosques puede hallarse en las regiones donde se elimina el bosque espontáneo original por substitución de otro bosque cultivado por el hombre; tal sería el caso del Brasil, del norte y sud de la Argentina, del sud de Chile, países de Centro América, etc. En tales regiones la substitución de la masa espontánea no puede ser considerada tampoco una medida antagónica de la silvicultura clásica; ella tiende a crear nuevas masas, puras o entremezcladas con pocas especies, siempre de aplicación comercial e industrial, las que en turnos cortos de explotación (8-15 años) producen suficiente materia prima valiosa para numerosas industrias: celulosa, papel, hardboard, maderas aglomeradas, aserraje menor, tornería, postes, etc. Pero no solo existen argumentos de caracter económico para inducir a tal substitución (necesidad de establecer industrias en tales regiones que estabilicen y aumenten el nivel de vida de sus poblaciones) sino que también los hay de carácter técnico, porque en tales casos el manejo de los bosques espontáneos resulta difícil sino imposible, dada la extrema heterogeneidad de su composición, por los todavía desconocidos hábitos biológicos y culturales de sus integrantes, y porque la aplicación de un manejo técnico-económico requiere primeramente un proceso de mejoramiento de la masa cuyas tareas suelen ser caras, no retribuibles por una comercialización de sus productos (raleos, podas, enriquecimiento por plantación, siembras, etc.) y de resultados futuros no bien conocidos.

Por otra parte cuando la propiedad de los bosques espontáneos que se han de substituir, es privada y no fiscal o pública, la diferencia económica de los dos conceptos se agudiza, pues mientras en estos últimos el Estado puede tratarlos con sentido de perpetuidad, aún cuando con rendimientos muy bajos y de no económica renta en relación con el dinero invertido, en los primeros todavía están resultando difíciles tales medidas sin una clara respuesta de valor financiero; aquí los principios biológicos o los planteos técnicos forestales teóricos deben en forma inexorable regirse por la unidad de la economía. Sin duda que una correcta solución es la de procurar hallar una coincidencia entre estos principios y la existencia de una nueva masa leñosa, que disminuya el peligro de una baja sanidad o de inferiores rendimientos con el tiempo.

Hay ejemplos en cantidad que demuestran que un bosque cultivado ha substituido con eficacia económica, técnica y hasta biológica, a otra masa espontánea, llevando el progreso y el bienestar a la población, y al país entero; así el Brasil, país forestal por excelencia, debió recurrir a los eucaliptos para crear la fuente de combustible a una de sus principales empresas de ferrocarril, y hoy es el centro mundial de mayor importancia en este tipo de árboles por la magnitud de lo cultivado, la diversificación de especies utilizadas, y los conocimientos técnicos adquiridos, a expensas todo del bosque original que en nada hubiera contribuido a la nación si se lo hubiese conservado, aún mejorado por ciertas prácticas técnicas costosas. Practicamente lo mismo ocurrió en Chile con sus inmensas plantaciones de *Pinus radiata,* y en la Argentina tenemos el ejemplo de la Pcia. de Misiones donde el cultivo de *Araucaria angustifolia* en substitución del denso bosque subtropical, heterogeneo, produce al décimo año de crecimiento tanto volumen de madera como en 100 años brinda el bosque espontáneo de igual especie en Argentina y Brasil, y estas plantaciones han permitido la instalación de plantas productoras de celulosa y papel, que de otra manera jamás hubiera sido posible.

Es cierto que se corre un peligro con tales substituciones, principalmente el de los daños por enfermedades y plagas, pero este no es el caso general en las forestaciones substitutivas; por otra parte es un riesgo consciente que se corre frente a la urgente necesidad de proveer a tales regiones de materias primas indispensables para la economía y la vida corriente. En todo caso se puede incluso reducir tal peligro si se adoptan medidas de precaución en la elección de la especie para el sitio o la estación (tipos y calidad de suelos) o para una región de ecología muy variada, realizando ensayos previos mediante la instalación de arboretum, estaciones experimentales, etc. Por ejemplo el *Pinus radiata* demuestra una extrema suceptibilidad a daños por ataques de *Diplodia* y otros hongos y a la *Rhyacionia,* un insecto que destruye sus brotes terminales, pero ello ocurre cuando es plantado en regiones de ecología diferente a la de su habitat original en California, Estados Unidos. Todavía tales riesgos pueden disminuirse si se tratan las masas cultivadas con medidas técnicas apropiadas: raleos periódicos, diversificación de las masas cultivadas, trabajos culturales del suelo y de las plantas, etc.

El criterio de que tales forestaciones realizadas mediante plantaciones regulares, y con cuidados culturales extremos, no integran el concepto clásico de la Silvicultura, y en cambio participa de la común arboricultura o de la agricultura forestal, no es del todo exacto; si bien se advierte que en la iniciación del bosque cultivado se realizan tareas más propias de la arboricultura, ellas se fundamentan sin embargo en el conocimiento biológico silvícola común al manejo de cualquier bosque espontáneo: necesidad de una alta densidad inicial de arboles—1,000 a 3,000 ejemplares por hectárea—la producción a corto plazo de la competencia mútua de los ejemplares para lograr el cierre de la copa, la aplicación de raleos de intensidad y oportunidad regulados por la misma especie, la densidad, por la calidad de la estación de crecimiento, y por el régimen de manejo y corta a adoptarse: tala rasa total o con árboles portagranos, tala rasa en franja, cortas selectivas, etc. Nadie puede negar que estas prácticas son propias de la Silvicultura común; todavía cabe recordar que con frecuencia muchos bosques cultivados iniciados con técnicas de la arboricultura, a poco se transforman en verdaderos bosques espontáneos porque en su proceso de adaptación y acomodación al nuevo ambiente alcanzan la completa naturalización, y al semillar dan lugar a la producción de renovales ahora irregularmente dispuestos que pronto reemplazan a la masa cultivada, y que deben ser manejados tal como un bosques espontáneo; esto es lo que en ciertas partes de Chile está ocurriendo con *Pinus radiata,* que no solo está libre de enemigos, sino que incluso una nueva masa espontánea reemplaza a la anterior, por su propia renovación, la que entonces no es absolutamente coetánea como lo fué aquella otra. Esto mismo sucede con algunas especies de Eucalyptus en la Argentina y en el Brasil, y todavía estamos observando que se produce el mismo fenómeno en las plantaciones con *Araucaria angustifolia.*

En aquellos otros países donde por ejemplo cultivan los álamos y otros árboles forestales con baja densidad por unidad de superficie, como si fueran plantas frutales, más bien cuidando al individuo y no a la masa, se acepta que tales plantaciones pertenezcan más al domino de la arboricultura, pero en todos aquellos otros donde se practica la forestación antes relatada, realmente están haciendo Silvicultura del bosque cultivado.

Masood Ahmad Mirza, (Pakistan):

I agree with Mr. Achaya of India who has rightly expressed that in some places there exists antagonism against trial of exotic species. But it has been suggested that when indigenous species have failed to meet the needs, the exotics have come to the rescue. If a fair trial is given to the right species, they prove to be an asset. In Pakistan, fuel wood is quite a problem, and the fast-growing species need serious consideration. Some time past, *Prosopis glandulosa,* and *P. juliflora* were introduced, and now they have spread and are flourishing in areas of low rainfall, about 6″ or so. They supplement the fuel-wood needs to a considerable extent.

Sessions F and G

Forest Ecology and Soils
Ecologie forestière et sols
Ecología Forestal y Suelos

Classification, Mapping, and Interpretation of Soils for Forestry Purposes

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In countries with a highly developed forestry, modern silviculture is characterized by the strong emphasis that is put on the site conditions. In Germany, the forester speaks of the "Iron Law of the Site." It means that there are, notwithstanding the fact that improper measures can ruin the best forest soils, deriving from the very nature of the site certain geared developments of the forest as well as unescapable reactions of the soil to forestry treatments. Those the forester must know for obtaining the best results.

It is because of this law that on one site certain tree species produce the most, on other sites, other species. Another example is that on certain soils in Scotch pine stands which were opened up for natural reproduction, a carpet of mosses will grow, creating conditions suitable for seedling establishment, while on other soils heavy growths of grasses or blueberries may take place, preventing any pine regeneration.

Forest soil mapping must be focused on helping to base forest management on the characteristics of the site; soil mapping must serve the purpose of making available to the practicing forester the specialist's ability to recognize the properties of the site and to realize the manifold connections with the management of a forest district.

The appraisal or interpretation of forest sites was very difficult as long as this tremendously complex phenomenon was considered to be a chance combination of countless soil factors. This difficulty was overcome when we learned to recognize that the soil factors do not combine arbitrarily, but in specific ways according to the laws of soil dynamics. Here is an example: The parent material may be basic rock. Under the climatic conditions prevalent in Central Europe the soil dynamics follow the pattern towards the development of a eutrophic (rich in bases) brown-forest-soil. The process of taking on the brown color by means of enveloping the soil particles with mixed gels goes along with the formation of clay minerals of the montmorillonite and Illite group. The saturation of the base exchange complex by basic compounds is high. Soil micro-organisms are active and the soil burrowing macro-fauna, earthworms, et cetera, are luxuriantly developed. The soil organisms and the high content of basic materials influence both the direction of the humus formation and the soil structure. Water conduction as well as aeration are dependent on the soil structure. Our example could be developed much further. It was selected to show the causal inter-relationship between soil factors and properties brought about by soil dynamics.

Furthermore, geological processes work mostly in such a way that locally only a limited number of parent substrates are found. For all these reasons, the number of possible combinations of soil factors—which theoretically appears to be unlimited—is, for all practical purposes, greatly reduced.

As soon as the forest sites were recognized as natural formations whose characteristics are defined by the rules of soil development, the difficulties of classification were overcome and the way to their grouping into "Site-Units" (Standorts-Einheiten or Standorts-Typen) was found. These site-units represent the genetically conditioned, locally occurring constellations of site factors.

There is a different school of thought whose followers do not consider the site to be such a natural entirety but rather consider the single properties of the soil separately, and try to arrive from there, by using a certain key, at an expression of nature and value of the site. This is bound to fail. The site belongs to those entities which cannot be expressed by the mere sum of the parts, however carefully they may have been determined. The site has to be appreciated as an indivisible unit. This may be illustrated by an example:

In Europe, as well as in the U.S.A., there are coarse sands and gravels near the terminal moraines which—because the streams of water from the melting glaciers had not transported them over large distances—contain about 30 percent weatherable minerals and 70 percent quartz. If somebody approached these soils by using common standards of evaluation he would find them to be very poor. They are absolutely low in minerals, have an unfavorable distribution of the size of the sand particles and a low water-holding capacity. However, on these sites mixed stands of pine, oak, and beech of site class 1 grow, even if the precipitation amounts to only 22 inches. How is this possible?

Though there are only 30 percent of weatherable minerals, physiologically speaking, these loose sediments are rich in nutrients, for in these loose sediments the hydrogen ion can attack the crystal lattice of the minerals down to a depth of several meters and continuously split off nutrients. Because the roots can grow on these sites to a depth of 8 meters and more, the total amount of water available to the trees is relatively great, in spite of the low water-holding capacity which is calculated on a weight basis. We know, furthermore, to what degree the productive capacity of these sandy soils decreases with increasing quartz content. We are able to classify these and other sandy soils very well with respect to their properties and productive potentials. However, we did not gain this knowledge—and that is the very point which needs emphasis—by directly integrating the results of a detailed analysis. We rather had to make a detour: we investigated these and other important site types and clarified their genetics as well as their present characteristics. This, of course, requires analytical methods. However, in addition to that we found by observation how different tree species grow on different types. Because the genetics of these fundamental types is well known, the types can easily be recognized from the soil profile, and the productivity of the site fairly exactly determined. To say it again: We are dealing with a judgment that is based on experience rather than on a schematic integration of single, analytically found properties.

The sites, then, are natural formations whose properties can be found by applying the laws of soil dynamics to the parent material and climate under discussion. Only by understanding them in this way are we able to recognize the constellations of site characteristics (of which only a few occur in any one locality) and to understand their properties. Without such a genetic foundation, the establishment of site-units remains unnatural and thus unsatisfactory.

However, we should just as well avoid the other extreme. We should not try to solve our practical problems by exclusively employing the strictly genetically oriented classification systems. With these classification systems, which presently are in a stage of development in several countries, one tries to accomplish systems of order similar to the genetically oriented classification schemes of botany and zoology. However, because our knowledge of the dynamics of many soils and of their phylogenetic relationships is still very incomplete, all these systems have considerable deficiencies, thus needing continuous adjustments.

The genetic "soil-types" in the meaning of the Russian and German schools, are generally considered to be the basic units of this system of order. These genetic soil-types must not be mistaken for the American "soil types" which represent already very specific local soil formations, thus falling into the category I of the system. The European soil-types come closest to the categories VI and V, that means to the "great soil groups" and the "little soils groups." The "soil-types" are broken down into lower categories (in Germany: sub-types, varieties, sub-varieties) and grouped together in higher categories (orders, classes, sub-classes).

The classification of such a purely genetical system is not sufficient for comprehending a soil as a forest site. A brown-forest-soil derives from the aforementioned loose sediments of coarse glacial outwash as well as from the sediments rich in clay, or from basic igneous rock. These brown-forest-soils which developed from different parent materials have very different properties as forest sites.

Similar to the American system, which, from the beginning, had been focused much more strongly on the practical goals of soil mapping, it has been tried recently to give more consideration in the lower categories to the lithogen characteristics. For these, the American system uses the term "phases." Taking into consideration the immense number of possible constellations (immense as long as we do not limit ourselves to the local conditions), it seems to me that even this does not serve to provide a complete picture of the nature of a forest site by just integrating it into such a system. We must not forget that the deeply root-penetrated forest soils, as opposed to agricultural soils, are often composed of layers having different dynamics. For example, a glacial till may show brown-forest-soil dynamics in the upper sub-soil, while the deeper sub-soil is gleyed by impeded drainage, and a shallow cover of poor windblown material shows the dynamics of podzol, even though it might be influenced by the litter which is rich in lime. Depending on climate and topography, impeded drainage (Stau-Nässe) affects the productive capacity of a site very differently. It is hard to see how such a multitude of possible variations can be expressed by a general classification system. We must, therefore, use specific site-units. According to the local particularities of parent material, climate, and topography, the specific local site-units occur in a manageable number of constellations only.

However, the systems of genetic classification have great value as supplements to the practical site-units because they deepen our understanding of the nature of the soils. Furthermore, in order to enable us to make full scientific use of the soil mapping, each profile should be classified according to the genetic system of order. However, this should not be done forcibly, but only to the extent that the system provides a proper place. This is the very best way to reveal the gaps and shortcomings of the system. The American "Soil Survey," by mapping according to its system, not only has served the objective of economy but at the same time has contributed a lot to the clarification of the development, nature, and regional distribution of the soils. It is conceivable that this system, which had been aimed from the beginning at practical soil mapping, can be further developed in such a way that the lowest categories can take the place of our local site-units of today.

Now to the practice of forest-site mapping. Nothing can be accomplished if we confine ourselves to transferring the characteristics of a profile under study to a map which is sometimes done with a very complicated system of identification. Such a map cannot be read any more, but requires elaborate translation. What is lacking is the intellectual integration of lifeless details into the living concept of the site. To leave this task of evaluating the data to others who have not seen the profiles does not make sense to me. Such data would not even enable the soil specialist to get a clear idea of the site.

Therefore, whoever describes the site has to do the job of interpreting and evaluating the data just as well. This should not be confined to what the expert has to say about the soil, but the relationships to forest management should be considered also. Of course, this cannot be done by the soil specialist alone. The results of soil mapping, evaluated in the way discussed before, have to be depicted in such a way that they provide an easily accessible basis for forest management. This can be accomplished without difficulty wherever the mapping is based on the locally occurring, characteristic site-units as is the case now throughout Germany.

In a unit, all those areas are combined which, because of similar origin, exhibit approximately the same site conditions and, accordingly, the same productivity and response to managerial treatment. There are two presuppositions for a suitable breakdown into such ecologically nearly equivalent units: namely, (a) that the number of units is not too large to remain properly manageable; and (b) that the individual characteristics of the site are comprehended accurately. As we have seen before, these presuppositions can mostly be met by properly delineating not too large areas. Of course, it would not be reasonable to use each and every small difference, which is of no real importance to the character of the site, for separating special units. In Germany, we are strongly promoting the breakdown of the country into properly delineated "regional units" having similar site conditions—so-called "growth-districts" (Wuchs-Bezirke). These, in turn, are combined to higher units—the so-called "growth-regions" (Wuchs-Gebiete). In the mountains, we delineate the growth districts, wherever possible, in such a way that they coincide with the natural regional forest associations.

The breakdown into site-units can either be organized for an entire growth-district or for parts of it, for instance, for forest districts, counties, et cetera. In the latter case, a more individual comprehension of the site conditions is possible. However, in this case, one should strive for a sufficient coordination of the individual mappings within the growth-district in order to insure that similar conditions are handled similarly. Otherwise, it may happen that the same site shows up with different names.

The most difficult part of soil mapping is to establish the locally occurring site-units. This must not be done too schematically. The methods have to be flexible according to the varying conditions. Sometimes one method has to be emphasized, sometimes another one. This holds true particularly for employing plant sociology. Today, it is quite generally agreed that mapping should neither be based one-sidedly on plant sociology nor on soil investigations, but rather on combinations of both. Depending on their suitability for certain conditions, we may rely more heavily on either method.

Commonly, we proceed as follows: Considering, first of all, localities which, because of their parent material, topography, and vegetation, appear to be most typical, a wide-meshed net of pits is spread over the area under study. From these pits we learn what kinds of local constellations of site factors we may encounter. To define the site-units immediately for each profile is not feasible. Rather, the details observed at the different profiles must be intellectually digested and related to the conditions of the forest stands, including the ground vegetation. In other words, the mapper must not limit his look to the profiles but must try to comprehend the relationship between the local constellations of site factors and vegetation, employing for this task all his understanding of forestry. The more he succeeds in these efforts, the more will certain site-units present themselves. One must check the provisional classification over and over again, always ready to make changes in line with the gradually improving understanding of the conditions. The net of soil pits which was wide-meshed at the beginning is made denser and denser until the number and kind of site-units are clearly recognized.

Wherever one deals with units whose soil properties cannot be recognized sufficiently from the profile, additional analytical studies are needed. The relationship between the site-units and the ground vegetation have to be clarified, for the ground vegetation alone does not suffice to reveal directly the different site-properties involved. The same plant association may be the expression of different combinations of individual factors, particularly when large areas are considered. However, after we have once achieved understanding of the local connection between soil and vegetation, we may quite safely use the ground vegetation as an indicator of the site condition. The same holds true for the forest stands. The forester is in the fortunate position that—considering individual stands—the annual growth is not harvested annually, as is the case in agriculture, but is allowed to accumulate. The growing stock thus accumulated over decades and the closely correlated height of the trees facilitate exact site classification. Any change in tree height may indicate a site change.

As far as the next step of site mapping is concerned, namely, the local delineation of the site-units, it is mostly quite easily accomplished by using, in addition to the indicators mentioned, the topography. Where additional investigation of the soil itself is necessary, use of a soil auger or even a simple spade will generally do. To cover sufficiently the site conditions of a forest district 5,000 ha. in size, about 40 different site-units will suffice under average conditions. In more uniform areas, particularly in the flat country where elevation and aspect do not come in as variables, fewer will do. On the other hand, areas with sharp changes in site conditions will require many more site-units. Under some conditions, for instance, in glaciated areas where the glacial till has been altered time and again by similar geological influences, a catena-like pattern of site-units may be indicated. The establishment of sub-units is commendable wherever, on a given basically homogeneous site, differences in soil conditions and productive capacity are encountered which are likely to disappear in the future. Sub-units may furthermore be practical where differences in the site are found, which do not seem to be effective ecologically, but which might gain practical importance later on. It need hardly be mentioned that the sites which are integrated into a unit are not entirely homogeneous. In nature, you will very seldom find such homogeneity. The only essential is that the sites are approximately equal in their main properties and ecological character. Beginners have to learn to distinguish between what is and what is not important.

As opposed to a certain judicious approximation needed for integrating all profiles into site-units, the descriptions of the profiles themselves have to be quite elaborate, covering all individual particularities. Sometimes it happens that within one site-unit and on areas so small that they cannot be depicted on the map, significant ecological deviations from the character of the site-units are encountered. This has to be explained in the legend of the site-unit. Should the deviations be correlated with differences in ground vegetation, stand-condition, topography, or others, this should be mentioned in order to enable the forester to find them in the field.

In addition to numbering the site-units, one should give them descriptive names, such as "Sandy loam derived from lime till with a 50–150 cm. layer of windblown material poor in minerals." With this, the most important components of the site are stated. Further details belong in the general description, such as conditions of podzolation in the upper layer, amount of bases in the till, accumulation of dispersed clay in the sub-soil accompanied by impeded drainage, et cetera. Other site-units may be named according to the conditions of water conduction, wherever these have special significance for their nature and productive capacity. Still others receive a name which depicts the parent material or the soil depths.

At certain places, for instance, in the mountains, the sites may be very heterogeneous, changing over short distances due to aspect, slope, moisture conditions, periglacial solifluctions, et cetera. There, in delineating the site-units, it may be advisable to follow closely the natural forest associations wherever they can still be reconstructed in managed forests, or otherwise to use for this purpose the ground vegetation as the resultant of all site factors. The shallower the soils are, the more the roots of the trees and of the ground vegetation will occupy identical areas, and the more useful will the "vegetation-type" become as a substitute for the site-units. Even then, however, we should try to clarify to the best possible extent the nature of the soils involved.

In order to meet special local conditions, other variations of the procedure which I have tried to sketch can be employed. I cannot explain them all. I hope my discussion has made clear that for the most important part of site-mapping, namely the establishment and delineation of site-units, not only thorough knowledge of soils is needed but, just as well, good knowledge of plant sociology and forestry. Otherwise, it is impossible to realize the close interrelationships between these fields and to succeed in making the necessary synthesis. The ideal case in which the individual mapper has sufficient competence in all relevant fields will be a rare exception. Commonly, teams are the solution which combine specialists in soils, plant sociology, and forestry.

The site-units are commonly depicted on a 1:10,000 scale map. It should have contour lines to make the connection between topography and site-units show up. If necessary, maps with a larger scale can be used. Sometimes, special maps are available, showing such things as soil-texture, genetic type, vegetation-type, site-quality, et cetera. However, they are all of supplementary nature. The fundamental map is the map of the site-units, which should be depicted by using different colors. To the extent that it does not interfere with the clear display of the site-units, additional symbols may be used to indicate the most important properties of the site. In any case, the main purpose of the map is to show the exact location of the site-units in the field. Important details about these site-units are dealt with in the general description (legend) telling, for example, of special properties and weaknesses, productive capacity, expected reaction to silvicultural treatments, and proposals for such treatments.

A legend aimed at the general information needed by the practicing forester is one thing; a scientific report, another one. If the latter is necessary, keep it strictly separated from the former. A report for scientific purposes, exclusively written for use by experts, can be written in the proper academic language, whereas the explanatory legend for the practitioner's use should be styled accordingly. Beginners are often inclined to display erudite writing even where very simple words would fully do.

The explanatory legend is generally broken down into a General and a Special part.

For the *General Part,* the following outline is commonly used in Germany:

1. *General comments.* Discussed are the general conditions under which the mapping was done and the method employed.

2. *Geologic conditions.* Here one explains in a simple way the geologic development and the properties of the resulting geologic substrate which is the parent material for the soil formation.

3. *Climate.* Has to be dealt with under two viewpoints, namely, (a) its influence upon the soil-formation, and (b) its importance as a growth factor.

4. *Forest or stand history.* Most important are those events which may have influenced the properties of the soils.

5. *Formation (genesis) of the soils from the parent material.* It is explained in simple terms how climate, vegetation, and human treatments molded the soils which were encountered in the forest area under study. This is followed by listing the site-units which were established. At this point, only as much information is given about the individual site-units as is indispensable for characterizing them and distinguishing them from each other. All other properties are dealt with in the "Special Part," where each site-unit has to find its elaborate discussion.

Special Part

This is the more important part. It is supposed to serve as a *vade mecum* of the practitioner. Site-unit after site-unit is thoroughly explained. Here is a rough sketch of an outline for such a discussion of individual site-units:

1. *Description of the site.* Although given in easily understandable terms, accuracy is indispensable. All important properties, not forgetting special weaknesses, must be explained. Some typical analytical data and photographs of soil profiles are desirable supplements.

2. *Natural forest association.* To be mentioned if it is known.

3. *General growth characteristics and productive capacity of tree species.* Comments are made on species presently occupying the site, as well as on those species which deserve consideration for the future. Hence, a clear distinction is needed between what can be said about the site-class or the basis of actual local measurements on the one hand, and estimates based on experience with similar sites on the other. This is followed by comments on special features of the site relevant to growth, root development, wood quality, et cetera. Very important, though at the time of the mapping generally not yet available, are comments on the growth relationships, particularly height-growth relationships of the different species involved. There are sites, for instance, where we can successfully grow larch single-stem-wise in spruce stands. On other sites, the use of such a pattern of mixture would be very unwise, because larch would be outgrown by the spruce and squeezed out of the stand by oppression. A tremendous amount of money was wasted by neglecting these connections. Provision is necessary so that for each site-unit an understanding of the special growth features of the most important species and species-mixtures is acquired by means of long-term observation of indicator stands. In the scheme employed for putting down the results of the site-mapping, space has to be provided for this and other information which may be gained in the future.

4. *Ground vegetation and condition of humus.* Their correlations with the most important stand conditions are explained. The changes which will take place in the course of stand development are to be stated. Of particular importance are information on how unincorporated humus layers and vegetation react to opening up of the stand or to complete clearing.

5. *Mechanical soil preparation and measures of amelioration.* Only the important viewpoints ought to be stated; for instance, whether and why a mixing of their soil horizons is desirable or not desirable. In a similar way, comments on possible measures of amelioration are given. All proposals have to be logically based on the previously explained properties of the soil. Details about the technical aspects of cultural procedures do not belong here.

6. *Choice of tree species.* All species and species mixtures which seem to be useful are listed. A scale evaluating them should be added which is based on their volume and value production, biological significance for the site, managerial safety or risk involved, et cetera. In this way, one leaves needed room for the final operational decisions which, with such larger holdings as State forests, may be made in the framework of regional planning. For operational decisions, viewpoints often come in which cannot be at hand when this chapter is written.

7. *Size of site-units in hectares.* This information is of particular importance wherever the local planning is to be integrated into a regional planning. Hereby, it is often advisable to combine local site-units into groups embracing site-units of sufficient similarity.

So much about our way of writing the legend. As you see, we are dealing with a method of mapping which is explicitly focused on the needs of forest management and which, therefore, has to go its own way. On the other hand, data are recorded and information comprehended which are just as useful for other kinds of maps on soils. Close cooperation between all people and agencies concerned is, therefore, highly desirable. Only by such cooperation can we secure the full possible use of the information gained by the soil-mapping and make the experiences of other experts available for our task of site-mapping for forestry purposes.

In conclusion, I should like to stress again this: What we want to accomplish is to make available to the foresters on the ground the faculty of experts at comprehending the properties of the sites in general, and their significance for forest management in particular. It seems to me that training for the forestry profession is already so broad and diversified that not enough time can be allocated to soils to make the foresters sufficiently expert in site evaluation to handle this job completely on their own. However, our procedure will help them to get acquainted with the site conditions of their districts and, by this, enable them to correlate their silvicultural observations and experiences with the underlying causes.

Confronted, for instance, with failures in natural reproduction, the foresters no longer will be inclined to make unsound generalizations but will ask where exactly did the failure occur; that means on what site-unit. In case success was better on other site-units, he may be able to find out the underlying causes by comparing the site-units which have reacted so differently.

I may remind you of those times when certain silvicultural methods which had been successful here or there because of their fitting into the local conditions were uncritically commended for completely different conditions. Those times have passed forever.

RESUMES

Classement, cartographie et interprétation des sols à des fins de sylviculture

Comprendre les propriétés d'une station donnée et leur incidence sur le régime forestier a été une tâche ardue aussi longtemps qu'on a pensé que ces stations constituaient uniquement une combinaison due au hasard des nombreux facteurs intervenus. Nous avons surmonté cette difficulté lorsque nous avons appris à reconnaître que les facteurs pédologiques se combinaient d'une manière non pas arbitraire, mais précise, selon les lois de la dynamique des sols.

Les processus géologiques se déroulent de telle manière que pour une zone donnée, particulièrement si celle-ci est tracée du point de vue écologique, on ne trouve qu'un nombre limité de couches inférieures mères pour la formation du sol, et celles-ci sont généralement disposées selon la topographie. Pour cette raison, le nombre des combinaisons possibles de facteurs pédologiques—lesquels apparaissent théoriquement sans limites—se trouve réduit dans des proportions considérables. C'est pour avoir reconnu ces divers rapports que l'on a commencé à établir des "unités de station."

Ces unités représentent des constellations de facteurs pédologi-

ques de caractère local, soumises à des conditions génétiques. Elles se sont révélé être le type d'unité qui s'adaptait le mieux au relevé cartographique du sol. Les systèmes généraux de classement des sols fondés sur la génétique et actuellement en cours d'élaboration ne suffisent pas à rendre compte des propriétés des stations. Il demeure toutefois hautement souhaitable que ces unités soient intégrées dans un système, ce qui serait en particulier un moyen supplémentaire de les délimiter. Il semble pour le moment impossible de réaliser ce que l'on avait tenté de réaliser en utilisant certaines "clés," à savoir d'exprimer la nature et la capacité productive des stations en intégrant directement les facteurs des différentes stations, quel que soit le soin avec lequel ces dernières ont été déterminées. Les stations doivent être considérées comme des entités naturelles indivisibles dont les propriétés sont déterminées par les lois de la dynamique des sols. Notre connaissance de leur productivité se fonde sur l'expérience.

Dans le cadre des méthodes de cartographie du sol actuellement appliquées en Allemagne, nous divisions les différentes provinces en petites "unités régionales" présentant des conditions de station analogues. Nous les appelons "districts de croissance" (Wuchsbezirke). Dans les régions montagneuses, elles coïncident généralement avec les associations forestières régionales naturelles. La division ultérieure en unités de station peut se faire pour l'ensemble d'un district de croissance ou pour certaines parties de celui-ci, selon le régime de la propriété, les subdivisions administratives, etc. Il faut s'efforcer a) de ne pas dépasser un nombre limité et commode d'unités et b) de pouvoir encore comprendre suffisamment les conditions de la station particulière. Cette dernière tâche se trouve facilitée par la division première des districts de croissance en parties plus petites; la cartographie devrait toutefois être suffisamment coordonnée au sein des districts.

Encore que l'on n'y arrive pas toujours parfaitement, il est souhaitable que les stations qui forment une unité présentent à peu près la même capacité de production et réagissent de façon comparable aux traitements sylvicoles. La partie la plus difficile de cet inventaire cartographique est l'établissement des unités de station, tandis que le tracé de leurs limites est relativement facile lorsque les indications fournies par la topographie, les conditions des peuplements, la végétation du sol, etc. sont utilisées convenablement. Les procédés cartographiques devraient s'adapter d'une manière aussi souple que possible aux conditions du terrain. Les cartes ne devraient pas se fonder uniquement sur la végétation, ou sur l'analyse des sols, mais sur une combinaison des deux. Dans certains cas, c'est la végétation qui fournit les meilleures indications, dans d'autres l'analyse des sols.

Les unités sont ordinairement reportées sur une carte en courbes de niveau au 1/10.000^e^, dont le but essentiel est de montrer l'emplacement exact des unités sur le terrain. Une légende rédigée séparément pour chaque unité fournit des renseignements détaillés. Parmi ces renseignements, on compte ses propriétés, y compris ses faiblesses particulières, la production de l'essence la plus importante, les réactions aux traitements sylvicoles et les propositions relatives à ces traitements.

Ainsi le forestier dispose-t-il des renseignements dont il a besoin pour comprendre ses stations. Il peut ainsi mesurer ses expériences sylvicoles en établissant un rapport entre eux et les conditions de la station. A des fins de planification régionale on peut, pour de plus grandes régions, combiner les unités locales en groupes comprenant des unités analogues.

Clasificación, Topografía e Interpretación de Suelos para Fines Forestales

La comprensión de las propiedades de un terreno y su significado para el cultivo de bosques fue muy difícil mientras se consideró al terreno simplemente como una combinación casual de muy numerosos factores conjuntos. Esta dificultad se salvó cuando se llegó a la conclusión de que los factores del suelo no se combinan arbitrariamente, sino de manera determinada según las leyes de la dinámica del suelo.

Los procesos geológicos del suelo ocurren de tal modo que, en pequeñas zonas, particularmente si se delinean desde el punto de vista ecológico, sólo se encuentra un pequeño número de subestratos originales para la formación del suelo, a menudo dispuestos de conformidad con la topografía. Debido a esto, el número de combinaciones posibles de factores del suelo, que teóricamente parecen ser ilimitados, se reduce considerablemente. Así, el reconocimiento de estas relaciones abrió el camino para la creación de "unidades de terreno."

Estas unidades de terreno representan las aglomeraciones genéticamente acondicionadas y locales de factores del suelo y han demostrado ser la clase de unidad más apropiada para el levantamiento de mapas. Los sistemas generales de clasificación de suelos que se basan en la genética y que al presente se perfeccionan, no son suficientes para mostrar las propiedades de los terrenos, pero siempre es muy conveniente integrar las unidades de terreno a esos sistemas, especialmente como otro medio para definirlas. Por el momento parece imposible lograr lo que se ha tratado de conseguir con el empleo de ciertas "claves" para expresar la naturaleza y capacidad productiva de los sitios integrando directamente los factores particulares de cada uno, por más cuidadosamente que éstos se hayan determinado, pues los sitios se deben apreciar como entidades naturales e indivisibles cuyas propiedades las determinen las leyes de la dinámica de los suelos. Nuestros conocimientos acerca de su productividad se basan en la experiencia.

En los métodos de levantamiento de mapas de los suelos que se siguen actualmente en Alemania, las provincias se dividen en numerosas "unidades regionales" pequeñas, de condiciones similares de suelo, las cuales se denominan "distritos de crecimiento" (Wuchs-Bezirke). En las montañas éstos se delinean a menudo de modo que coincidan con asociaciones regionales y naturales de bosque. La subdivisión en unidades de terreno se puede hacer por distritos de crecimiento como totalidad o parte de éstos, según la clase de propiedad que sean, subdivisión administrativa, etc. Ahora, es necesario tratar de (a) no excederse de limitado número de unidades fáciles de administrar y (b) abarcar suficientemente las condiciones particulares de cada unidad. Esto se facilita con la división inicial de distritos de crecimiento en partes más pequeñas, pero el levantamiento del mapa se debe coordinar suficientemente en el propio distrito de crecimiento.

Aunque no siempre es fácil de lograr, es conveniente que los terrenos que se combinen en una unidad sean, aproximadamente, de la misma capacidad productiva y que respondan por igual a los tratamientos de silvicultura. La parte más difícil en el levantamiento del mapa es el establecimiento de las unidades de terreno, en tanto que su delineación es relativamente fácil si se aprovechan debidamente las indicaciones de la topografía, las condiciones de los arbolados, otra vegetación, etc. Es aconsejable, por tanto, la muy flexible adapatación de las fases del levantamiento del mapa a las condiciones que se encuentren en el terreno. El mapa, pues, no se debe basar en parcialidad por la vegetación ni en el análisis del suelo, sino en la combinación de ambos elementos, ya que en ciertos casos es la vegetación y en otros el análisis del suelo, lo que proporciona la mejor información.

Generalmente, las unidades de terreno se delinean en un mapa de perfiles de escala 1:10,000 cuyo objeto principal es el de mostrar la situación exacta de las unidades en el campo. En una relación que se prepara para cada unidad se consignan todos los informes respecto a ella, indicando sus propiedades, inclusive deficiencias particulares, producción de las especies más importantes, efectos de los tratamientos de silvicultura y proposiciones para éstos.

De este modo el administrador del bosque obtiene los informes necesarios para conocer sus unidades, capacitándose, por lo tanto, para relacionar su experiencia en el ramo con las condiciones de cada sitio. Para fines de fomento regional, en casos de zonas extensas, se pueden combinar las unidades locales en grupo que abarquen más unidades semejantes.

The Mapping, Classification, and Interpretation of Ghana Forest Soils for Forestry Purposes

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The Ghana forest soils discussed here are, to a considerable degree, comparable with forest soils elsewhere in West Africa, and, but to a lesser extent, with those of some other parts of the tropics. Our knowledge of these soils is, however, in its infancy, and some of the many problems which remain to be investigated are indicated.

The Ghana Forest Zone

That part of southern Ghana where the natural vegetation is, or was, high forest covers some 30,000 square miles, though over much of this area the vegetation has been modified by man, principally by farmers clearing the forest for food and cocoa farms. Probably only some 11,000 square miles of little-disturbed high forest remain, mostly in the west (Ahn, 1959a), half of which is now included in forest reserves. Elsewhere, the high forest has been replaced by farms and by regrowth vegetation of various ages.

The climate of the forest zone varies little as regards temperature, either from place to place or from season to season, being uniformly high. The rainfall, on the other hand, decreases from a maximum of over 85 inches in the southwest to under 50 inches in the northern fringe where the forest merges into savanna. Differences in totals are accompanied by differences, perhaps more important, in the length and severity of the dry seasons, of which there is a major one in November-February and a minor one in August. Despite the fairly high totals there are, therefore, several months in each year when potential evapotranspiration exceeds rainfall, soil moisture is depleted, and plants may suffer from water shortage. Such periods are likely to be longer and more severe in the northern forest areas, and both the soils and the vegetation of the forest zone can be divided into a number of belts or zones correlating broadly with rainfall. These, and their significance to forestry, are discussed further below.

Unlike the soils of North America and Europe, developed in the relatively recent deposits of the last glacial period, many Ghana forest soils have an extremely long history and are often developed in a mantle of residual products incorporating material derived from early geological and geomorphological eras, e.g., the broken-up remains of old lateritic or ironstone crusts and of once extensive deposits which mantled former peneplains of the Tertiary age, of which only small remnants now survive. Such material has often been subjected to weathering forces for a very long period, so that little except unweatherable residues (quartz, kaolinitic clay and sesquioxides) remain. Weathering processes under hot, wet conditions are, in any case, far more rapid than in temperate areas, and most forest soils are characterised by the great depth of weathering (solid rock is often not found for several hundred feet below the surface) and by the intensive leaching and breaking down of decomposable minerals in the upper part of the profile. Such deep, poor soils, from which most of the nutrients have long since been removed, form the normal (or zonal) soils of the Ghana forest zone and of similar areas in West Africa. What fertility they possess is largely stored in the topsoil and in the wood and the leaves of the trees, the nutrients circulating in a closed cycle (from leaf to topsoil to root to leaf), from which losses may be negligible. Such fertility has accumulated over considerable periods, and nutrients still circulating may have originated in rocks and soils long since removed: in short, the present forest, though appearing luxurious, is living on its own capital.

Tree crops are undoubtedly the form of land use best able to exploit these soils on a sound long-term basis, to protect them and to preserve some of the accumulated fertility for succeeding generations, hence the interest and importance of forestry.

Soil Survey Methods Employed in the Forest Zone

The soil survey methods evolved by the late C. F. Charter for use in Ghana were designed to cover relatively large areas, often of low population, in a preliminary way, in order to assess Ghana's soil resources as a whole and to indicate what areas might merit more detailed subsequent investigation for specific agricultural projects. The aim of the survey was the practical one of assisting agriculture by the provision of basic soil maps (Charter, 1957a), and a special feature of the system, among the first of its kind in the tropics, was the use of considerable numbers of only partly trained African staff who brought back soil samples to local field bases for description and identification by a more experienced soil surveyor in general charge of the survey.

For soil purposes the whole of Ghana was divided into convenient river basins, often of 2-3,000 square miles in extent, and of those in the forest zone, some two-thirds have now been surveyed by detailed-preliminary methods which aim at mapping the extent of major soil associations. This is done by means of a fairly broad network of traverses, along roads, footpaths or cut lines, along which samples are taken to a depth of 4 feet at every 10 chains, i.e., at eight points per mile of traverse. Such traverses usually total 20-30 miles per 100 square miles surveyed and are supplemented by more detailed surveys of a number of sample strips (at least one per major soil association), each a quarter of a square mile in extent, in which individual soils series, relief, vegetation and land use are mapped in detail (Hotson, 1956). Such sample strips are sited so as to be typical of a soil association, i.e., of a group of soil series, usually forming a more or less regular catena, whose distribution is related to the relief. The final soil map, on the ¼-inch scale, maps these associations, not individual soils.

Samples from selected soil pits are analysed at a central laboratory in Kumasi, and analytical results are incorporated in comprehensive memoirs issued by the Soil Survey Branch (such as Brammer, 1955; Ahn, in press), or in smaller technical reports, of which several have been concerned with forest reserves (Crosbie, 1955, 1956, 1957; Ahn, 1958a; Obeng, 1959). Other methods of survey involving regular grids of cut lines are available for more detailed mapping, and larger scale maps showing specific features such as depth of induration (Ahn, 1957 and 1959c) or salinity are also produced when required.

Problems of Soil Classification

It has been claimed that only a system based on soil genesis can include all soils in a logical framework allowing valid connections and deductions to be made, and certainly, though present-day systems vary in detail, most of them stress factors held to indicate differences in genesis. Even though the pedologist, remembering that pedology is the child of agriculture, cannot rid himself entirely of an agricultural bias, such systems are not necessarily concerned with characteristics of practical importance to the farmer or forester, just as in botany, the floristic classification of plants does not group them with reference to their practical use to man. Thus, an increasing need has been felt for an additional, often simpler, parallel soil classification for agricultural purposes, and several attempts at less profound but more immediately practical local groupings of this nature for specific purposes (such as cocoa growing or irrigation) have recently appeared (e.g., Smyth and Montgomery, 1959; Cutting, 1959; Radwanski, 1959; Thomas and Vincent, 1959). In the Belgian Congo, the pedological map is often supplemented by another map entitled "utilisation des sols," indicating the agricultural potential of the soils, as far as these are known, with regard to present-day techniques and conditions: obviously, the first is the more fundamental, the second is the more ephemeral but immediately practical.

In tropical Africa, the French, Belgian, Portuguese and British classifications all put considerable emphasis on the age of the soil as shown by the degree to which alterable minerals in the profile have been weathered. Obviously, younger soils in which minerals are decomposing to release plant nutrients can be expected to be more fertile than soils subjected to prolonged leaching and weathering, or to soils developed in exhausted or nearly sterile parent material, such as the deep desert sands of much of the central Congo. Ghana's cocoa success is due largely to the presence of soils which are not quite as strongly weathered as many tropical soils.

The criteria involved in defining "age" differ, however, between various workers. The Belgians have stressed the decreasing silt content of the older soils (Van Wambeke, 1959) and the presence of clay skins (Sys, 1959b). The French and Portuguese stress the lower silica/alumina ratio in the more highly weathered soils (Aubert, 1958; Aubert and Duchafour, 1956; Botelho da Costa, 1959). In each case the broad lines of classification follow those of Guy Smith in the United States (D'Hoore, 1959). Broad generalisations as to the agricultural value of orders and groups are sometimes possible, though the same divergence of interest between theoretical classifications and practical utilitarian examinations is seen in the laboratory, usually better equipped for routine base analyses than for investigating factors of possible importance to genesis.

In Ghana, C. F. Charter's system (Charter, 1957b; Brammer, in press) tried to classify soils according to all major soil forming factors (i.e., climate, vegetation, relief and drainage, parent material and age), dividing soils at the highest level, the orders, according to which of these factors, or which pair of factors, were of most importance. Thus, soils whose characteristics are due mainly to relief and drainage (e.g., poorly drained gley soils) are "topohydric earths," those due mainly to climate and vegetation (the normal upland latosols) are "climatophytic earths." This system suffers from the usual difficulties, including those posed by polygenetic soils and the absence of agreed quantitative measurements which alone can make many divisions more than a matter of opinion and possibly dispute. While much of his system is theoretical and tentative, however, his division of the widespread latosols of the forest zone into the highly leached and acid oxysols (oxy = acid) and the less leached, less infertile, often more brightly coloured ochrosols (ochro = reddish yellow) is one which has proved of considerable practical significance in Ghana and is discussed more fully below.

Even soils of a single series "do not provide units homogeneous in all properties important for land use" (Cline, 1949). Thus, there may be very considerable agricultural differences at the lowest level of all, the phase, e.g., between an eroded phase and a normal one, or between a cultivated phase and a high-forest phase, differences which, to the forester, might make all the difference between success and failure.

One may summarise by saying that a classification is likely to be entirely satisfactory to the forester only if it is made with his specific needs in mind and only in as far as the importance of soil characteristics to forestry are known, but that, nonetheless, other classifications will be of value to him to the extent that the criteria used at different levels and their possible relevance to tree growth are understood.

The Interpretation of Specific Soil Properties for Forestry Purposes

General Considerations: Soil-Vegetation Relationships

If the results of physical and mechanical analyses are to be anything more than meaningless figures, we have to know their significance to the plant itself. Normally, laboratory results have to be correlated with field trials and observations, and this would apply even if chemical analyses showed us exactly what was actually available to the plant, which they do not.

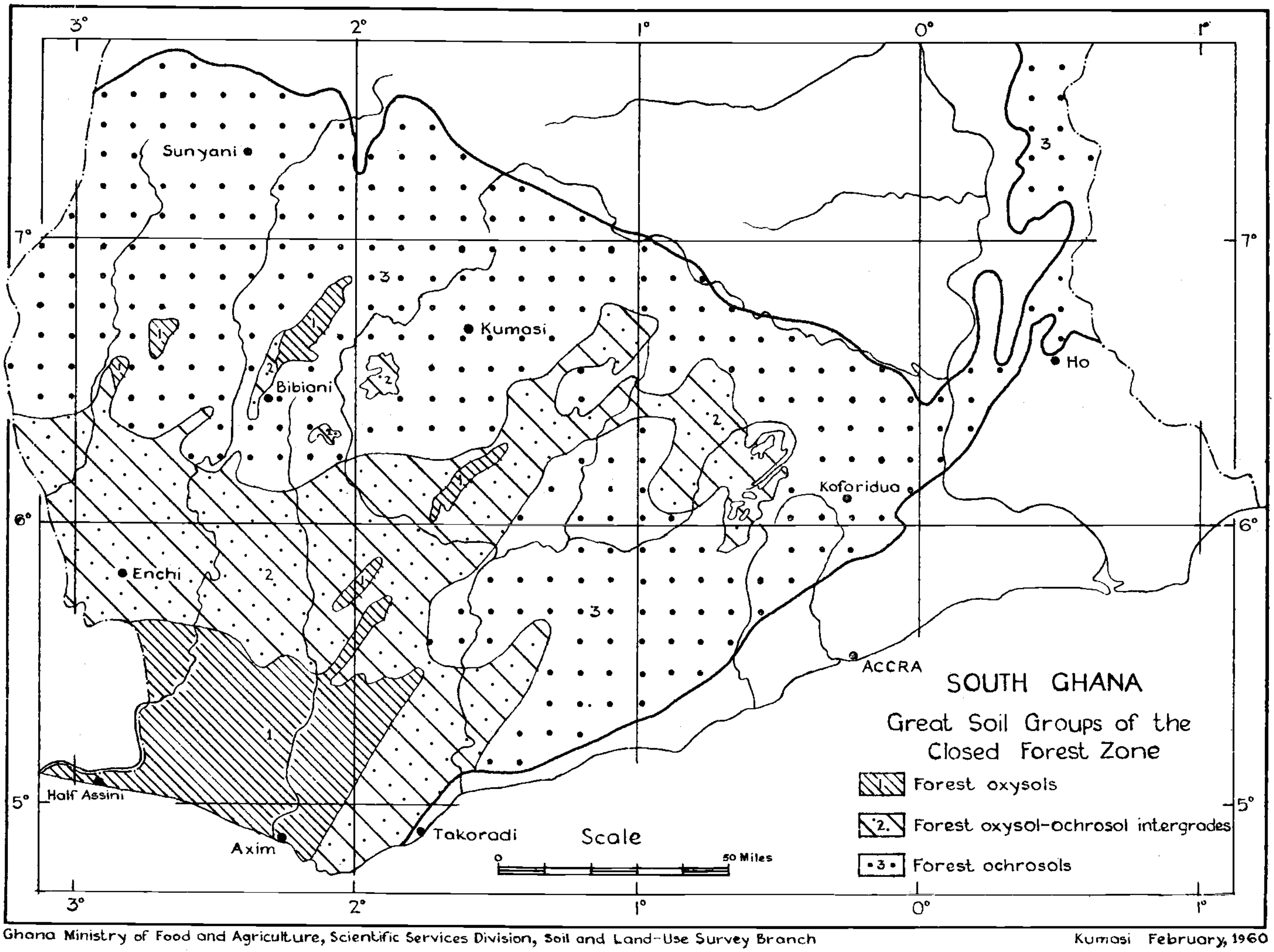

Figure 1. Great soil groups of South Ghana's closed forest zone.

In the case of soil interpretation for forestry, they can be usefully supplemented with an examination of relationships between the soil and the natural forest vegetation, though here, too, relatively little is yet known. In an earlier paper (Ahn, 1959b) the author outlined some of the difficulties attending such investigations and the finding of species indicating specific soil conditions. The important concept is that of the minimum static area, it being misleading to compare smaller atypical areas (e.g., over-mature patches, or pole forest) with a specific soil, but since soil patterns in the forest zone are complicated, such a minimum static area may include several different soil series (albeit topographically related ones). With a forest containing (as distinct from temperate forests) many hundreds of species, some markedly gregarious, it is not easy to demonstrate, in a small area, that the presence or absence of a specific tree is more than a matter of chance. Apart from the obvious correlation with drainage, therefore, which produces a well-marked vegetation catena in the valleys, valid correlations are likely to be broad ones involving considerable areas.

The natural vegetation of the Ghana forest zone is becoming better known, both structurally and floristically, and a number of divisions are now accepted, at least in outline, even though problems of definition remain (Taylor, 1952; Lane, in press; Mooney, 1959). In the high rainfall area (70-85 inches) of the southwest, the evergreen rain forest area is characterised, more or less, but not entirely satisfactorily, by the presence of three main indicators, *Cynometra ananta, Lophira alata,* and *Tarrietia utilis.* This very wet forest is less high than the more extensive semi-deciduous forest of the remaining forest areas and, while there are more pole-size trees, there are considerably fewer large trees, so that the total weight of vegetation (and hence the nutrients stored in it) is less than in the less wet forest areas. Mooney (1959) has shown that trees of 15-foot girth and over in the rain forest occur at only 11-20% of the frequency found in representative semi-deciduous forest, while the same figures converted to Hoppus basal area are shown, in graph form, in Fig. 3. The great interest of these observations from the soil point of view lies in the fact that the rain forest is more or less co-extensive with the oxysol zone (Ahn, in press).

The oxysol/rain-forest area is one of highly leached soils, almost all the upland soils being oxysols. A typical

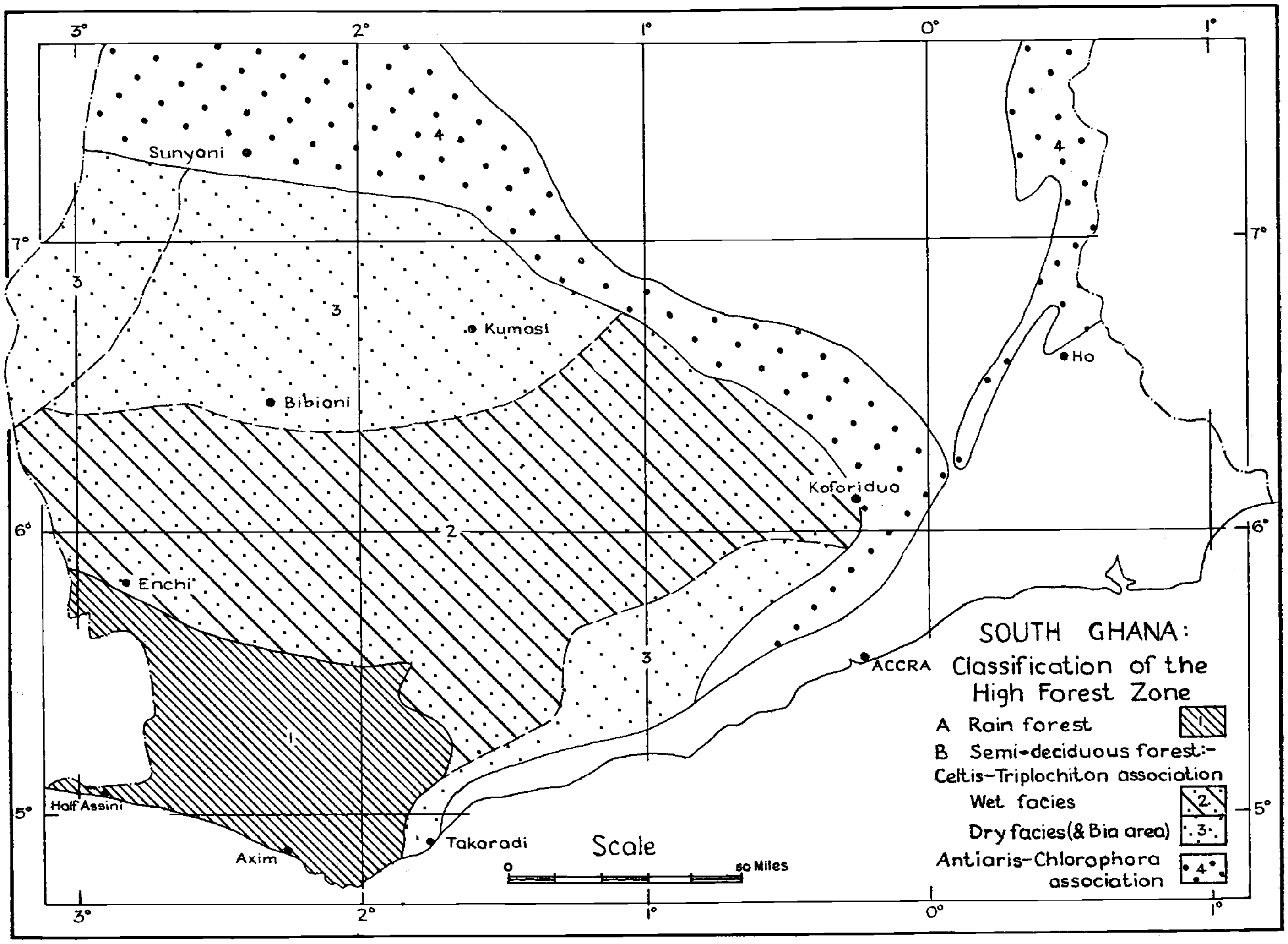

Figure 2. Vegetation of South Ghana's closed forest zone.

oxysol has a topsoil reaction more acid than pH 5.0, usually about pH 4.4, although topsoils as acid as pH 3.6 have been recorded. Such soils are deeper and paler than the normal ochrosols of the rest of the forest zone, the subsoil colour being yellow to orange-brown, and total exchangeable bases average as little as about 3 m.e., even in the upper topsoil of little disturbed soils under high forest (Tables 1 & 2). In Ghana, such soils are developed over a range of parent materials (phyllites, granites, Tertiary sandy clays) but all the soils have been reduced, by the extreme climate, to a common low fertility level. Differences between them are therefore more differences of site, texture, drainage, and coarse material content than differences of nutrient status.

The rain forest merges into the more extensive semi-deciduous forest (in which some species shed their leaves at one season or another) and most of this forest is characterised by two very frequent species, *Celtis mildbraedii* and *Triplochiton scleroxylon,* both quite absent from the rain forest. The Celtis-Triplochiton association has been divided by Mooney (1959) into wet and dry facies (Fig. 2) while a somewhat drier association (the Antiaris-Chlorophora) occupies the northern fringe of the forest.

The soils of the ochrosol/semi-deciduous forest zone are more varied than those of the oxysol/rain-forest area, both because of a more complicated geomorphology and because the less extreme climate allows greater soil variations due to differences in parent rock. A typical ochrosol is developed under 45-64 inches of rain and has a topsoil pH in the range of 5.5-7.0, often about 6.4-6.6. It is brighter in colour (red subsoils being common on the better drained sites) due possibly to the greater oxidation of soil iron permitted by the more marked dry seasons. The upper topsoil may be expected to have a total exchangeable base content of 15-30 m.e. of the fine earth fraction, i.e., up to ten times the oxysol average (Tables 1 & 2). The ochrosol zone can itself be divided into a less fertile southern or intergrade zone (corresponding with the wet facies of the Celtis-Triplochiton association), a central ochrosol zone of maximum agricultural productivity (at least as regards cocoa and the major food crops), which corresponds with the dry facies, and a northern belt where the soils, though not infertile, are limited by dry-season water shortages, and this belt, in turn, correlates to some extent with the Antiaris-Chlorophora association (Figs. 1 & 2). Some of the individual

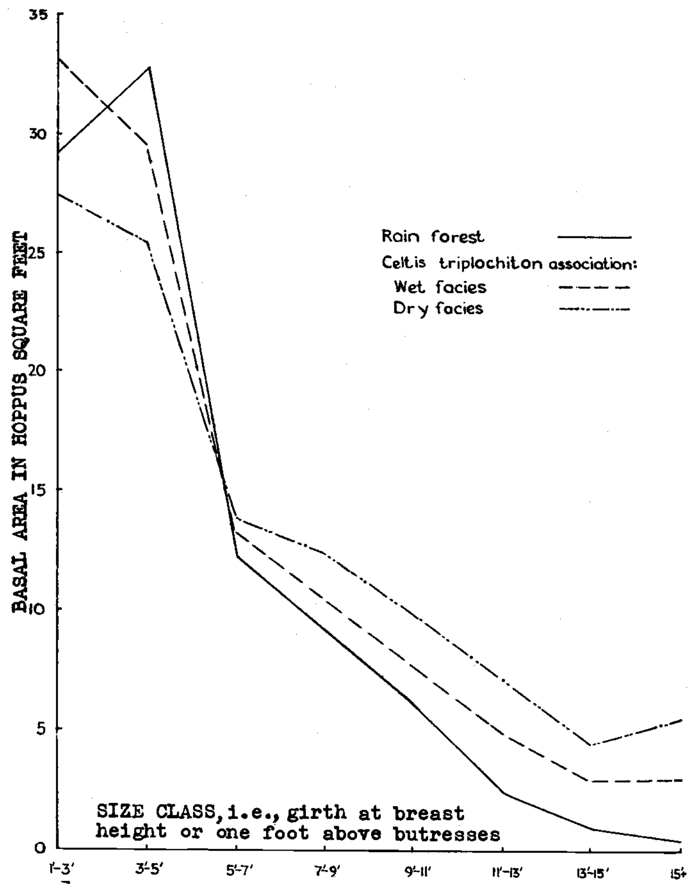

Figure 3. Graph showing basal area (in Hoppus square feet) of all-species size classes in the rain forest, and in the wet and dry facies of the Celtis-Triplochiton association of the semi-deciduous forest. (From Mooney, 1959).

soil factors which may contribute to these correlations are discussed in the following paragraphs.

Physical Soil Characteristics

Physical soil conditions, particularly structure, texture, pore space and arrangement, govern the availability to the plant root of the primary requirements of water and oxygen, as well as influencing the availability of chemical nutrients. Although much research remains to be done on the varied factors affecting the growth and extent of rooting systems in tropical forests, it is possible that they may be limited largely by competition for oxygen, soil aeration thus influencing tree size and density. In regeneration, the removal of competing rooting systems may be more important than the opening of the canopy to admit light, the factor formerly thought dominant (Wilkinson, 1939), though it is not clear to what relative extent root competition is for oxygen or for mineral nutrients.

Lack of oxygen and excess CO_2 is common in valley-bottom soils, especially in the wet southwest, where typical swamp forest communities of the Raphia-Calamus-Ancistrophyllum type are widespread, and downward root penetration is limited by the water table. Pneumatophores are a partial adaptation to such conditions. Soils of sites waterlogged for considerable periods are grey and/or highly mottled. These soils grade upslope into less poorly drained, yellowish, slightly mottled soils subject to only occasional flooding. There is a well-marked vegetation catena corresponding to these soils, but it is poor in species and varies little, in the Ghana forest zone, with rainfall or soil reaction (Ahn, 1958b). No local species has been found suitable for forestry on such sites. Bamboo could be grown, if a commercial use could be found for it, and exotics (e.g., from the swamps of Florida) are being tried.

Downward root penetration is also limited in soils containing an ironpan or bauxite layer. Such soils often cap the flattish summits of hills, particularly in the northern forest areas where they represent remnants of Tertiary peneplains. Where the pan is less than a foot from the surface, the forest becomes lower and thinner; while where it approaches to within 2-3 inches or less of the surface, edaphic savanna patches, often with frequent swamp-tolerant herbs, are found instead. On such sites water relationships are extreme, the soils being waterlogged during rains but drying out rapidly during dry spells, hence the specialised vegetation. Where the induration is deeper, however, forestry may still be possible, the total volume of soil required depending on the species planted, the climate, and the water-retaining capacity of the soil. At Bamoro, in the Ivory Coast, for example, with a rainfall of 1,200 mm. (48 inches), teak plantations on fairly fertile clay soils were found to add wood in proportion to the depth of a limiting indurated horizon when this horizon was at less than five feet; when deeper than this, growth rates were not affected. The main factor is the water storage possible in relation to the length of dry season.

A more widespread factor limiting the effective soil volume exploitable by tree roots is the presence of the large quantities of gravel so characteristic of the subsoils of most upland Ghana forest soils. This gravel consists mostly of ironstone concretions and ferruginised rock fragments, (partly derived from the break-up of former ironstone crusts) together with various amounts of quartz gravel and stones derived from veins in the parent rock. It often reduces the fine earth fraction (i.e., material passing a 2 mm. sieve) to as little as 20–50% by weight of the total. Thus up to 5 feet of such a subsoil may be necessary to store the nutrients and moisture held by a single foot of an otherwise similar subsoil without gravel. Certain contrasting non-gravelly upland soils also occur, developed in a mantle of so-called drift material, but it is not known to what extent root systems differ in the two soil types as a result of this factor alone, though it has been shown in the Amazon area of Peru that roots go far deeper in podsolic sands than in normal clay soils (Ellenberg, 1959).

In general, the shallowness of tropical forest rooting systems is notorious, there being a dense root mat for 6–8 inches, but few roots below. A main tap root often appears to be absent. Large buttresses, a characteristic feature of Ghana forests, help to support such poorly anchored trees, even if not causally related to the need for support. The reasons for the concentration of roots in the topsoil are partly chemical, since most plant food is liberated there, but also partly physical, since forest topsoils usually possess a good structure, being crumbly and well aereated by soil fauna, whereas the subsoil is often struc-

Table 1. Analytical data for a typical forest ochrosol (Bekwai series, above) and a forest oxysol (Boi series, below), both developed over phyllite.

Lower horizon depth (inches)	Fine earth %	pH	Exchangeable bases, m.e. per 100 gm. fine earth, oven dry						C %	N %	C/N	O.M. %	TOTAL P p.p.m.
			Ca	Mg	Mn	K	Na	TOTAL					
2	100	6.4	23.74	7.87	0.36	0.30	0.66	32.93	6.1	0.454	13.46	10.51	556
11	94	5.1	1.63	1.24	0.05	0.10	0.15	3.17	1.28	0.137	9.34	2.20	424
21	42	5.0	0.50	0.30	0.05	0.07	0.19	1.08	0.71	0.085	8.35	1.22	436
33	31	5.1	0.46	0.24	0.02	0.07	0.22	1.01	0.40	0.061	6.56	0.69	453
46	79	4.9	0.32	0.33	0.03	0.03	0.14	0.85	0.31	0.069	4.49	0.53	395
64	100	5.5	0.22	0.37	0.01	0.03	0.23	0.86	0.28	0.057	4.91	0.48	402
3	95	4.7	1.17	0.79	0.03	0.22	0.25	2.46	2.47	0.189	13.07	4.25	174
7	96	4.8	0.30	0.44	0.01	0.07	0.27	1.09	0.82	0.081	10.12	1.41	123
16	52	5.0	0.31	0.35	0.01	0.02	0.27	0.96	0.67	0.070	9.57	1.15	140
27	93	4.9	0.26	0.31	0.01	0.04	0.16	0.78	0.52	0.059	8.81	0.89	140
42	98	4.9	0.25	0.30	0.005	0.04	0.13	0.72	0.42	0.051	8.24	0.72	112
66	98	5.2	0.22	0.25	0.005	0.02	0.15	0.64	0.28	0.032	8.00	0.48	107

Table 2. Table comparing analytical data for 42 latosols from the Lower Tano Basin, Southwest Ghana: above, average of 12 ochrosols; centre, average of 8 ochrosol-oxysol intergrades; below, average of 22 oxysols.

Lower horizon depth (inches)	pH	Fine earth %	Exchangeable bases, m.e. per 100 gm. fine earth, oven dry					K% TOTAL	Ca Mg	Mg K	C %	N %	C/N	O.M. %
			Ca	Mg	Mn	K	TOTAL							
2.7	6.1	73	14.42	3.81	0.32	0.55	19.10	2.9	3.78	6.93	4.35	0.383	11.36	7.23
7.9	5.8	63	2.87	1.26	0.08	0.17	9.38	1.9	2.78	7.41	1.24	0.130	9.54	2.09
20.8	5.2	63	0.73	0.60	0.02	0.09	1.44	6.2	1.22	6.67	0.83	0.080	10.38	1.38
44.4	5.2	58	0.45	0.49	0.01	0.09	1.04	8.7	0.92	5.44	0.51	0.060	8.5	0.98
2.0	5.1	74	3.50	1.64	0.18	0.38	5.70	6.7	2.13	4.32	2.90	0.246	11.38	5.196
7.6	5.0	65	1.05	0.73	0.03	0.11	1.92	5.7	1.44	6.64	1.14	0.112	10.18	2.02
19.0	5.03	62	0.52	0.35	0.02	0.08	0.97	8.2	1.49	4.38	0.74	0.082	9.02	1.33
35.9	5.14	66	0.69	0.52	0.03	0.08	1.26	6.3	1.52	6.50	0.53	0.063	8.41	0.90
2.2	4.4	85	2.26	1.02	0.14	0.32	3.74	8.5	2.22	3.19	3.49	0.275	12.69	5.98
6.5	4.5	69	0.65	0.42	0.05	0.14	1.26	11.1	1.55	3.00	1.44	0.129	11.16	2.48
17.2	4.8	50	0.41	0.30	0.02	0.09	0.82	11.0	1.37	3.33	0.85	0.087	9.77	1.45
33.2	4.9	55	0.34	0.29	0.01	0.07	0.71	9.9	1.17	4.14	0.58	0.071	8.17	0.01

tureless, or nearly so, and in gravelly subsoils poor volume may be relatively low.

The all-important topsoil is, however, subject to drying out, though in some cases the horizon immediately below the topsoil (especially if gravelly) may dry out first. This does not necessarily imply that topsoil feeding ceases, for there is evidence that roots can obtain cations from an air-dry soil, and the topsoil is, in any case, sometimes moistened by early morning dew.

The available moisture stored in the soil, i.e., that held between field capacity and wilting point, obviously depends, as elsewhere, on soil texture. In the Ivory Coast, for example, Porteres (1934) showed that, after a given rainfall, plants wilted after 9–17 days on a clay soil at Man, but after only 4–8 days on the sandy soils of Bingerville. Though sandy soils store less, they may give up their water more easily; moreover, a light fall of rain may penetrate a sandy soil more deeply and therefore be less quickly evaporated. Conversely, clays may puddle, and then be able to absorb little further rain. The effective rainfall is always a function of both soil and climate, and the distribution of forest types is therefore influenced by soil texture (Richards, 1959), while the same type of forest is found under different climates if the soil is also different, e.g., teak in Burma is found under 190 cm. (75 inches) on sandy soils but under only 130–140 cm. (55 inches) on loams (Stamp, 1925).

In Ghana, the usual rain forest indicators, Cynometra and Tarrietia, disappear on the particularly well-drained Tertiary sand soils, while trees (e.g., *Antiaris africana*) found mainly in the drier forest areas of the north tend to reappear (Ahn, 1959b). In the Ivory Coast, foliar suction measurements showed a greater physiological water shortage in trees on these soils than on those on adjoining clay soils (Lemée, 1959). Such considerations suggest that the distribution of species in the Ivory Coast and Ghana, and probably in much of the tropics, reflects differences in climate and soil moisture relationships rather than, primarily, of nutrient status. This, if true, is of obvious importance to forestry, since the physical conditions of the soil are less easily modified than the chemical.

As regards the different questions of total weight of wood, rates of growth, and height and structure of the forest, it is tempting to correlate the better figures of the semi-deciduous forest simply with the higher nutrient status of its less-leached ochrosols, assuming that this offsets the possibly longer growing season in the wetter south. The higher rainfall, however, has other effects besides reducing the base content, particularly perhaps on the oxygen supply, and indeed this is suggested by the reddish hue of the ochrosols as against the predominant yellow colour of the oxysols. The relative importance of these and other soil factors remain to be worked out.

Chemical Soil Conditions

The pendulum swung from the early exaggerated idea of tropical soil fertility to one which emphasised, and possibly exaggerated, their poverty and fragility. Greater knowledge of the chemical and physical processes involved is now defining this fragility more closely and assisting in rational ways of overcoming it.

Despite the very great range in natural soil fertility found, due to differences in parent rock and degree of soil evolution, there seems to be little correlation between soil fertility and the *floristic* composition of tropical forests, except in the case of the very poorest soils such as the nearly sterile white sands of British Guiana, supporting wallaba forest, and of Sarawak, supporting heath forest (Davis and Richards, 1933–1934; Richards, 1936). Normally, however, the same forest floristically covers soils of different fertility, the vegetation itself influencing the ultimate development of relatively uniform zonal soils.

Nutrient differences can nevertheless be expected to be important to forestry. Younger soils with weatherable minerals include relatively shallow soils on steep slopes and others with weathering rock within the root zone. The more deeply leached and weathered soils, or soils developed in very old mantles of often re-worked material are poor in contrast, and have low recuperative powers if once the topsoil nutrients are lost: many over-deep senile forest soils are "fragile" for this reason.

In soils under undisturbed long-established forest, however, it is hardly likely that outstanding deficiencies of any one single element will be detected, nor can we reasonably hope to transform their potential by adding a mere pinch of some minor element, as has been done with some poor Australian soils. Moreover, since the safest way to store nutrients is in the plant itself, and the amounts present in the vegetation are in any case as great as those in the soil, nutrients revolving in the cycle will tend to be those needed by, or at least absorbed by, the vegetation. It is not surprising, then, that crops grown on newly cleared forest land, despite the nutrient losses entailed in clearing, burning, and topsoil exposure to sun and rain, usually fail to respond to fertilisers until deficiencies have been revealed by several years of cropping (Nye and Stephens, in press). Thus, the problem of applying chemical fertilisers to forest trees, economically, is not likely to be a simple one.

Of the major individual nutrients, possibly phosphorous is in the shortest supply, though past emphasis on the locking up of phosphorus in compounds which dissolve only very slowly may prove exaggerated in the case of some soils. Available phosphorus is probably mainly organic. Nitrogen reserves, also contained in the organic matter of the soil, appear high on all except degraded soils, though the rate of conversion by bacteria to ammonia and nitrates is slower in the more acid areas and has also been shown to vary with the season (Greenland, 1958): it is slow in the dry season, but rises sharply during the first rains, after which quantities present are again reduced by leaching and plant absorbtion. The significance of this cycle to forestry has received little attention as yet, though the N content of coffee leaves has been shown to vary parallel with that of the soil (Loué, 1957).

The rate of organic matter decomposition is very high, and raw humus cannot normally accumulate, though direct comparisons with European mors and mulls are difficult. Not enough is known of the difference between the humus of a neutral or near neutral ochrosol topsoil and that of an oxysol topsoil with a reaction of pH 4.0–5.0. The C/N ratio of the ochrosols is usually 9–12, as in many European forests, but rises to 14–17 in the rain forest oxysols. This might suggest a lower rate of decomposition, but this can hardly be the case, since there is no more organic matter here than in less acid soils, though it is spread down the profile a little more.

The acid reaction of rain forest soils is due to the washing out of bases by up to 85 inches of water yearly. Calcium, followed by magnesium (Tables 1 & 2) is the base most affected: potash varies relatively little between soils of the wetter and drier areas and may form a greater proportion of the total bases in the more acid soils. Nye (1959) suggested 2% as the critical potash level for crops, but in most forest soils this is exceeded. Even on the acid soils, there is probably no direct shortage of calcium and magnesium, the effects of acidity being indirect: all bases become less available and other effects may prove important (e.g., aluminium toxicity and accumulation in roots so as to reduce their power to absorb phosphorus).

It should not be forgotten that the soil, including its chemical composition, is modified by the vegetation itself. In temperate areas the influence of different forests on soil formation is becoming better known, Chandler (1939), for example, showing calcium differences related to different forest types: in Ghana, the well-known variety of the forest and the presence of several hundred different species in relatively small areas makes such studies difficult, but preliminary tests on topsoils below some of the commoner tree species in the Bobiri forest reserve (Brammer, in preparation) suggest considerable variations due to the trees themselves. *Chlorophora excelsa,* for example, may form large lime accretions in the trunk, and when such a tree falls and rots the local soil balance will be modified, while different species have different nutrient requirements and different powers of extraction. Moreover, bases are washed out of the leaves into the soil directly in greater quantities than was formerly realised (Nye and Greenland; in press) and this too, may vary with the species. Although the close interaction between soil and vegetation is often emphasised, the details of all the mechanisms involved remain to be elucidated: what is clear is that, in forestry, the establishment of particular species will in some measure itself tend to give the soil conditions suited to them.

Soils and Forestry Methods

The practical consequences of the soil differences outlined above are reflected in the different forestry methods so far found successful in Ghana and in similar areas nearby. Forestry in Ghana is confined to the forestry reserves, the permanent forest estate, timber exploitation outside them being in the nature of a rapid salvage operation designed to market the commercial species before they are felled, or made inaccessible, by the farmer. Within the reserves there are three main methods of which one, normal selection working, relies mainly on natural regeneration, and the other two involve different degrees of assistance in order to intensify production (Mooney, 1958).

Within the oxysol/rain forest area of the wet southwest, natural regeneration is slow and the stockings of large commercial species in the primary forest itself are very low. In this zone, enrichment planting of seedlings is necessary. This involves the clearing of all or part of the original forest, depending on methods: in Ghana, line planting is practised, with little-disturbed forest between the lines (Lane, 1958) but in the Ivory Coast, mixed stands of *Tarrietia utilis* (nyankom) and *Khaya ivorensis* ("mahogany") appear successful if thinned early enough. These methods are necessary because of the low-percentage success of methods involving natural regeneration, due partly to poor soil conditions and the high root competition for available oxygen and nutrients, and partly to the low stockings of commercial species.

In the Celtis-Triplochiton association of the semi-deciduous forest, on the other hand, selection working is possible, though to reduce cutting to only the natural increase would probably not be economic for extractors, and the natural increase must therefore be supplemented by more intensive methods. In the wetter, southern semi-deciduous forest areas, clear felling and concentrated planting, as in the rain forest, is possibly the only practical proposition, but in the less wet "dry" facies of the association, where the upland soils are mostly ochrosols, the tropical shelterwood system has proved practicable. This involves the encouragement of natural seedlings through partial canopy clearing and the elimination of competitors. In the Mpameso forest reserve, for example, this method applied to *Entandrophragma utile* resulted in a 55% success at 10 years, i.e., 55% of a calculated optimum density of 160 to the acre. Obviously, the factors involved are partly soil, partly botanical, it being difficult to separate the two or assess them apart. Any system of this type must depend on an adequate number of parent trees and on a large enough supply of seedlings. The first does not always imply the second. In the Mamiri forest reserve, for example, there are high stockings of Khaya, but no regeneration; although the soils are leached and poor (Ahn, 1958b), we are not yet able to say to what extent soils are responsible, or in what way.

There are many local areas where the natural forest is unaccountably poor and others where stockings are surprisingly high, and a greater knowledge of both soils and forest is necessary before these can be explained. As regards attempts to associate the soil with specific defects such as black wood in wawa (*Triplochiton scleroxylon*) or corky, coarse-grained growth in *Entandrophragma,* no correlation has been established; the second was found to be a tension growth associated with sloping sites, though not with the soil itself.

In conclusion, a word is necessary on forestry on non-forest soils. Present-day savanna is often the result of man's activities, particularly annual burning, and when protected, these former forest soils may once again revert to forest, provided that parent species are near enough. The rainfall of certain areas, now savanna, is adequate for local species, while many exotics (e.g., eucalypts and teak) have possibilities in long dry-season areas where the local species have not. Savanna soils in general are characterised by lower organic matter levels than forest soils and a lower volume of nutrients circulating in the grass vegetation, so that the main forestry problem here is one of raising these levels. Certain soils, however, are potentially very productive. At Kpong, for example (Brammer, 1955), neem (*Azadirachta indica*), cassia and various eucalypts, now 2-4 years old, have grown very rapidly on the black clays of the Accra Plains. In the case of these particular soils, however, the very heavy nature of the clay may restrict later root growth and aeration, and it is possible that a short 3- to 4-year rotation, for much needed firewood, will be the best way of using them, thus illustrating once again the importance of physical soil factors.

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RESUMES

Relevé, classification et interprétation des sols forestiers du Ghana à des fins de sylviculture

Les régions forestières du Ghana couvrent quelque 30.000 milles carrés dont 11.000 peut-être sont encore à l'état de futaie. Les précipitations vont de plus de 85 pouces dans le sud-ouest à moins de 50 pouces dans la région où la forêt devient savane, et les zones pédologiques et climatiques sont liées à ces précipitations. En raison de la chaleur et de l'humidité, la plupart des sols sont profondément altérés et fortement lessives, et tendent à être pauvres. Toutefois, de longues périodes de végétation forestière ont permis à une couche de terre arable assez fertile de se constituer, les produits nutritifs évoluant en circuit fermé entre la couche arable et les arbres.

A des fins d'étude pédologique, les régions forestières ont été divisées en un certain nombre de bassins fluviaux qui font l'objet d'examens par des méthodes préliminaires relativement rapides fondées sur des prélèvements d'échantillons le long d'un réseau de levés par traverses. On compte environ 20 à 30 milles de levés par 100 milles carrés et on les complète par un examen plus approfondi de bandes témoins. Les cartes pédologiques définitives font apparaître non des séries individuelles, mais des associations; une association est généralement un groupe de sols ayant un rapport topographique, ou chaîne de sols. Les sols choisis sont ensuite analysés et les renseignements sont incorporés à des rapports pédologiques complets.

Les systèmes modernes de classement pédologique insistent généralement sur les facteurs qui sont censés indiquer des différences d'origine. Dans une certaine mesure, ces systèmes théoriques ont également une valeur pratique, comme dans les cas où ils soulignent l'importance des sols, puisque les sols jeunes qui contiennent encore des minéraux inaltérés devraient être plus fertiles. Quoi qu'il en soit, il est également nécessaire de disposer de systèmes plus simples et plus pratiques qui correspondent à des besoins précis. Les sols d'une même série, par exemple, peuvent être différents quant à leur valeur forestière, et seule une nomenclature établie expressément pour les spécialistes en sylviculture, et fondée sur une meilleure connaissance des rapports existant entre les sols et les arbres, serait probablement tout à fait satisfaisante.

Une comparaison entre les caractéristiques connues d'un sol et la forêt naturelle se trouve compliquée, en pays tropical, par le très grand nombre d'essences existantes. Toutefois les grandes lignes d'une importante corrélation émergent. A la région humide du sud-ouest du Ghana, la forêt dense (rain forest) relativement peu élevée et qui compte peu d'arbres de grande taille, correspond assez nettement à une région de latosols acides, fortement lessivés et connus au Ghana sous le nom d'oxysols. Le reste de la zone forestière porte (ou portait) des forêts de feuillus mixtes qui à leur tour se rattachent aux sols moins stériles, les ochrosols plus rouges. Ceux-ci se développent dans des régions de moins grande pluviosité, ont une couche superficielle moins acide ou presque neutre et une alimentation basique infiniment plus élevée.

La pénétration des racines se trouve matériellement limitée dans les terres basses par le plan d'eau et, dans un certain nombre de terres plus élevées, par une cuvette de fer ou de bauxite. Dans les premiers cas on trouve des forêts marécageuses, et de telles régions sont de peu d'utilité pour la sylviculture. Dans le cas de sols qui présentent une cuvette, la sylviculture est possible dans

les cas de couches profondes où le volume du sol est suffisant pour emmagasiner de l'eau pendant toute la durée de la saison sèche, encore que l'un des facteurs qui empêchent le plus souvent les sols d'emmagasiner de l'eau soit la présence de gravier dans les sous-sols forestiesr. La capacité du sol à emmagasiner l'eau exerce une influence sur la répartition des essences, les arbres de forêts plus sèches réapparaissant dans des régions très humides où les sols sont particulièrement bien drainés. Il est nécessaire d'étudier plus à fond les systèmes radiculaires dans les différents sols: le peu de profondeur de la plupart des systèmes radiculaires forestiers semble lié au fait que le sous-sol est relativement mal aéré, sans structure et pauvre en éléments nutritifs.

Du point de vue chimique, on ne sait pas dans quelle mesure la plus forte teneur basique des ochrosols est à elle seule responsable du plus grand poids du bois dans les régions de forêts de feuillus mixtes qui leur correspondent, ni quels sont les effets précis de la faible réaction des souches superficielles d'oxysol. Dans les sols des forêts peu pertubées, on a peu de chances de trouver des déficiences alimentaires marquées quelles qu'elles soient, encore que le phosphore soit peutêtre un élément limitatif dans certains sols et que la nitrification soit plus lente dans les régions acides.

Les méthodes de sylviculture applicables dans la pratique varient avec le sol. Dans les régions de forêts denses (rain forest), la régénération naturelle est lente et il est recommandé de procéder à des éclaircies et à des plantages d'enrichissement. Dans les meilleurs régions d'ochrosol, cependant, les travaux de sélection sont possibles, à condition que la régénération naturelle soit encouragée par un éclaircissage en voûte et par l'élimination des arbres concurrents.

La sylviculture est également possible sur quelques sols de savane, dont certains ont autrefois porté des forêts, particulièrement si l'on plante des essences exotiques. Dans ce cas, le problème pédologique fondamental consiste souvent à élever le faible niveau de matière organique et nutritive dans la plupart de ces sols.

Preparación de Planos Topográficos, Clasificaciones e Interpretación de Suelos en Ghana, para Fines Forestales

La zona forestal de Ghana cubre una superficie de aproximadamente 30.000 millas cuadradas, de las cuales quizá 11.000 están cubiertas de montes altos. La precipitación pluvial disminuye desde más de 85 pulgadas en el extremo Sudoeste a menos de 50 pulgadas en la región en la que el bosque se transforma en pradera, y tanto el suelo, como las fajas de vegetación tienen íntima relación con la precipitación pluvial. A causa de las temperaturas y de la humedad elevadas, la mayoría de los suelos han sido profundamente desgastados por las condiciones atmosféricas y sumamente lixiviados, razón por la cual tienden a ser pobres. No obstante, prolongados períodos de vegetación forestal han dado lugar a la formación de tierra superficial fértil. Las substancias nutritivas circulan en un ciclo cerrado entre la capa superficial de tierra y el árbol.

Con el fin de llevar a cabo estudios de los suelos, la zona forestal ha sido dividida convenientemente en diversas cuencas de ríos, que se estudian por medio de métodos preliminares relativamente rápidos que comprenden el análisis de muestras de suelos a lo largo de una red de transversales. Hay aproximadamente de 20 a 30 millas de transversales por cada 100 millas cuadradas de superficie, que se complementan con fajas más detalladas para el estudio de muestras. Los mapas definitivos de los suelos indican asociaciones y no series individuales: una asociación es por lo general un grupo de suelos topográficamente afines, como ser, por ejemplo, una catena de suelos. Se hacen análisis de suelos seleccionados y los datos obtenidos se incorporan a informes detallados y completos sobre los suelos.

Los sistemas modernos para la clasificación de suelos por lo general hacen hincapié en aquellos factores que son indicio de las diferencias de formación. Hasta cierto punto, tales sistemas teóricos son también de aplicación práctica cuando, por ejemplo, se otorga especial importancia a la edad de los suelos, dado que los suelos más jóvenes que aún contienen minerales no desgatados, suelen ser los más fértiles. A pesar de ello, existe la necesidad de aplicar sistemas más simples y prácticos, diseñados para satisfacer necesidades específicas. Aun suelos de una sola serie, por ejemplo, pueden diferir en su utilidad para la silvicultura y únicamente una clasificación hecha especialmente para silvicultores, basada en conocimientos más amplios sobre la relación que existe entre los suelos y los árboles, resultará ser enteramente satisfactoria.

En los trópicos resulta difícil establecer una comparación de las propiedades conocidas de los suelos, con las del bosque natural, debido a la gran variedad de especies existentes. A pesar de ello, surgen importantes correlaciones generales. En el Sudoeste húmedo de Ghana, la selva hidrográfica que se desarrolla a baja altura y que no cuenta con muchos árboles grandes, puede compararse bien con una zona de suelos lateríticos muy lixiviados, que en Ghana se clasifican como oxysoles. El resto de la zona forestal sostiene (o sostenía) bosques de árboles de hojas semicaedizas, que a su vez se desarrollan en suelos menos infértiles como ser los ochrosoles más rojizos. Tales bosques crecen con menos precipitación pluvial y en capas superiores del suelo cuyo contenido ácido es menor, o que son prácticamente neutrales y que tienen un mayor abastecimiento de base.

Físicamente, en tierras bajas, la penetración de las raíces es limitada por el nivel de las aguas del subsuelo, y, en algunas tierras altas por los depósitos de hierro y de bauxita que forman una capa en el subsuelo. En el primero de los casos se encuentran bosques que se desarrollan en pantanos y tales terrenos son de poca utilidad para la silvicultura. En el caso de los suelos con capas el cultivo de árboles es posible en lugares donde el suelo es mas profundo y el volumen del suelo es suficiente para almacenar agua para la época de la sequía, aunque la frecuente presencia de abundantes cantidades de piedras en los subsuelos forestales es un factor común que limita la capacidad de los suelos para almacenar agua y materias nutritivas. Se ha comprobado que la diversa capacidad de los suelos para almacenar agua influye en la distribución de las especies. Arboles de bosques que requieren menor cantidad de agua están reapareciendo en regiones muy húmedas pero cuyos suelos tienen muy buen avenamiento. Serán necesarios nuevos estudios de los sistemas de raíces en diversos suelos: la poca profundidad de la mayor parte de los sistemas de raíces de árboles forestales parece tener relación con la circunstancia de que el subsuelo está mal aireado, carece de estructura y contiene pocos elementos nutritivos.

Químicamente, se desconoce hasta que punto el contenido más elevado de base en los ochrosoles es responsable del mayor peso de las maderas en bosques asociados de árboles de hojas semicaedizas, o cuales son los efectos exactos de la baja reacción de las capas superiores de los oxysoles. En suelos de bosques expuestos a pocas alteraciones, es poco probable encontrar deficiencias individuales importantes de materias nutritivas, aunque en algunos suelos el fósforo puede ser un factor limitante y la nitrificación es más lenta en las regiones de suelos ácidos.

Los métodos de cultivo aplicables varían de acuerdo con las condiciones del suelo. En las regiones húmedas de selvas hidrográficas, la regeneración natural es lenta y se recomienda la apertura de claros y el plantío artificial. Sin embargo, en las regiones mejores de ochrosoles, el trabajo de selección es posible, siempre que se fomente la regeneración natural mediante el aclareo de copas y la eliminación de competidores.

El cultivo de árboles también es posible en ciertos suelos de praderas, en algunas de las cuales solían existir bosques, particularmente de especies exóticas; en este caso, a menudo el problema más importante es el de elevar los niveles de las materias orgánicas y de los elementos nutritivos bajos en la mayoría de estos suelos.

Relation of Forest Diseases to Soils and Soil Management

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Inclusion of this subject on the program of this session denotes widespread recognition of the importance of soils to forest diseases. Successful multiple-use forestry is partially contingent upon understanding the numerous ecological factors correlated with disease incidence. The need for understanding environment relations becomes further accentuated when one realizes that diseases rank as the most destructive agent affecting forest resources in the United States (24)*. Combined growth loss and mortality attributed to forest diseases in the United States in 1952 was 19.9 billion board feet, almost 2.5 times that caused by insects, the second most destructive agent. All too often, enormous amounts of disease damage escape observation because they occur slowly and are not spectacular.

Adverse environmental conditions were ascribed as sole precursors of plant diseases as early as the time of Theophrastus (300 B. C.). As knowledge accumulated, the concept of host-pathogen relations developed. Many workers held tenaciously to the idea that although pathogens were the ultimate cause, their influence was controlled largely by environmental factors that predisposed plants to disease attack. Adherents to this tenet became known as "predispositionists."

Within the past four decades, a growing awareness of the relation of diseases to ecological factors has developed. During the past 20 years, increased attention has been devoted to properties of the soil mass, the medium for tree growth. Consideration of soil properties in disease research is now commonplace; thus, the horizons of causal conditions are widened. This facet will be treated in the discussion that follows. Clear-cut soil relations are now known for several forest diseases; other diseases whose characteristics suggest similar relations are now being investigated. Among soil properties most correlative with disease prevalence are moisture (either deficiencies or excesses), aeration, reaction, fertility, and temperature.

Certain selected diseases will be discussed to illustrate the influence of the various soil properties involved.

Littleleaf Disease of Southern Pines

The littleleaf disease of shortleaf and loblolly pines (*Pinus echinata* Mill. and *Pinus taeda* L.) is abundant on 5 million acres and occurs sporadically on another 10 million in seven southeastern states. Crown symptoms of littleleaf are those of a nitrogen deficiency—reduced twig growth and development of sparse, shortened, tufted chlorotic needles. A marked reduction or often complete cessation of radial growth occurs.

The littleleaf problem is a classic example of frustration that plagued investigators for several years. Its solution illustrates the value of a coordinated team attack. Because the solution to this problem was aided by soil investigations, a discussion of the many facets of this problem is appropriate.

Characteristic littleleaf symptoms could stem from a number of causes: climatic aberrations, insects, fungi, nematodes, nutrient deficiencies, a virus, and possibly others. Investigation of these possible causes extended over a period of about 15 years and demanded versatility in the many approaches. After years of intensive study, littleleaf was shown clearly to be the manifestation of a root rot caused by *Phytophthora cinnamomi* Rands, a fungus known commonly as a water mold.

In 1949, the author (6) demonstrated a marked relation between the incidence of littleleaf and the internal drainage characteristics of soils supporting shortleaf pine stands in South Carolina. Subsequent surveys in other states strengthened this finding. After painstaking efforts, Campbell (3) successfully isolated the parasitic fungus from root pieces. But the isolation technique employed was not highly rewarding because this fungus confines its infection to non-resinous tissue which, after being invaded and killed, is overrun by a host of saprophytic organisms that often obscure *Phytophthora cinnamomi.*

This fungus attacks uniquely only the young non-resinous root tips of pine. If pines could regenerate new roots faster than rootlet mortality occurs, they would grow normally without showing signs of disease. When adverse soil conditions prevail, this situation seldom occurs, and as the moribund condition of the root system advances, decline symptoms become evident.

Extensive field surveys revealed that shortleaf pine is about three times more susceptible to attack by this fungus than loblolly. Laboratory trials demonstrated a major difference in root tissue susceptibility between the two species. An intensive field study (7) showed shortleaf pine prone to greater rootlet mortality; for example, total root mortality on old healthy loblolly was only 6 percent, for old healthy shortleaf, 18 percent, and for old littleleaf-diseased shortleaf, 34 percent. Thus it was hypothesized that a critical threshold of perhaps about 25 percent rootlet mortality existed, beyond which trees were incapable of sustaining normal growth.

* Numbers in parentheses denote the references listed at the end of this paper.

Zak[2] demonstrated under rigidly controlled greenhouse conditions that soil moisture levels influence directly the amount of infection of pine roots by *Phytophthora cinnamomi*. He showed also that aeration has but negligible effect on root infection. Campbell (2) used a modified isolation technique to determine the widespread distribution of the fungus in soils throughout the southeastern United States. But because abundant moisture is prerequisite to the production of infectious swarm spores, root damage is limited primarily to those soils that are poorly or imperfectly drained. Root infection is likely to be severe in silts and clays, less severe in loams, and least severe in sands or sandy loams. It is obvious that the development of the littleleaf disease is conditioned almost wholly by soil factors (4).

Sweetgum Blight

A disease lacking a host-pathogen causal relation is prevalent on sweetgum (*Liquidambar styraciflua* L.) over most of its range (22). Overall blight symptoms resemble those of drought-affected trees—a gradual dying from the top downward and high mortality of fine feeder roots. This disease has been studied intensively in Mississippi. No pathogen has been discovered as a causal agent, but certain soil properties that militate against adequate soil moisture supply are correlated with blight incidence. They include soil potassium and sodium contents, imbibitional water values, and soil bulk density. Disease severity became greater with increases in values of these soil properties. Significant blight development since 1950 coincided with severe and prolonged drought periods. Thus, soil properties or climatic aberrations that operate to produce moisture stresses affect adversely the growth of sweetgum and result in a blighted condition.

Birch Dieback

Throughout the three Maritime Provinces of Canada and in some areas of the northeastern United States, yellow birch (*Betula alleghaniensis* Britton) has experienced severe mortality from a decline unlinked to any infectious pathogen. Symptoms of the disorder were observed in 1932, and since then losses have aggregated approximately 2,400 million cubic feet (17).

Birch dieback is characterized by gradual thinning of foliage from the crown periphery inward. If foliage remains, it is usually in the lower crown. Within 3 to 5 years following symptom development, mortality may occur.

Considerable attention was devoted to determining the relation of the bronze birch borer (*Agrilus anxius* Gory) attacks to this disease, but the role of this insect has been relegated to secondary importance. No other organism has been associated with birch dieback.

From about 1920 until 1950, air temperatures over the Maritime Provinces are reported to have increased from 1° to 3° C. Redmond (16) considered this increase enough to raise soil temperatures sufficiently to induce abnormal root mortality, a forerunner to dieback. Controlled studies of soil temperature revealed the sensitivity of birch rootlets to rises in soil temperature. Raising temperatures of the soil mass 1° and 2° C. with embedded electric heating cables increased rootlet mortality to 19 and 60 percent, respectively, compared with a normal rootlet mortality of 6 percent, as determined in a healthy 55-year-old birch stand. All rootlets were killed by raising soil temperatures 6° or 7° C.

Yellow birch is a shallow-rooted species. From 75 to 90 percent of the rootlets are found in the upper 5 cm. of the soil mantle, including litter (18). The shallow-rooting habit, coupled with the demonstrated sensitivity of rootlets to temperature increases, requires that measures be followed to insure against soil disturbance and undue exposure. To this end, Canadian researchers recommend that clear cutting should be practiced in merchantable-sized stands, and, in young stands, cutting should keep to a minimum the exposure of residual trees and soil to disturbance, desiccation, and higher temperatures.

Loblolly Spot Die-Out

An unusual and sometimes sudden decline of portions of loblolly pine plantations 12 to 20 years old, and occasionally young naturally regenerated stands, was first observed about 1945 in the southeastern United States. Symptoms of the disease are: excessive root mortality, stunted growth, tufted, and occasionally slightly chlorotic needles near the branch tips; death soon follows. Mortality is confined to small areas generally circular in shape. No entire plantation has yet failed.

No fungus or insect has been associated with the disease. In 1953 and 1954, numerous diseased areas were examined and described. Without exception, soil features reflected site deterioration conducive to unthrifty growth.

Results of studies of soil characteristics disclosed major differences between site conditions in healthy and diseased areas. Diseased areas occur most frequently on severely eroded sites underlain by heavy clay soils at shallow depths. Soil permeability on these areas was only about half that in healthy areas. Periodically, oxidation-reduction potentials were measured to ascertain levels of and changes in the degree of oxidation within the soil mantle—high potentials indicate oxidized and aerated soils. During periods of soil saturation, oxidation-reduction potentials in diseased areas reach extremely low levels.

In the absence of a biological causal agent, loblolly spot die-out is attributed to adverse soil and root conditions that operate simultaneously: excessive soil moisture, reducing conditions resulting from deficient aeration, keen root competition, and slow soil permeability. This combination of suboptimal edaphic factors leads to excessive root mortality, loss of vigor, and eventual tree mortality.

Red Pine Malady

Stone, Morrow, and Welch (21) reported a serious dying of small portions of red pine (*Pinus resinosa* Ait.) plantations in New York. Affected plantations range in age from 5 to 40 years, but most are 20 years old or more. Mortality may be rapid or gradual. A soil characteristic common to all disordered stands is that of imperfect to very poor internal drainage. No insect or pathogenic fungus has been ascribed as the cause. This

[2] Bratislav Zak. Aeration and other soil factors affecting southern pines as related to littleleaf disease. U. S. Dept. Agr. Tech. Bul. (In preparation).

problem bears a striking similarity to loblolly spot die-out. Inability of trees to withstand fluctuations in moisture saturation and extremely poor aeration invariably leads to reduction in vigor and frequent mortality.

Mortality of Monterey Pine

Widespread rapid mortality among shelterbelts composed of Monterey pine (*Pinus radiata* D. Don) occurred in New Zealand following exceptionally wet seasons in 1953-54 and 1956-57. Isolations of soil pathogens revealed a marked abundance of *Phytophthora* species whose activity was related directly to the abnormally wet periods. Symptom expression and subsequent mortality are attributed to destruction of fine roots exceeding the rootlet regenerative capacity of the affected tree.

Newhook (14) states, "The main difference between the disease of pines in New Zealand shelterbelts and littleleaf disease of *Pinus echinata* (involving *Phytophthora cinnamomi*) in forests of the southeastern U.S.A. is one of rapidity of symptom development. This could be explained by different transpiration demands of full- and reduced-crowned trees. The two diseases are considered to be basically the same."

Pole Blight of Western White Pine

Pole blight has been recognized for at least 30 years. It is presumed to be a new disease. About 95,000 of the 750,000 acres of pole-size stands of western white pine (*Pinus monticola* Dougl.) in northern Idaho, northeastern Washington, and western Montana are moderately to severely damaged by this disease (9). It also extends into western Canada.

Dwarfed needle growth, tufting of chlorotic needles, reduction of height and radial growth, vertical lesion development along the bole, and excessive rootlet mortality characterize this disorder. Root deterioration is pronounced both in diseased stands and in healthy portions of diseased stands. Moribundity of the root system parallels the intensification of pole blight. Because normal growth depends upon normal functioning of the root system, a logical sequential disease development pattern is: root system deterioration, radial growth reduction, appearance and intensification of crown symptoms, and eventual death.

The cause of pole blight remains undetermined despite several years of intensive research. No organism has yet been determined to be the primary causal agent. Several fungi are highly correlated with the incidence of pole blight but thus far appear consigned to secondary roles. Evidence indicates that deterioration of the fine root system likely precedes manifestation of advanced crown symptoms.

Leaphart and Copeland (10) found that rootlet mortality is more pronounced in stands occupying soils of limited effective depth and low available water storage capacity within the upper 3 feet of soil mantle. Healthy stands do occur under these adverse edaphic conditions, but blighted stands have not, as yet, been found on deep permeable soils having available water storage capacities of 6 inches or more in the top 3 feet of the soil mantle. Soils limited in effective depth by excessive rock content or impervious hardpans possess limited water storage capacities, inhibit root development and penetration, and thereby contribute to rootlet deterioration. During periods of prolonged moisture deficiency, recurrent moisture stresses are believed to result in loss of vigor through failure to provide both moisture and mineral requirements. From research findings to date, tentative conclusions are that adverse site conditions increase unthriftiness in white pine stands, and any organism capable of inducing rootlet deterioration accentuates the decline termed pole blight.

Drought Injury

Major periods of below-normal precipitation often accompanied by above-normal temperatures, result in serious damage and oftentimes high mortality in both plantations and naturally regenerated forest stands. Characteristically, trees affected by drought die from the top down and from the outside in.

Numerous instances of major damage to growing stock by droughts are recorded. Meinecke (12) reported severe drought mortality of yellow pine (*Pinus ponderosa* Laws.), sugar pine (*P. lambertiana* Dougl.), white fir (*Abies concolor* (Gord & Glend.) Lindl.), and black oak (*Quercus californica* (Torr.) Copper) in Sierra Nevada forests in 1924. Drought mortality losses to loblolly pine (*Pinus taeda* L.) forests in southeastern United States in 1954 were reported by Brender (1). Scarlet oaks (*Quercus coccinea* Muenchh.) succumbed to drought in 1953 and again in 1955 in West Virginia (23). Leaphart (11) described severe drought damage to western white pine (*Pinus monticola* Dougl.), western larch (*Larix occidentalis* Nutt.), grand fir (*Abies grandis* (Dougl.) Lindl.), and lodgepole pine (*Pinus contorta* Dougl.) following a prolonged period of precipitation deficiency.

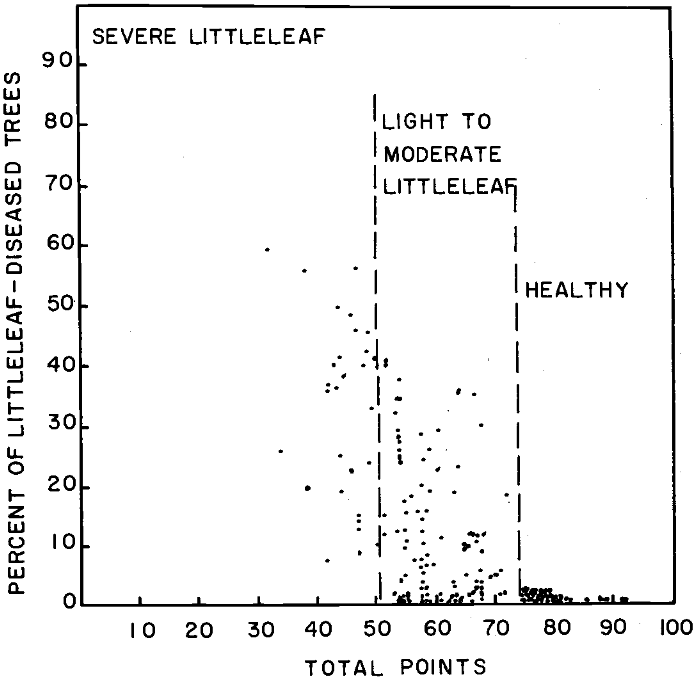
Nearly all reports emphasize the shallow depth or low water-holding capacities of soils that support the stands suffering greatest damage.

Future Soil Management Practices

Demands for wood products within the forthcoming decades will inevitably increase despite possible higher production costs. Yet productive acreage, subject to minor fluctuations, is not likely to change appreciably. This situation makes the tasks of the pathologists and timber management specialists unmistakably clear. Disease losses must be reduced and productivity increased.

What part can soil management play in this assignment? What specific practices can be applied? To persons accustomed to thinking of the present relatively low and infrequent returns from forest lands and the high costs of soil improvement (as now known in agriculture), it teeters on the brink of fantasy to envision direct soil management in forestry. Only a few years ago, we were in the atomic age; today the space age is upon us, and the term "astronaut" is on the tongues of even preschool youngsters. In keeping pace, practices seemingly far-fetched today may likely become realities tomorrow. In time, soil management as a disease preventive or alleviatory measure will be practiced with determination and zeal.

Several soil management practices show real promise as disease alleviatory measures. They include the use of soil survey information to aid in species selection, site rating



SOIL CHARACTERISTICS AND CLASSES	POINTS
EROSION	
Slight	40
Moderate	30
Severe	20
Rough gullied	10
SUBSOIL CONSISTENCE	
Very friable	32
Friable	24
Firm (slightly plastic when wet)	16
Very firm (plastic when wet)	8
Extremely firm (very plastic when wet)	0
DEPTH TO ZONE OF GREATLY REDUCED PERMEABILITY	
24 - 36"	15
18 - 23"	12
12 - 17"	9
6 - 11"	6
0 - 6"	3
SUBSOIL MOTTLING	
None	13
Slight	9
Moderate	5
Strong	1

Figure 1. A soil rating scale for estimating the littleleaf hazard of a site, in which a high index indicates a low littleleaf hazard. Using four soil factors, the 158 plots in the South Carolina littleleaf disease survey are classified as to condition in the scatter diagram.

and selection, and fertilization. Soil fumigation is a reality in nurseries; inoculations of plantable seedlings with mycorrhizal species hold promise; controlled burning can be used. Modifications in logging methods can reduce stem and root damage. Drainage can improve wet sites. These practices, and possibly others, can effect a more intensive forest management whose objective is greater disease-free production of timber.

Soil survey information will become a necessity for intensive forest management. A major use of soil survey information will guide the purposeful selection of species that are best adapted to given soils as a means of circumventing conditions conducive to diseases. Interpretive grouping of soils by taxonomic units will likewise provide information about the manner and degree of responsiveness that like soils exhibit to fertilization, trampling disturbance, fire effects, drainage, and other circumstances. As stronger relations between soil properties and disease incidence become established, disease hazard ratings can be developed. These would logically be included in soil-survey interpretive information which would facilitate site selection for regeneration treatments.

Recognition of hazardous sites is exemplified by a soils rating system developed during the course of littleleaf research (5). This site rating system is based on observable soil characteristics to which numerical values are assigned. A site expected to remain disease-free is assigned a total of 100 points; 40 points are alloted to the erosion factor and 60 points to the internal drainage factor. Internal drainage can be estimated by considering subsoil consistence, depth to zone of greatly reduced permeability, and the presence or absence of soil mottling. To test its usefulness, the rating scale was applied to 158 plots of the soils-littleleaf survey conducted in South Carolina. Results compare favorably with the actual field classification of the disease condition of the plots. Those healthy plots shown in the light-to-moderate littleleaf category in the scatter diagram (figure 1) average 8 years younger than the healthy group and probably represent stands approaching the threshold of disease expression.

Fertilization is a proven management tool in combating numerous diseases. Judicious application of inorganic nitrogen, broadcast on the forest floor, prevented effectively the onset of littleleaf disease in apparently healthy trees in diseased areas and promoted recovery of diseased trees that subsequently produced remarkable growth (19). Fertilizing with phosphorus improved strikingly the growth of forest stands in Australia and New Zealand where that element was definitely deficient (20). Potassium applied to soils deficient in that element in New York State induced marked recovery and growth in reforested pine and spruce stands (8).

Although these practices have proved highly effective in overcoming symptoms of a disorder, they are simply alleviatory. They have not corrected the cause in all instances. For example, nitrogen deficiency associated with littleleaf can be corrected by fertilization; yet this practice fails to eliminate the causal fungus which destroys the fine root system.

Discreet selection and improvement of planting sites offer other means of disease control. Enough is now known about soil-disease relations that to disregard current information would constitute folly. When less desirable sites must be used, they can be improved. Where erosion has reduced fertility and exposed denser soil horizons, mulching, fertilizing, subsoiling, and planting leguminous "catch-crops" may promote rapid site improvement.

Where soil-borne pathogens are known to be present and active, they may be eliminated by soil fumigation. Successful control of certain root rots in nursery soils has been achieved by fumigating with methyl bromide. Advances in mechanization have rendered the application of anhydrous ammonia an everyday farming practice. Ingenuity and economic feasibility could extend this principle to forest soil fumigation in preplanting site preparation.

Extensions of plantations onto sites long devoid of forests could result in partial or total failures if symbiontic mycorrhizal relations are lacking. Little would be gained by provoking a discussion of the beneficent influence of mycorrhizae; it is generally accepted that they contribute materially to assimilation of nutrients by some tree species. To assure the presence of desirable mycorrhizal species, nursery bed soils and perhaps even the roots of seedlings will likely be inoculated with mycorrhizal fungi before planting. Many agricultural seeds are commonly treated with nitrogen-fixing bacteria with excellent success. Why should forestry not draw on proven techniques?

Controlled burning may become an integral part of soil management. Where excessively deep litter is a detriment to natural regeneration, it could be reduced by burning. The use of fire in site preparation and the control of *Ribes* prior to planting western white pine is now an accepted practice. In time, other valuable applications may be developed.

Logging methods and equipment are experiencing modifications. Damage to residual stems and their root systems sometimes reaches intolerable proportions (15). Excessive soil disturbance, particularly of precariously balanced soils on steep slopes, leads to an unraveling of the site. Erosion follows, and fertility is reduced. Even the microclimate can be altered, and as in the case of birch dieback, deleterious consequences ensue. Thus, the days of "wantonly tearing up the woods to create a seedbed" may soon become only a memory. Instead, systematic site preparation will be followed. Excellent results have been achieved in the ponderosa pine type commensurate with site preparation requirements. In all instances where seedbed preparation is needed, it is a matter of how to do it properly, rather than how to avoid it.

Biological control of soil-inhabiting pathogens may be achieved through induced antagonism. It is entirely reasonable and compatible with future trends, to expect forest pathology to advance somewhat comparably to human pathology. "Miracle" antibiotics are proving phenomenally successful antagonists to many of the once stubborn, dreaded human diseases. Moss (13) reported remarkable success in controlling blister rust fungus (*Cronartium ribicola* J. C. Fisch.) on the trunks of young western white pine by spraying with a chemotherapeutic solution of Actidione. Forest disease research, in time, will likely develop techniques for controlling many pathogens by antagonistic fungal populations as a countermeasure.

Drainage of wet sites that militate against healthy vigorous forest growth is a distinct soil management practice now coming into its own. Economical engineering and equipment advances now make such an operation feasible.

Indirectly, sites may be improved by altering stand composition. Mixed stands of hardwood and coniferous species occupy different levels of the soil mantle with their root systems. Many hardwood species, for example *Cornus* and *Cercis*, are calcium accumulators and therefore tend to enrich the upper soil layer with more basic litter than do conifers. In turn, decomposition of litter is enhanced, and over a sufficiently long period a degree of soil management has been obtained. Even mixtures of conifers may exert the same influence to a degree.

The future is bright. Forest management, forest pathology, and soil science are inextricably linked. The interplay of these disciplines and coordinated integrated application of their principles by bold, indefatigable researchers and administrators will surely result in remarkable achievements in disease control.

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RESUMES

Les maladies forestières—leur rapport avec les sols et l'aménagement des sols

Les maladies des essences forestières sont la principale cause de destruction des ressources forestières aux Etats-Unis, mais les énormes dommages qu'elles occasionnent échappent souvent à l'attention parce que leur action est très lente et très insidieuse. Pour agir avec le maximum de chances de succès dans tous les différents aspects de son travail, il est indispensable que le sylviculteur ait une connaissance plus approfondie du rapport existant entre les maladies et le milieu, un des éléments principaux de ce dernier étant le sol. Il a maintenant été établi evec certitude qu'un rapport étant sol-maladie existe dans le cas de plusieurs maladies parmi les plus importantes. Les facteurs le plus souvent associés avec la fréquence de maladies sont les suivants: insuffisance ou excès d'humidité, aération, réaction, fertilité et température. L'auteur étudie le rapport qui existe entre ces facteurs et certaines maladies.

La maladie dite "de la petite feuille" des pins méridionaux est le fait d'une pourriture des racines occasionnée par le *Phytophtora cinnamomi* Rands qui cause le maximum de ravages lorsque la teneur du sol en humidité est élevée. Son action sur le réseau de radicelles détruit une grande partie de ces dernières, ce qui entraîne pour l'arbre une déficience en azote suivie de dépérissement et de mort.

Il n'a été possible d'attribuer la rouille du gommier à aucun microbe pathogène, mais on a découvert que certains facteurs relatifs au sol, tels que teneur élevée en potassium et en sodium, capacité d'imbibition élevée et forte compacité, qui empêchent le sol de bénéficier d'une humidité suffisante, sont présents lorsque cette maladie se manifeste.

Le dépérissement du bouleau est une maladie déconcertante que l'on croite associée à l'élèvemente des températures du sol résultant de variations climatiques à long terme. On a réussi à provoquer une mortalité très élevée des radicelles et un dépérissement de l'arbre analogues aux symptômes naturels de la maladie en élevant artificiellement les températures du sol.

Le dépérissement du pin Loblolly (*Pinus taeda*) est une maladie qui attaque les jeunes arbres croissant dans des terrains ne leur convenant pas et qui présentent les caractéristiques suivantes: humidité excessive du sol, certaines conditions du sol superficiel résultant d'une aération défectueuse, lutte serrée des racines pour l'espace vital et lente perméabilité du sol.

Un taux élevé de mortalité a été enregistré dans les plantations de pin rouge de l'état de New York, notamment dans les terrains mal aérés par suite du drainage insuffisant ou défectueux du sol.

En Nouvelle-Zélande, le pin de Monterey a été l'objet d'attaques en masse du *Phytophthora cinnamomi* pendant des périodes anormalement humides.

La maladie dite "rouille des perchis" du pin blanc occidental est associée avec des sols ayant une capacité de rétention limitée et où, pour certaines raisons, les racines des jeunes arbres ne peuvent s'enfoncer à une profondeur suffisante.

C'est dans les méthodes d'aménagement des sols que réside la promesse d'une lutte efficace contre certaines maladies. Les enseignements tirés des études pédologiques peuvent être utilisés pour aider à la sélection des essences, à l'évaluation des terrains et au choix des emplacements favorables, ainsi qu'à la fertilisation. La fumigation du sol, actuellement pratiquée par les pépiniéristes, peut être étendue au besoin aux terrains susceptibles d'être plantés. La fertilisation du sol, en vue de remédier à l'insuffisance de certains principes nutritifs, a donné dans de nombreux cas des résultats encourageants. Son application plus large dépend du rendement économique et de la réaction que l'on attend de certaines essences. L'amélioration des emplacements susceptibles d'être plantés peut être réalisée à l'aide de plusieurs types de traitement des sols ayant pour objet d'améliorer la fertilité, de corriger certaines carences déterminées ou de modifier les caractéristiques physiques du sol. Ces traitements peuvent comprendre le drainage des terrains humides, la fertilisation, la culture préalable de plantes ou l'utilisation de produits ayant pour effet d'améliorer le sol.

Il est possible que l'inoculation des racines des brins de semence avec des mycorhizes permette d'assurer la présence de variétés désirables dans des régions ayant été longtemps dépourvues de forêts. Pour la préparation des semis, on peut réduire les accumulations de couverture végétale ou autres débris en les brûlant. Les changements apportés dans la composition d'un peuplement modifieront le terrain et, lorsque effectués à bon escient, en assureront l'amélioration.

Appliquées judicieusement, ces méthodes—pour n'en citer que quelques unes—ne manqueront pas de réduire les pertes dues aux maladies et d'améliorer la productivité forestière.

Relación de las Enfermedades Forestales con los Suelos y la Administración de Suelos

Las enfermedades forestales son el principal agente destructor de los recursos forestales de los Estados Unidos, pero como actúan despaciosa e insidiosamente, el enorme daño causado por ellas a menudo suele pasar desapercibido. El uso eficaz y múltiple de los recursos forestales depende, en parte, de una mejor comprensión de la relación de las enfermedades con el medio ambiente, en el cual el suelo representa un elemento de importancia. Se ha establecido ya una clara relación del suelo con varias enfermedades forestales mayores. Las propiedades del suelo más correlacionadas con la preponderancia de enfermedades son la falta o exceso de humedad, la aeración, reacción, fertilidad y temperatura. Este trabajo señala la relación de estas propiedades con algunas enfermedades.

La enfermedad conocida vulgarmente por el nombre de "littleleaf", que ataca al pino del Sur de los Estados Unidos es la manifestación de la pudredumbre de las raíces ocasionada por el *Phytophthora cinnamomi* Rands, que suele causar los mayores daños cuando la humedad es abundante. Al atacar la parte más fina de las raíces, ocasiona una mortalidad anormal de las raicillas y causa una deficiencia de nitrógeno en los árboles, los cuales comienzan a marchitarse lentamente hasta que se secan.

No se ha identificado todavía ningún microbio patógeno causante del añublo del liquidambar, pero un alto contenido de potasio y de sodio en el suelo, un alto grado de absorción del agua y una alta densidad de volumen, impiden el suministro adecuado de la humedad y se correlacionan con las ocurrencias de esta enfermedad.

La enfermedad llamada "dieback", del abedul, es un tanto extraña y se supone que esté relacionada con el aumento de la temperatura del suelo, como resultado de prolongadas aberraciones climáticas. En los experimentos hechos, los aumentos artificiales de la temperatura del suelo han producido la misma mortalidad entre las raícillas y los mismos danos a los arboles que los observados en la naturaleza.

La "die-out", es una enfermedad que ataca a los cultivos jóvenes del *Pinus taeda* cuando se plantan en lugares inadecuados. El execeso de humedad, las condiciones reductivas del manto causadas por la falta de aeración, la superabundancia de raíces y la lenta, permeabilidad del suelo son características de los lugares en que existe esta enfermedad.

Las plantaciones de pino rojo del estado de Nueva York han registrado una gran mortalidad en lugares que tienen poca aeracion debido a la falta de avenamiento adecuado del subsuelo.

En Nueva Zelandia, el pino de Monterrey sufrió grandes daños ocasionados por el *Phytophthora cinnamomi* durante períodos anormalmente lluviosos.

La enfermedad "pole blight", del pino blanco del Oeste de los Estados Unidos suele achacarse a suelos con limitada capacidad para retener la humedad y con poca profundidad para las raíces.

Las prácticas de administración de suelos prometen algo como medidas aliviadoras para ciertas enfermedades. Los informes sobre los reconocimientos de suelos pueden utilizarse como medio para la selección de especies y de lugares de cultivo y para determinar las condiciones locales y de fertilidad. La fumigación de suelos, practicada actualmente en los viveros y semilleros, puede emplearse también en las tierras plantables, si la necesidad lo exige. El abono destinado a restificar deficiencias nutritivas, ha tenido mucho éxito en numerosos casos, pero su empleo en grandes proporciones depende de las utilidades y del rendimiento que se espere de las especie en cuestión. El meoramiento de los plantíos puede conseguirse mediante la adopción de ciertas prácticas destinadas a aumentar la fertilidad, rectificar ciertas deficiencias nutritivas específicas o modificar las características físicas del suelo. Entre las citadas prácticas se incluyen el avenamiento de lugares demasiado húmedos, los fertilizantes, el cultivo de plantas mejoradoras del suelo antes de plantar los árboles, y el empleo de rectificantes del suelo.

Con la inoculación del hongo mycorrhizal en las raíces de los árboles plantados, se consigue asegurar la presencia de hongos beneficiosos en las áreas en que no han existido bosques por mucho tiempo. Para evitar la acumulación de herbajes y malezas debe quemarse el terreno antes de plantar los semilleros. Los cultivos pueden mejorarse también cambiando la composición del arbolado, práctica que, expertamente dirigida, puede mejorar el sitio.

Todas éstas y otras prácticas, aplicadas conocedora y atinadamente, puede esperarse que reduzcan las pérdidas ocasionadas por las enfermedades y mejoren la productividad forestal.

The Use of Factor Gradients in Evaluating Site

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Canada is a land of many forests but few foresters. Most of them have found it impossible to be familiar with every one of the thousands of acres of forests for which they were responsible. A logical outcome of this situation was the desire to classify the forest into types with which the forester could become familiar. In classifying the forest, an increasing number of foresters have become convinced that a classification based on ecological principles would be most suitable for forest management purposes. In other words, a forest classification should be a site classification.

In speaking of the work done in Canada on site, I do not claim that there is a unanimous Canadian viewpoint. Much less do I claim to be a spokesman for Canadian foresters. Indeed, I must admit, or should I say boast, that violent arguments about site have been raging across Canada for several decades and show no signs of abating. The use of factor gradients in the study of site is only one of several methods which have been used in Canada.

There are a few points on which most Canadian site specialists do agree. For example, they feel that it is pointless to study a forest apart from its environment and the other organisms occupying the ecosystem. They are keenly aware of the complex interrelationships within an ecosystem (Rowe 1953). The evaluation of site has usually been preceded by the classification of site in contrast to direct evaluation as exemplified by the work of Coile (1948). Consequently, it is impossible to speak of site evaluation in Canada without emphasizing site classification.

Beyond these few points, there has been a great variety of philosophies and procedures. In recognizing the ecosystems, some rely mainly on the vegetation, following the site indicator concepts of Cajander (for example: Sisam, 1938; Heimburger, 1941; Spilsbury and Smith, 1947), or the plant community concepts of the Zürich-Montpellier school (for example: Krajina, 1959; Linteau, 1955, 1959; and Lafond, 1958, 1959). On the other hand, Hills (1959b) and Brown (1953) feel that physiographic features constitute the logical frame of reference within which ecosystems should be recognized.

Others are of the opinion that these differences are perhaps not as distinct as might first appear. For example, Rowe (1959b) pointed out that investigations of site begun with either vegetation or physiography inevitably lead to a consideration of the other concept. The writer has observed that on field trips plant sociologists do not hesitate to use physiography where the vegetation has been disturbed, and those who favour physical factors are quite willing to use the vegetation to determine the extent of the conditions they have observed in a soil pit. It is interesting to note that back in 1913, Connell (1913) set up a number of sites in central Ontario based on physiography, soil, and ground vegetation.

Most phytosociologists feel that the various ecosystems constitute natural entities which could be described and recorded in somewhat the same way as plant species. Others feel that the forest is a continuum and all subdivisions and their boundaries are arbitrary. Often these basic premises are left unstated.

The writer's basic premises with regard to the classification of forest ecosystems may be stated as follows:

1. Land is a multiple continuum. All land classifications and all subdivisions of land are arbitrary. Every parcel of land is unique and differs in some way from all other land.

2. Regardless of size, any area of land can be treated as an ecosystem if included with it are all organisms, the soil below, and the atmosphere above.

3. Regardless of size, any area of land can be subdivided arbitrarily into any number of ecosystems which may then be grouped into any number of classes.

4. A site classification is a classification of land for forestry purposes—particularly the study of yield. To be useful, it must be based on ecological principles, thus taking cognizance of the ecosystem concept. However, the reasons for needing a classification are matters of convenience and economics.

5. The site classification designed for a particular area is unique. It is not necessarily related to any other site classification (apart from the fact that both are based on general principles of ecology).

6. Advances in the scientific aspects of forestry do not depend on site classification. A site classification is an aid to management in its early stages. When the forest manager becomes familiar with every piece of his land, then his site classification will be unnecessary.

These premises could be applied to any system of site classification regardless of whether it is based on vegetation or physical factors.

A system of site classification based on the concept of factor gradients has been developed by Hills and reported in a series of papers (Hills, 1945, 1950, 1952, 1953, 1959a). Although in his recent papers Hills has emphasized the use of land type in site classification, I feel that the concept of factor gradients is well worthy of detailed consideration. Tamm (1931), in a study of forest sites in North Sweden, arranged them in a gradient from dry to wet. Whittaker (1956) has used the concept of a gradient in the moisture factor in discussing the relation of vegetation to site in the Great Smoky Mountains. Fraser (1954) has used Hills' concept of a moisture gradient to classify an area in Ontario where he has conducted an intensive series of observations on ecological conditions related to birch die-back.

Due to the complexity of the relationships within an ecosystem, any scheme of site classification is necessarily based on a number of simplifying assumptions. Hills' simplification is that the effective levels of a factor can be arranged in a continuous series from the lowest value to the highest value. The continuum can then be divided into any desired number of arbitrary classes. For example, the effective temperature of a number of sites is arranged in increasing order from the coolest to the warmest. Of course, such a simple continuum does not exist. The effective temperature of a site is a complex function comprising minima and maxima as well as average temperatures and greatly dependent on the time factor. It cannot be evaluated by any one parameter. Also, the effect of a given temperature is modified by the condition of the other factors, soil moisture, for example. Besides, the responses of different species to temperature are by no means equivalent.

However, such objections do not in themselves indicate that the simplifying assumption should be abandoned. The test of such an assumption is how well it works in the situation where it is being used. In this case the test is, will it aid in the classification of site.

A second simplifying assumption is that differences between sites with regard to productivity can be expressed in terms of a small number of factors. These factors are soil moisture, soil fertility, temperature, and exposure to drying. Other factors of importance in the productivity of a site are either essentially uniform from site to site (for example, concentration of carbon dioxide in the air) or they are highly correlated with one of the other factors (for example, soil aeration is negatively correlated with soil moisture).

Hills has developed in detail the concept of a gradient in the moisture factor. He thinks in terms of "moisture regime," which represents the moisture condition of the site averaged over a period comparable to the life of a tree. The series of moisture regimes runs from the dry end, where moisture is inadequate, to the wet end, where there is so much water that aeration is inadequate. In between, there is a theoretical optimum where moisture is available at all times, yet aeration is adequate. However, this may not occur because of low soil moisture storage in relation to the precipitation pattern and its amount. Hills (1950) has suggested the concept of the "normal" moisture regime to replace the optimum. Normal moisture regimes are those which occur on deep, loamy parent material on the slopes of rolling topography where there is no water table within reach of the roots. They are usually the best sites in the area.

For a detailed classification, Hills used 11 subdivisions of the gradient in moisture regime. These were recognized on the basis of topographic position, physical nature of parent material, its depth, position of water table, and soil profile features. To this I would add precipitation; it may vary from site to site within a forested area, for example, on the west coast of America.

Within a given type and depth of parent material and with a given amount of precipitation, moisture regime is determined by topographic position. Lower slopes are moister than upper slopes because they receive seepage water from above. Steep slopes are drier than gentle slopes because more precipitation runs off on the surface. The moisture regime can often be deduced from topography alone. It can be recognized more definitely by examining the soil profile. In some parts of Ontario, dry moisture regimes show very weak profile development; normal moisture regimes show a strong balanced profile development (Hills, 1945); wet moisture regimes have gley horizons which indicate the effect of the water table. The accumulation of organic matter also indicates the wetness of the moisture regime. Hills (1945, 1952, 1959a) has presented a number of diagrams which show the profile characters of the moisture regime gradient for several regions of Ontario. Similar diagrams could be prepared for other locations.

Where there is variation in the nature of the parent material, the situation is more complicated, and it is necessary to classify the parent material with regard to its facilities for storing water for later use by vegetation and for permitting the percolation of excess water. This property is referred to as "pore pattern" (Hills, 1953, 1958, 1959a). In earlier publications this property was referred to as "permeability." Pore patterns have been organized into a single gradient (Hills, 1950). At one end of the scale are the "open" pore patterns which store little water but provide for rapid percolation, e.g., a coarse sand. At the other end are the "restricted" pore patterns which store much water but which seriously restrict percolation, e.g., massive clays. In between are the "retentive" pore patterns which retain considerable quantities of water without unduly restricting percolation, e.g., loams. Pore pattern is affected not only by texture but also by other soil features. Structure is important; a crumb structure can improve the pore pattern of a clay from restricted to retentive; a hard pan in a sandy soil will impede percolation and increase the supply of stored water. The fabric of the material as determined by geologic origin will also affect pore pattern. Where pore pattern varies from one horizon to another, an average value for the site is estimated.

Now to get back to moisture regime. It will be evident that a given position on the scale of moisture regime will result from several combinations of topographic position, depth of soil material, and its pore pattern. A shallow layer of retentive material at the top of a steep slope will be just as dry as a deep layer of open sand on a flat. A sand flat with a water table at three feet (1 meter) will provide a favourable supply of water similar to a sandy loam at the lower end of a slope underlain by bedrock. Where a bed of massive clay is underlain by the coarse materials of an esker, the moisture regime will be no wetter than a sandy loam with a water table maintained by the configuration of the bedrock. Hills (1950) has presented a chart showing the moisture regime resulting from several dozen combinations of slope, pore pattern, nature of underlying strata, and position of water table. These relationships will alter under different climatic conditions.

The moisture regime gradient is not adequate to cope with those sites which are too wet immediately after a rain and too dry at other times. Fotunnately, such sites are comparatively rare—at least in Ontario. The moisture regime concept is also complicated by the variation in precipitation from year to year (Fraser, 1957). With evenly spaced rains equal to the evapotranspiration, all well-drained sites provide adequate water. After a period of drought even good loams will have no available water.

The arrangement of soil fertility classes into one series is a simplification which works more often than might be expected, considering there are about a dozen essential elements derived from the soil. These elements are required in adequate amounts and in the right proportion—an excess or deficiency of any one will lower the productivity of a site. However, within one type of geologic material, fertility is fairly well correlated with pore pattern. Open pore patterns are less fertile than the retentive ones. Fertility is also likely to be low in the wetter moisture regimes regardless of pore pattern because lack of aeration renders the elements unavailable to plants. Moreover, when water is moving laterally through the soil, fertility is higher than when water is stagnant.

Where soils are derived from two kinds of geologic material, and various degrees of mixing have occurred, e.g., in a glacial till, a gradient of proportions can be set up. When more than two kinds of parent material are involved, it may be possible to establish a gradient based on two groups. Otherwise, the gradient concept should be abandoned and unrelated classes established, each with its own gradients of pore pattern and moisture regime. Lutz (1958) gives a number of examples of the large effects which geologic materials exert on vegetation. Deep accumulations of peat may be dealt with as separate parent materials which are associated with the wet end of the moisture regime scale.

Thus far we have considered soil features which affect site quality. Now we will consider two climatic features, temperature and exposure to drying. Hills (1952) has often grouped these climatic factors into a single series called ecoclimate. However, under some circumstances temperature and exposure are best kept separate, for example, when the area to be classified has a great range in either altitude or latitude. In evaluating local climatic features, the extremes are not well marked, so the primary reference point is the "normal" climate. This is the local climate which occurs over gently rolling topography where the soil materials have a retentive pore pattern and the moisture regime is normal. Some problems in rating effective temperature were mentioned earlier; they applied to areas of any size. Effective temperatures of local areas are hard to assess by a single parameter for the additional reason that daytime temperatures are affected mainly by solar radiation, while night temperatures are affected by the drainage patterns of cool air. Thus, sheltered valleys may be warmer than normal by day and cooler than normal by night. In spite of these difficulties, it is usually possible to put sites into three broad classes with respect to temperature: warmer, normal, and cooler. In northern regions the warmest climate is usually the most favourable. Effective temperatures which are warmer than normal occur in sheltered valleys with good air drainage at night, near larger bodies of water, and on steep south and southwest slopes. Effective temperatures cooler than normal occur on steep north slopes and in wet lowlying areas where cool air is dammed up at night. Other things being equal, a moister site is cooler due to the heat lost in vaporization of water. Hills (1952) found that vegetation was useful in indicating that differences in local climate existed. For example, the presence of vegetation characteristic of a more southerly region than was usual for the particular moisture regime and pore pattern indicated a warm ecoclimate.

Exposure to drying is a factor associated with the atmosphere. As with effective temperature, the most favourable condition occurs at one end of the scale where exposure is weak. Increasing exposure is correlated with reduced productivity. Only three classes of exposure are recognized, weak, normal, and severe exposure.

Severe exposure occurs on ridge tops and hillsides which are exposed to the prevailing wind because of the configuration of topography. Crossley (1952) described a knoll in a mountain valley that was devoid of trees on one aspect due to severe exposure. Reduced tree growth due to exposure is a matter of common observation on small islands and promontories. The preceding phenomena occur during the day. In mountainous regions severe exposure may occur at night on the slopes due to air currents associated with the drainage of cool air (Cameron, 1952; Crossley, 1952).

Weak exposures occur in valleys so oriented that the prevailing wind does not sweep through. Valleys and lakeshores which are wetted by ground fogs in the early morning also come into this exposure class. In the mountains, fog may be effective on certain aspects and elevations.

Hills (1959a) has shown diagrammatically some relationships between ecoclimate and topography.

It might be worth while at this point to summarize the features of the site which have been used in identifying factor gradient classes. Topographic position is an outstanding feature. It affects moisture regime, effective temperature, and exposure to drying. The depth and nature of the parent material affects fertility, pore pattern, and moisture regime. Soil profile features can be interpreted to indicate moisture regime and fertility. Depth to water table is a key feature in identifying moisture regimes. Fogs reduce the drying to which a site is subjected. Proximity to bodies of water may influence moisture regime, effective temperature, and exposure. Vegetation cannot be omitted. Plants are useful mainly in indicating *changes* in site conditions. Rainfall and altitude may be significant, and latitude is important if the area is large. However, it is emphasized that the exact relationship between site feature and factor gradient class must be worked out for each area being classified.

This completes the description of the factor gradients. It is evident that a classification based on:

11 classes of moisture regimes,
11 classes of pore patterns,
3 classes of effective temperature,
3 classes of exposure, and
2 or more types of parent material

gives an enormous number of combinations and is suitable only for classifying individual stations. A site classification which is useful for forest management should have less than a dozen classes (Kabzems, 1951). The necessary reduction in the number of classes is achieved by omitting certain factors, reducing the number of steps in a gradient, and/or grouping those combinations which remain. For example, type of parent material may be omitted where it is uniform. Moisture regime and effective temperature may be combined if the dry sites are warm and the wet sites are cool. For some purposes, three classes of moisture regime and three of ecoclimate are sufficient (Hills, 1959a).

The extent of the area occupied by the various sites influences their grouping. For example, if all dry moisture regimes occupied less than one per cent of the area being classified, they would be grouped into a single site type, regardless of how much they differed in parent material or any other feature.

To facilitate mapping, it may be convenient to group those sites which occur together on the ground, especially where the group constitutes a land type (Hills, 1958). For example, in parts of Ontario, a common land type is a shallow mantle of glacial till over a low relief of granitic bedrock. The moisture regimes change every few yards, so that no separation is possible on a map. Instead, the land type is mapped, and an accompanying description indicates which moisture regimes are present. Since so many site factors are related to land types and since land types can be identified on aerial photographs, land types are often convenient and useful features of a forest map (Hills and Pierpoint, 1960).

It is evident that the classification and evaluation of site by the use of factor gradients requires a thorough knowledge of ecological principles plus an extensive knowledge of the area to be classified. The classification must be preceded by a reconnaissance which indicates the range of each factor and the relation of the variation in each factor to variation in the occurrence and vigour of the various tree species. Factor gradient classes must be described so they may be recognized in the forest. Then a system of grouping must be worked out to reduce the number of site types to a workable number and fulfil the objectives laid down by the forest manager.

One should not expect a workable classification to be 100 per cent efficient. Inevitably there will be areas which do not fall into any category. However, they should not form a substantial part of the total, or the classification is not acceptable.

One of the most frequent criticisms of the factor gradient method is concerned with the absence of measurements of the factors concerned. In meeting this criticism, the following arguments are submitted. In arranging sites in a single series, with regard to moisture regime for example, some quite dissimilar soils must be assigned to a moisture regime class. No conceivable set of measurements could result in a single numerical parameter which would provide an accurate comparison between a medium water-laid sand with a water table at six feet and a sandy loam four feet deep over bedrock in a mid-position on a slope. Yet, experienced ecologists working together in a given area would have little difficulty in deciding whether to put them in the same or a different class of the moisture regime scale.

The time factor is also important. One must choose between taking quantitative data at a few stations as Fraser (1957) has done or making qualitative observations at many places. Both methods are useful, but for different types of research. The factor gradient method depends on a comparison between the largest possible number of stations, hence must be based on qualitative observations.

Since factor gradients cannot be measured, how does one compare a Class 2 moisture regime in Ontario with a Class 2 in Washington? The answer is simple. Such a comparison should not be made. Each site classification is designed for a particular area. Extrapolation of results beyond that area is not justified. A site classification is for the purpose of recognizing similarities and difference within the area being classified. It should not be used to try to identify sites on a second area—particularly since it is certain that no site on Area No. 2 is the same as a site on Area No. 1. Of course, it is always possible to compare any two sites with regard to the qualitative and quantitative aspects of the hydrologic cycle or any other basic function of an ecosystem. However, there is no need for the scale of moisture regime used in an area in Ontario to be comparable with the scale used elsewhere. Each scale should be specially adapted for the prevailing conditions. Hills (1952) has presented a contrary opinion and an argument in favour of a universal scale of moisture regime.

Some advantages of the factor gradient method of site classification are shared by all ecological methods. These have been set out in detail by Sisam (1935) and Spilsbury and Smith (1947). The growth curves of height and volume are shown as they are, instead of being moulded into a fixed relation to a general average. The site classes are applicable to all species and to all-aged stands. The site classes are useful for silvicultural purposes as well as for the prediction of growth. They can be identified on the ground after a relatively simple examination.

The factor gradient method has a number of special advantages. Since the classification is related to topography and geology, site types can usually be recognized and mapped on aerial photographs. This is a tremendous advantage; while the use of aerial photographs does not eliminate the need for field work, it enormously extends the area one worker can cover (Burger, 1957; Losee, 1942; Lueder, 1959).

The factor gradient method is extremely adaptable. It can be applied to areas of any size at any level of management. Site types can readily be combined or subdivided, or sites can be regrouped as necessary. The method can be used on areas which have been deforested or affected by insects or disease or poor land-use practice. They are relatively permanent; topography does not change greatly during a rotation. Of course sites do change; the nutrient capital may become tied up in undecayed organic matter; fire may be followed by erosion and reduced infiltration; vegetation changes the climatic and soil conditions on the forest floor. The factor gradient method facilitates an understanding of these phenomena.

The factor gradient method deals with basic factors influencing the growth of plants. Hence it leads to a better understanding of the ecological characteristics of the species. While the writer concedes that the complexities of the ecosystem must never be forgotten, he agrees with Mason and Langenheim (1957) that "the greatest value to ecological interpretation is obtained by discussing environmental phenomena in their separate and related impingements upon an organism."

The use of site types established by the factor gradient method is illustrated by the work of Bedell and MacLean (1955), who carried out a yield study in the Superior Section (B–9) of the Boreal Forest (Halliday, 1937; Rowe, 1959a). Their site types were based on gradients of moisture regime and pore pattern as established by Hills (1950). They found that the usual forestry growth data concerning height and wood volume separated well according to site type. Later, the same investigators (MacLean and Bedell, 1955) carried out a similar study in the Northern Clay Belt Section (B–4) of the Boreal Forest. They used the same gradient groupings and found the sort of differences that might be expected in two adjacent regions. For example, consider site type A; it comprised a group of moisture regimes which were normal and slightly wetter, and a range of pore patterns centering around retentive. In the Superior Section, this site type occurred mainly on gentle slopes of upland till. In the Clay Belt, the site type given the same name occurred to a considerable extent on lacustrine clay underlain by sand or gravel of buried eskers. On site type A in the Superior Section, the height of trembling aspen (*Populus tremuloides*) at 100 years was 91 feet (28 meters), whereas in the Clay Belt Section, it was 83 feet (25 meters). In Alberta, Smithers (1956) made a study of lodgepole pine sites classified by the Hills system. Previously, difficulties had arisen with classifications based on either height growth or ground vegetation because those features were strongly affected by the number of trees per acre. The classification based on moisture regime and pore pattern resolved difficulties and indicated the potential productivity of the sites.

Hills and Pierpoint (1960) have approached site evaluation in a more comprehensive way. They point out that potential productivity is only a part of site evaluation. It is also necessary to consider the species composition of the crop which it is desired to grow, and the effort which is required to grow the crop. Since such evaluation on a quantitative basis is a tremendous job, Hills and Pierpoint have given an immediate qualitative evaluation based on observation of the growth and quality of individual trees of various species on the various sites.

Apparently no one in Canada has attempted to measure site productivity on the fundamental basis espoused by Odum (1959), that is, as the rate synthesis of organic material in terms of dry weight per unit area. Wassink (1959) gives an average for wooded areas in the temperate zone of 1 kg/m^2/year (about 4.5 tons per acre). Ovington (1958) has made measurements of the productivity of Scots pine forests on a dry weight basis in Great Britain. He measured separately bole wood, branch wood, leaves, and lesser vegetation. He found that bole wood constituted less than half of the organic matter produced. This fundamental approach to productivity will eventually lead to a more meaningful evaluation of site.

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RESUMES

Evaluation qualitative d'une station au moyen de gradients écologiques

Avant de pouvoir évaluer une station, il faut en effectuer la classification. Les classes sont considérées comme des subdivisions arbitraires d'un continuum. Dans le système de classification de Hills les niveaux effectifs d'un facteur sont disposés en un gradient de la valeur la plus faible à la plus élevée. Les différences entre stations, en ce qui concerne la productivité, peuvent découler du régime d'humidité du sol, de sa fertilité, de la température effective et de sa faculté d'assèchement. Chacun de ces facteurs, qui constitue un gradient, est subdivisé en une série de trois à onze échelons ou classes. (Les différences dues à l'origine géologique peuvent nécessiter un certain nombre de catégories sans rapport entre elles au lieu d'un gradient.)

La position d'une station à l'intérieur de chaque gradient est déterminée après examen de la situation topographique, de la profondeur et de la structure du sol, de la position du plan d'eau, des caractéristiques relatives au profil du sol, de la pluviosité, de l'altitude et de la végégation.

On obtient la classification définitive de la station en groupant les nombreuses combinaisons de classes de régime hygrométrique, de fertilité, etc., en un petit nombre de types de stations. La base utilisée pour ce groupement est unique pour chaque région faisant l'objet d'une classification. Par la suite, on mesurera la productivité en termes de poids de matière organique synthétisée par surface unitaire.

El Uso de Factores en Escala para la Evaluación del Sitio

Antes de proceder a la evaluación del sitio es necesario determinar su clasificación. Las clases están consideradas como subdivisiones arbitrarias de un continuo. En el sistema de Hills para la clasificación de sitios, los niveles efectivos de cada factor están ordenados por escala, desde el grado más bajo hasta el más alto. Las diferencias de los sitios con respecto a su productividad, pueden tener relación con el régimen de humedad del suelo, la fertilidad, temperatura efectiva y el grado en qu esté expuesto a secarse. Cada uno de estos factores está graduado a escala y subdividido en una proporción que varía entre tres y once clases. (Hay casos en que las diferencias de origen geológico requieren cierto número de categorías no relacionadas entre sí, en vez de una escala graduada.)

La posición de una estación en cada escala se determina después de tomar en consideración la situación topográfica, la profundidad y naturaleza del material que forma el suelo, la situación del nivel freático, el contorno del suelo, el índice pluviométrico, la altitud y la vegetación.

La clasificación final del sitio se obtiene agrupando las diversas combinaciones de clases, humedad, fertilidad, etc., en un pequeño número de tipos de sitios. Las bases para la agrupación son especiales en cada área clasificada. Finalmente, se determina la productividad en términos del peso de materias orgánicas sintetizado en cada unidad del área.

Evaluation of Forest Site Quality From Ecological Factors

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There are various interpretations of the concept of "site" and, consequently, many different definitions.

One of the simplest and clearest definitions is, without doubt, that of Tansley (1923) who considers the "site" of a plant or of a vegetal community "the sum of the effective conditions under which the plant or plant community lives."

If we accept this definition, when the algebraic sum of the effective environmental conditions can be considered more or less constant, within the limits of a certain area, this represents a "site," that is, an *elementary ecological unit,* an *ecotope.*

But the site can also be understood in a wider sense, as the complex of the environment in which a given vegetal community lives and grows and of the plant community itself: in this way, one arrives at the concept of a bioecological unit, that is, of an integrated system of causes, effects and reactions, which is customarily called an *ecosystem.*

It is a complex or holistic concept which is gradually calling attention to itself in modern biogeography (cf. Danserau), based on the description and the interpretation of natural and chorological units, which correspond to the different results of the action of physical factors on biotic factors and the reactions of the latter to the former.

In silviculture the principle of site as an integrated system of environment plus biocenosis is generally accepted for the purpose of the description of the site (cf. Rules of the International Union of Forest Research Organizations, 1936; Etter, 1953), while for the practical purpose of the evaluation of forest site quality, it is taken into consideration only by some tendencies of forest typology, e.g., the Russian tendency of Sukachev and the Canadian tendency of Hills, based on the concept of ecosystems, known respectively as "biogeocenosis" and "land type."

At the present time it is not possible to express an opinion on the results attainable by the application of these ideas, for their application seems rather complicated, given the multiplicity of the surveys required.

It is to be hoped that well-founded grounds of judgment will be able to be drawn from the results of comparative research arranged and carried out by a work-group of the International Union of Forest Research Organizations, following the proposal put forward by Sukachev at the 4th World Forestry Congress at Dehra Dun.

Forest Site Quality

If we consider the site, following Tansley's definition, as an environmental unit, the conditions it offers for the life and growth of a tree community, present or possible, express its quality.

We can arrive at an evaluation of the site quality in two ways:

1. by measuring the concrete effect of the environmental factors of the site on the vegetation found there;
2. by examining the single factors of the local environment, and determining, by more or less analytic methods, the result of their combined general action.

The former is the simpler way in the case of already existing forest stands, where we can make use of incremental or typological methods.

Incremental methods ascertain the quality classes, on the grounds of timber production (volume or increment) or of indices of the same (mean height of the stand or of the dominant trees, etc.); typological methods, on the grounds of specified features (the floristic composition, structure, etc.) of the natural vegetation, both of the tree layer and of the ground vegetation.

In denuded areas or in areas where the vegetation has been profoundly modified by the action of man, as we cannot use incremental methods, valid information can be obtained only from the study of the existing vegetation, where this is not too badly deteriorated.

The information can be particularly significant in relation to certain characteristics of the soil (pH, permeability, organic matter content).

The first approach cannot be an end in itself, especially if incremental methods alone are used, because it does not allow us to establish what the concrete factors of the site quality are, or to compare sites which are widely distant or, at least, occupied by different vegetal species.

The second approach, instead, allows us to verify the relations of cause and effect between environment and vegetation, and also makes a comparison of widely distant sites possible, even though the sites may belong to different floristic regions.

The first way allows us to ascertain only the *present site quality* in relation to a species present; the second also makes the evaluation of potential site quality possible, in relation to any species.

The multiplicity of the acting factors and the frequent scarcity of data available would make the second approach too long and often of too uncertain a result, if we were to examine all the factors and weigh all their possible local combinations.

But the knowledge of some fundamental laws of ecology (laws of the physiological limits, of the minimum or of the most important factor, of the compensation and interaction of the factors) allows us to limit the examination to a restricted combination of factors or even to single factors, whenever the combination of factors or the single factors may be considered as having a *determining ecological influence* and therefore indicative of the site conditions.

Presented in this way, the problem can be faced within the limits of restricted geographical areas (as, for instance, the *Wuchsgebiete* of German authors), comprising a part or the whole of the distribution area of a species, or, on a wider scale, for the general purposes of comparative ecology.

In both cases, first inductive and then deductive methods are used, then integrating the results of both.

One begins by studying, in a certain number of suitably chosen areas, the correlation between the productive capacity of a species or of a forest type, and the ecological factors considered most important in each individual case. Once specific correlations have been ascertained, scales of the values of the factors considered must be established, and these serve as a basis for the comparative evaluation of analogous sites or even for pronouncing laws of a general nature.

Evaluation of Site Quality Within a Particular Region or Distribution Area

Numerous research workers have tried to establish, usually for single tree species, correlations between the productive capacity of a site and the principal determining ecological factors.

Even an examination limited to the most notable works of this kind would be too long and tedious.

Examples are particularly plentiful in the literature of the United States of America (beginning with the early works of Munger, 1913, and Woodward, 1913, and those of Pearson, 1920 and 1931, which are already much better supported by evidence, and going up to the most recent works by Hocker, 1956, Doolittle, 1957, Zahner, 1958, Zinke, 1958, and Bethune, 1960), but examples also exist in the forest literature of almost every country. We might recall, simply to mention some of them, the works of Dagnelie, in Belgium, of Hirama and Kiriyama in Japan, of Beaucorps-Marion-Sauvage in Morocco, and of the Verein f. Forstl. Standortskunde, in Germany.

But rather than making a list of the examples which can be found in such literature, it is advisable to pause for a moment for some considerations of a general nature.

Important correlations of the productive capacity have been proved to exist with the climatic and edaphic features or the topography of the site; that is, with factors which are directly measureable (for example, thermic conditions, rainfall, soil moisture, soil nutrients, pH), or with features which may be useful as indices of indirect evaluation of factors for which there are no data or for which data are difficult either to obtain or to check. In this way, the depth of the water table can indicate the soil moisture; the aspect and the slope of the ground can be indices of microclimatic variations; the slope and the depth of the soil, indices of its moisture, etc.

The characterisation of sites on the basis of the physical properties of the environment can be useful as a basis for a "physical typology," of immediate application, if based on features which are easily and directly perceivable, as topographic and some edaphic features generally are.

The validity of the "physical types" established in a given region is more or less liable to be extended to other regions according to the wider or more limited significance of the action to the factors considered.

For example, the availability of water in the soil is of general action (the most important factor, following Baker's concept of the limiting effect of water deficiency) and the meaning of the types based on its evaluation (through the depth of the water table, as, for instance, the Ukrainian school by Pogrebniac is doing).

The characterisation of the types of forest humus, which F. H. Hartmann considers as the fundamental criterion of his ecological typology, is also important.

Evaluation of Site Quality on a Geographic Scale

However wide the meaning of evaluation of the physical types may be, it cannot usually go beyond the limits which separate the principal categories of climates and climatic soils.

Consequently, when one wants to proceed to comparisons at a distance, one cannot leave out of consideration the evaluation of the site variations within the framework of a wider comparative ecology based on general classifications of the environment.

This need was particularly felt when, at the beginning of this century, plantations of exotic species began to be extended, and since the environmental factors of most general actions are the climatic factors, it has become the basis of the study of particular climatic classifications, known as phytoclimatic classifications, which aim above all at an investigation into the analogies and the ecological differences between sites occupied by different species (or between different factors of the distribution area of a species) and the regions, more or less distant, where these species can be introduced.

We owe the first phytoclimatic classification, based on the forest vegetation of the northern hemisphere, to Mayr (1906), who distinguished six different forest zones whose boundaries where determined on the basis of the average temperature during the period from May to September (considered as the period of growth), the mean annual temperature, the average minimum temperature, the rainfall during the period of growth, the relative humidity during the same period and the date of the first and last frosts.

After some years, another attempt at phytoclimatic classification was made by Pavari (1916), who pointed out the deficiencies of Mayr's system and suggested a more complex one, which was much better characterised climatically (by means of mean annual temperature, mean temperature of the coldest and hottest months, mean annual minimum and maximum temperatures, seasonal rainfall distribution, and the precipitation for the year and for the warm season) and which reproduced more faithfully the real distribution of forest formations.

Other phytoclimatic classifications have since been proposed for the same purpose, as well as schemes based on indices which consider the value of single climatic factors or of groups of climatic factors combined in various ways: thermic, pluviometric, radiation, evapotranspiration, etc., indices (cf. de Philippis, 1937 and 1951; Curé, 1943; Knoch and Schulze, 1954; Champion and Brasnett, 1958).

The combining and representing of data are obtained by means of numeric values, diagrams, or even colours (Gaussen).

The validity of a classification or of an index for the characterisation of "climatic types" having a biological meaning (bioclimates) can be ascertained only by concrete study of the correspondence between the area of the types themselves and that of a specific biological phenomenon, as, for example, the distribution of a vegetation type or of a plant species.

Research of this kind has been attempted by Livingston and Schreves (1921) for the United States, Hesselmann (1932) for Sweden, de Philippis (1937) and Giacobbe (1949) for Italy, and by many others. They show that a solution of a universal nature is not as yet available. There are, however, classifications and indices of the climate which allow us to arrive, with sufficient approximation, at a knowledge of the similar climatic areas (homoclimes) of the same continent or of different continents.

The method of "climatic analogues" is based on research about homoclimes. Forestry workers and agricultural specialists (cf. American Institute of Crop Ecology) use this method, in fact, both for the introduction of exotic species and for the comparison of cultural practices.

And it is in the zone of influence of a given climatic type and of its homoclimes that the evaluation of the site quality can assume a comparative meaning capable of fully establishing the dependence of the site quality itself on climatic factors.

It is in a subordinate way and "within the range of given coordinates that the problem of the relationship between soil and forest productivity must be studied and solved" (Wilde). The same concept is valid for the relationship with the biotic factors.

A recent attempt at evaluation of site quality on a comparative scale, by means of an essentially climatic index and of a "functional climatic system" was made by Paterson (1956).

Paterson estimates that the productive potentiality of a given region can be expressed on the basis of the values of the index CVP. (C = climate; V = vegetation; P = production). By multiplying the ratio of the temperature of the warmest month to the annual range of temperature, by the annual rainfall, by the length of the growing season (ascertained in various ways), and by the intensity of the evapotranspiration (ascertained by means of values of solar radiation), one obtains numeric values which, according to Paterson, are in correlation with the potential productive capacity of natural forests.

Paterson's own application of this theory, on a world-wide scale and, in more detail, for Sweden (1959), and its application on a more limited scale by other people (Pardé, 1959; Weck, 1957; Gambi, 1960), reveals a sufficiently satisfactory correspondence with the incremental values indicated by Paterson.

The study of the possibilities afforded by this index, and by possible future modifications of it, to evaluate productive capacity on a general scale deserves to be gone into more thoroughly (a special work-group of the International Union of Forest Research Organizations is at present going into the problem), especially for the practical purposes of evaluation of single sites and of their present and potential quality.

The index is valid for expressing the productive capacity of forests of species indigenous to the various regions, while, in the case of artificial plantations of exotic trees, the production indicated by the values of CVP—at least in the range from 100 to 500—is increased two or more times.

The phenomenon of a high growth of many exotic species is well known, but it deserves to be better clarified as regards its causes, because it may be that spontaneous vegetation is not always capable of expressing the maximum site quality and that this can, instead, be revealed by species of greater yield rate. It may also be that these species, in the new sites, benefit from transitory favourable factors whose action would be reduced or annulled in successive crop cycles.

The problem needs to be carefully considered, because it substantially affects the whole concept of site quality.

Another necessary consideration concerns the production figures which are expressed in terms of wood volume; in this form they are sufficient for practical purposes but are not fully comparable in their ecological meaning, since the real productive capacity of the site is expressed by the quantity of dry matter, a quantity which, with equality of volume, can vary considerably from one species to another, as pointed out by Burger and Weck.

RESUMES

Evaluation de la fertilité de la station d'après les facteurs écologiques

L'interprétation du concept de station est aussi variée que sont nombreuses les définitions afférentes.

Si nous acceptons la définition de Tansley (1923), la station représente une unité écologique élémentaire, un *écotope*.

Mais la station peut être considérée en un sens plus large, comme *unité bioécologique*, c'est-à-dire comme un système complet de causes, d'effets et de réactions (*écosystème*).

Si nous considérons la station comme une unité de milieu, les conditions d'habitat qu'elle offre, en comparaison d'un peuplement forestier, présent ou possible, expriment sa *fertilité*.

Le degré de fertilité peut être évalué:

1. en mesurant l'effet concret des facteurs de milieu de la station sur la végétation qui l'habite.
2. en examinant chaque facteur du milieu local et déterminant la résultante de leur action.

Le premier procédé est le plus simple dans les cas de peuplements déjà constitués: on peut alors recourir à des méthodes qui se basent sur l'étude de l'accroissement ou à des méthodes typologiques. Ce premier procédé notamment, s'il utilise uniquement des méthodes se basant sur la mesure de l'accroissement, ne permet pas d'établir quels sont les facteurs concrets de la fertilité, ni de comparer les stations lointaines ou, tout au moins, occupées par des espèces forestières différentes; il permet de vérifier uniquement la fertilité actuelle par rapport à une espèce présente.

Le deuxième procédé, au contraire, permet d'établir les rapports de cause à effet entre milieu et végétation et rend possible la comparaison avec des stations lointaines, même si elles appartiennent à différentes régions floristiques, ainsi que l'évaluation de la fertilité potentielle, par rapport à une espèce quelconque.

Le problème de l'évaluation de la station peut être affronté dans les limites d'aires géographiques restreintes comprenant une partie ou toute l'aire d'une espèce, ou bien sur une plus ample échelle.

Dans le premier cas, une fois constatées les corrélations significatives de la productivité avec des caractères variés (climatiques, édaphiques, topographiques) de la station, on peut établir des

types physiques dont la validité est généralement circonscrite à la région dans laquelle ils ont été étudiés.

Pour des comparaisons à distance, on ne peut se passer d'évaluer les variations de station dans le cadre de classifications générales du milieu, climatiques et pédologiques.

Ce concept a trouvé une application utile à travers l'emploi de particulières classifications climatiques (classifications phytoclimatiques) et de la méthode des "analogues" climatiques.

Un essai d'évaluation de la fertilité sur une échelle largement comparative, au moyen d'un indice essentiellement climatique, a été récemment effectué par Paterson avec des résultats, dans l'ensemble, satisfaisants.

Evaluación de la Calidad del Sitio Forestal Según los Factores Ecológicos

Existen varias interpretaciones sobre el concepto de "sitio" y consecuentemente, numerosas definiciones diferentes.

Si aceptamos la definición de Tansley (1923) el "sitio" es una unidad ecológica elemental, un *ecotope*.

Pero el sitio puede interpretarse también en forma más amplia, como unidad bioecológica, o sea, como un sistema integrado de causas, efectos y reacciones, un *ecosistema*.

Si consideramos el sitio como unidad ambiental, las condiciones que ofrece para la vida y crecimiento de una comunidad arbórea, presente o posible en el futuro, expresa su *calidad*.

La evaluación de la calidad *del sitio* puede determinarse así:

1. Midiendo el efecto concreto de los factores ambientales del sitio en la vegetación allí encontrada;
2. Examinando los factores aislados del ambiente local y determinando el resultado de su acción.

La primera constituye el método más simple cuando se trata de bosques ya existentes, en cuyo caso pueden aplicarse tanto los métodos incrementales como tipológicos. Esta forma no nos permite asegurar cuáles son los factores concretos de la calidad del sitio, especialmente si se usan tan sólo métodos incrementaleso para comparar sitios distantes o al menos, sitios ocupados por diferentes especies. Ello simplemente permite asegurar *la calidad del sitio actual* en relación con una especie presente.

El segundo método nos permite asegurar las relaciones de causa y efecto entre ambiente y vegetación y permite además comparar los sitios muy separados, aun si éstos pertenecen a diferentes regiones florales y también la evaluación de *la calidad potencial del sitio*, en relación con cualquier especie.

El problema de la evaluación del sitio puede enfocarse tanto desde dentro de los límites de áreas geográficas restrictas que comprenden parte del total del área de distribución de una especie, o en escala más amplia.

En el primer caso, una vez establecidas las correlaciones significativas de la productividad con varios elementos (climático, edáfico y topográfico) del sitio, pueden establecerse "tipos físicos," cuya validez se limita generalmente a la región en la cual han sido estudiados.

Para comparaciones a cierta distancia, no se puede dejar de considerar la evaluación de las variaciones del sitio dentro del cuadro de las clasificaciones generales climáticas y pedológicas del ambiente.

Este concepto ha encontrado aplicaciones útiles mediante el empleo de clasificaciones climáticas particulares (clasificaciones fitoclimáticas) y el método de las analogías climáticas.

Recientemente Paterson ha intentado evaluar la calidad del sitio sobre una escala mayormente comparativa, mediante un índice esencialmente climático, cuyos resultados por lo general son satisfactorios.

The Nutrient Cycle and Its Modification Through Silvicultural Practice

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Introduction

Forest management continues to become more intensive as a growing demand for timber necessitates both an increase in forest production per unit area of land and the afforestation of areas which at one time were regarded as unsuitable for commercial forestry. Increased yields are being obtained by better utilisation, reducing damage caused by pests, disease and fire, establishing the fastest growing tree species, controlling the stocking density of wooded areas and improving site conditions. Clearly, forestry is becoming more agricultural in approach and, just as occurred much earlier in agriculture, with more intensive management there is a greater awareness of the need for precise information on the mineral requirements of forest crops and the possibilities of improving growth and preventing soil impoverishment by applying mineral fertilisers. Although trees are basically similar to other plants in their nutritional requirements, greater consideration must be given to the natural nutrient cycle of woodlands than for agricultural land because of certain distinctive features of forest communities. For example, trees take many years to mature, they attain large dimensions with their roots usually penetrating deep into the subsoil, and the harvest of wood represents only a small and highly selected part of the total biological production of the community.

Many chemical elements are contained in woodland plants and have well defined biogeochemical cycles, some, such as carbon, circulate in huge quantities whilst others, for example, nickel and cobalt, are present only in small amounts (Warren and Delavault, 1954 and 1957). Not all of the elements absorbed by plants can be regarded as being essential nutrients, but potassium, phosphorus, calcium, magnesium and nitrogen are required in relatively large amounts, whilst other nutrients such as iron, manganese and copper are needed in much smaller quantities.

The Natural Nutrient Cycle

Some aspects of the nutrient cycle in woodlands are illustrated in Figure 1. The rate and magnitude of movement along individual pathways differs for different chemical elements, and the general pattern of flow within the system depends upon many factors, particularly the nutrient status of the soil and the type and age of the woodland. The system is not a closed circuit, since nutrients are continually being added to or removed from the nutrient capital by various natural and artificial processes.

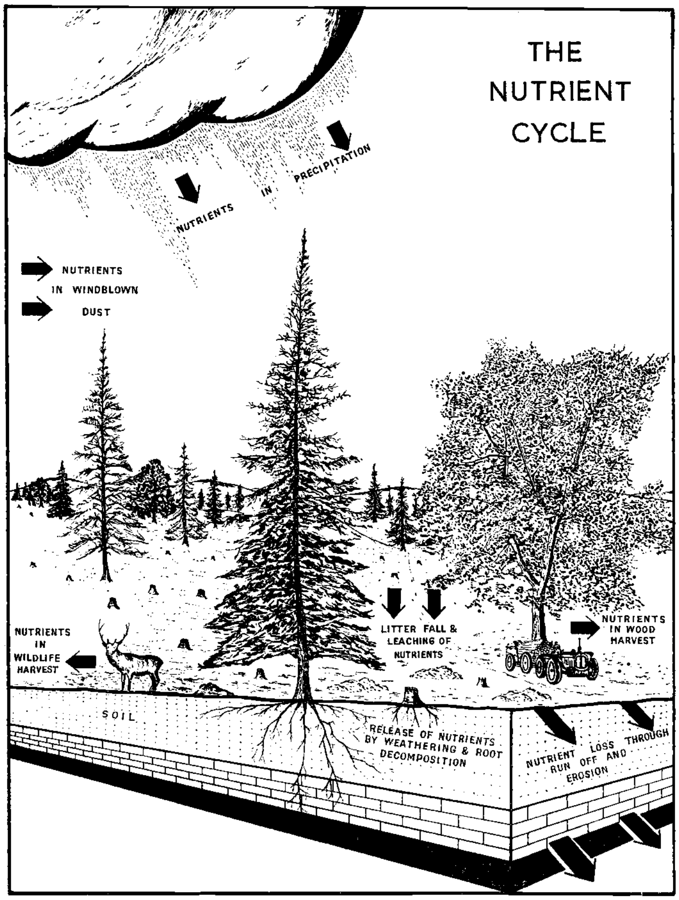

Figure 1.

The most striking feature of a woodland community from the point of view of nutrient circulation is the regular annual return of nutrients to the soil in the litter falling from the vegetation cover. Smirnova and Gorodentseva (1958) report that in birch woods of about seventy years of age, annual defoliation returns 80 to 90 per cent of the nutrient uptake to the soil. Litter is shed over the forest floor throughout the year, and in reasonably stocked woodlands the major part of this litter is derived from the trees; leaves are usually the largest component, but bark, branches, dead stems, inflorescences and seeds are also included. In open woodlands with a well-developed shrub and herb layer, the contribution of the understorey to litter fall may exceed that from the trees (Scott, 1955). Nutrients are also returned indirectly to the soil as animal excreta or in the bodies of dead animals, and when woodland plants are heavily defoliated by pests this becomes the main route of nutrient return to the soil. The litter falling to the ground in woodlands, is very heterogeneous, being composed of organic material differing greatly in structure and chemical composition, and the mechanism and efficiency of litter breakdown varies greatly even in the same wood. Litter fall and decomposition, with the consequent release of nutrients to the soil has been the subject of much research and need not be elaborated here (Wittich, 1939; Alway and Zon, 1930; Mork, 1944; Tarrant, Isaac and Chandler, 1951; Owen, 1954).

Considerable weight of nutrients may be returned to the soil by annual root mortality and decay, but few accurate data of this process are available. Orlov (1955) reported that the annual death of tree roots in plantations of Norway spruce is equivalent to about 70 per cent of the annual needle fall.

Important natural additions to the nutrient capital of forest ecosystems occur and affect the general pattern of circulation between plants and soil. Detailed investigations of the chemical composition of rain and snow in Scandinavia have shown that appreciable amounts of plant nutrients are present in the precipitation (Emanuelsson, Eriksson and Egner, 1954; Viro, 1953). In Western Europe, the weight of nutrients supplied by the precipitation is broadly equivalent to the quantity in the tree stems harvested by foresters (Neuwirth, 1957).

Some of the nutrients in rain water intercepted by the tree crowns may be absorbed directly through the leaves (Wittwer and Teubner, 1959), but foliar absorption of chemical elements is probably not very important, since washing out or "leaching" of elements by rain water occurs. Tamm (1953) found that the rain water collected under a forest canopy is richer in calcium, sodium, potassium, phosphorus, iron, manganese and silica than rain water collected in the open during the same period of time. Less rain water reaches ground level in woodlands than in corresponding open areas because part of the precipitation intercepted by the tree crowns is evaporated directly back into the atmosphere (Ovington, 1954a). Nevertheless, the enrichment of the woodland precipitation as a result of interception more than compensates for the reduction in volume, and the rain water collected at ground level in a woodland may contain ten times as much potassium as the rain water collected in the open over the same period of time (Will, 1959; Madgwick and Ovington, 1959).

Using radio-active isotopes, Tukey and Tukey (1959) have demonstrated differential leaching of nutrients from plant leaves, and Fraser and Mawson (1953) showed that nutrients may be translocated up a tree stem and into the canopy at a rate of up to one foot per minute. The part of the nutrient cycle involving leaching of the leaves by rain water, nutrient absorption by surface roots and subsequent translocation into the canopy could take only a few days to complete and is probably a very important factor in forest dynamics. Tamm (1953) has suggested that under certain forest conditions the growth of *Hylocomium splendens* and other similar mosses depends largely upon this type of nutrient cycle.

The increase in the nutrient content of precipitation as a result of interception cannot be attributed completely to leaching out of chemical elements, since extraneous material such as dust and pollen caught on the tree crowns is washed off later by rain water. Tamm and Troedsson (1955) have drawn attention to the large amount of dust that may be distributed over forest areas after being blown from road verges and arable fields. Forest canopies probably act as huge filters, trapping airborne material carried in the wind, and so effectively increase the amount of nutrients in the ecosystem.

The atmosphere contains about 80 per cent nitrogen by volume, and additional supplies of this element are made available by the fixation of atmospheric nitrogen by free living or symbiotic micro-organisms. Bond, Fletcher and Ferguson (1954) have shown that active fixation of gaseous nitrogen occurs in the root nodules of non-legumes and is sufficient to sustain healthy growth in a rooting medium devoid of combined nitrogen.

Physical and chemical weathering of the mineral soil and subsoil increases the availability of nutrients in forest ecosystems, but little is known of the rate at which nutrients are released by these processes under natural forest conditions. The release of nutrients by weathering will depend greatly upon the soil type and underlying rock but is also influenced by the nature of the woodland cover (Keller and Frederickson, 1952). Actively growing woodlands, with deep, spreading root systems and a high level of biotic activity resulting in a rapid turnover of organic matter, would be expected to have the greatest rate of mineral weathering. Lutz (1940) has suggested that wind-throw of trees is also an important factor in increasing the availability of nutrients since, as the tree roots become dislodged, rocks are shattered and brought to the surface where they are exposed to weathering. In addition, any hardpan or incipient hardpan horizon would be broken so that the roots of the succeeding trees are able to penetrate deeper and draw upon a larger soil volume.

The gain of nutrients to forest ecosystems as a result of precipitation, the addition of extraneous material and mineral weathering is offset to some extent by minerals being carried away in water draining from forest areas. Since there is evidence that the outflow of water from catchment areas is reduced when a forest cover is established, the total loss of nutrients through drainage may be less under woodlands than under other types of plant cover. Fortunately, soil leaching will tend to be at a minimum in areas with infertile soils where the supply of nutrients is not greatly in excess of the requirements of the woodland plants. Viro (1953) has calculated the gross loss of nutrients by drainage for Finland by determining the chemical composition and flow of river water in the five main river basins of the country and concludes that the amount of nutrients removed by drainage generally exceeds the amount added by precipitation. Some of the nutrients carried away in river water may not be leached out of the soil but may be of geological origin, so that the reduction in the nutrient capital of the forest ecosystem would not be so great as is implied by these observations.

Woodlands are essentially dynamic communities, the amount and distribution of nutrients depending upon the balance between the different processes concerned in the nutrient cycle. When areas are successfully afforested or active natural regeneration takes place, the weight of nutrients in the tree stock and humus layers frequently increases whilst the understorey vegetation is suppressed. The build-up of organic matter after 55 years of afforestation with *Pinus sylvestris* on open heaths in Britain results in an accumulation of 52 kilograms of sodium per hectare, 305 of potassium, 643 of calcium, 142 of magnesium, 86 of phosphorus and 1,062 of nitrogen (Ovington, 1959a). In old, natural forests mortality may equal new growth so that the nutrient status of the community is relatively stable, but this situation is uncommon and may be changed slowly by natural succession or more dramatically by fire or windblow. Tree growth may also influence soil development and affect the content and distribution of nutrients in the soil (Coile, 1940; Duchaufour, 1954; Zrazhevskii and Krot, 1955). Investigations of nutrient dynamics must take into account the changes that are taking place in the nutrient capital and in its distribution within the community as a result of nutrient circulation.

The Influence of Forest Practices

The circulation of nutrients in woodland communities is affected by various forest operations, and for convenience these can be grouped under three main headings: (1) establishment practices; (2) management practices; and (3) harvesting practices.

Establishment Practices

Natural or planted tree seedlings often benefit from preliminary site preparation which may involve changing the vegetation cover or improving soil conditions.

Tree seedlings compete with other plants for light, water and nutrients, and clearing of the vegetation to reduce competition was one of the earliest techniques of site preparation. When the vegetation is removed by screefing or turfing from a small area around individual tree seedlings, the effect on the nutrient cycle is only local and temporary. At the other extreme, when derelict woodlands are being reforested the complete clearance of the old trees and shrubs and the resultant soil disturbance has a long lasting effect. The removal of the protective vegetation cover exposes the soil to precipitation and leaching and the woodland flora may be replaced by plants characteristic of open areas.

In upland Britain, drainage and deep ploughing are used on a large scale to improve soil conditions prior to planting. Drains and plough furrows persist for many years and excess water is drained away so rapidly that a potential source of nutrients is lost, but at the same time the lowering of the water table increases the volume of soil and hence the amounts of nutrients available to the trees. Other important consequences of ploughing are the exposure of the mineral soil in the plough furrows and on the ridges, the loosening up of compacted soil horizons, the inversion of the soil profile and the mixing of surface and deep soils. All of these modify the processes concerned in nutrient circulation to varying degrees.

Young trees may be seriously damaged by browsing animals such as deer which have to be killed off or excluded by fencing. The growth of the ground flora is also improved when the number of animals is reduced so that the nutrient reserve in the ground flora and its contribution to the nutrient cycle are enhanced during the early stages of tree growth.

Tree seedlings used for planting are normally raised in nurseries where soil fertility is maintained at a high level and luxury consumption of nutrients frequently occurs. A crop of Douglas-fir, for instance, has been found to contain 209 kilograms of nitrogen per hectare, 38 of phosphorus, 105 of potassium and 48 of calcium (Youngberg, 1958). Nutrients are transferred from the nursery soil to the forest area either in the seedlings or in the soil adhering to their roots. On infertile soils a further application of mineral fertiliser may be needed at the time of planting to ensure adequate survival and growth of the transplanted seedlings, and when poor heath or wet peat soils are being afforested in Britain, 2 ounces of ground rock phosphate are applied per plant as a regular procedure (Zehetmayr, 1954). The high nutrient content of nursery-grown seedlings and the application of mineral fertilisers make the seedlings less dependent upon the soil for nutrient supply and enables them to form a complete forest cover quickly. Other plants are suppressed beneath the forest canopy so that the nutrients they contain become available to the trees.

Management Practices

Once a forest stand reaches the thicket stage, pruning and thinning may be used to improve the growth of the crop trees. As a result of these two operations, dead organic matter is added to the soil since unmerchantable tree boles and crowns are left on the forest floor and the roots of the felled trees remain in the soil. In most woodland types decomposition is stimulated by thinning (Möller, 1954) and the annual release of nutrients by litter mineralisation is increased. At the same time, woodland plants require greater amounts of nutrients because the ground flora becomes more luxuriant following thinning and the crowns of the surviving trees expand to close up any gaps created in the woodland canopy. The main effects of thinning and pruning on the nutrient cycle are a temporary speed-up of nutrient exchange between woodland plants and the soil and a transfer of nutrients from the suppressed trees to the more vigorous crop trees and the understorey vegetation.

Toxic chemicals are now being applied to woodlands to control pests, particularly insects, and the use of toxic chemicals is likely to become more widespread as aircraft are used more intensively in forest management. The indiscriminate use of toxic chemicals may upset the natural balance of forest communities, but, at present, our knowledge of the effects of this treatment on the soil fauna, litter decomposition and nutrient circulation is limited (Balch, Webb and Fettes, 1955).

Many natural forests show evidence of repeated burnings, and certain tree species regenerate best after burning so that the use of fire as a tool of forest management is not surprising. Prescribed burning has been used extensively in the southeastern states of the U.S.A. to reduce the danger of accidental wildfire and to improve natural regeneration and the feeding value of the understorey vegetation for cattle and game (Biswell, 1958). Prescribed burning obviously effects the nutrient cycle (Burns, 1952) but the results are not so serious as those following uncontrolled wildfires. The high temperatures reached in wildfires completely destroy the fauna and flora, and all organic matter is burnt off to expose the mineral soil to erosion. The nitrogen contained in the organic material is lost completely and the mineral elements left in the ash may be washed or leached away.

Harvesting Practices

Traditionally forests are examples of multiple land use and the harvest may be in the form of wildlife, domestic animals, water, tree litter, Christmas trees or wood.

In some forests wildlife and domestic animals such as cattle and hogs are an important crop, but if management is directed too much towards the animal harvest the whole community may be threatened due to damage to tree seedlings and the soil. When a woodland is overstocked with grazing animals or the recreation interest is excessive, the soil becomes compacted by trampling and the capacity of the soil to absorb water is reduced so that surface runoff and soil erosion with the resultant loss of nutrients are increased. Normally, the amount of nutrients removed from the forest ecosystem in the animal crop does not represent a serious drain on the nutrient capital, for the ash content of the animals is only about 3 per cent of the fresh weight.

Forest litter is occasionally harvested for animal bedding or for manuring agricultural land. Large amounts of nutrients are contained in forest litter (Ovington, 1954b), and repeated removal of the litter layers seriously depletes the nutrient reserves of woodland communities, reduces chemical weathering and, by exposing the mineral soil to precipitation, increases soil compaction. In West German forests where litter has been removed continuously, forest productivity has declined, and Mayer (1956) states that the annual growth of woodlands does not reach its normal level until 40 years after litter removal is stopped.

Trees take up large quantities of nutrients, and although much of the nutrient uptake is returned to the soil in the litter fall, appreciable amounts are removed in the timber harvest (Ovington, 1959b). This drain of nutrients from the nutrient capital of forest communities is likely to increase as more forest land is used for Christmas tree production or for growing softwoods on short rotations to supply pulp or chipboard mills. Rennie (1955) has suggested that some soils now being used for commercial timber production are incapable of replenishing the nutrients, notably calcium, removed in the timber so that intensive forestry is liable to reduce the nutrient reserves of the soil and eventually lower site productivity. Monoculture, particularly with rapidly growing coniferous species that form acid mor humus, has been condemned but some authors have questioned the supposition that monoculture is the cause of soil deterioration (Harper, Frank and McQuilkin, 1957). Nevertheless, there is abundant evidence that changes occur in the nutrient status of the soil as a result of forest growth (Ovington, 1958). It is doubtful on scientific and economic grounds that "soil improving" tree species can be used extensively to increase the nutrient reserves in the soil, and mineral fertilisation of forest stands has been advocated as a more satisfactory method of preventing soil degradation and of increasing forest productivity. Numerous experiments have shown a clear increase of annual production of timber as a result of applying mineral fertilizers to forest stands (Tamm, 1958; Heiberg, Leyton and Loewenstein, 1959), but the improvement in growth tends to decrease as the inherent fertility of the soil increases. The use of mineral fertilisers in forest stands will both increase the nutrient capital of the community and affect the pattern of nutrient circulation by increasing the nutrient content of the tree leaves and litter. More research is needed into the long-term effects of repeated applications of mineral fertilisers over several crop rotations.

The use of heavy machinery in forest management, utilisation and road building may also have far-reaching effects on the nutrient cycle, since there may be considerable soil disturbance, and badly located roads can encourage erosion and run off.

Conclusions

Woodlands are essentially dynamic communities within which nutrients circulate in relatively large amounts. The nutrient status of a woodland reflects the balance between the various processes concerned in the internal circulation and the inflow and outflow of nutrients. Most silvicultural practices modify nutrient circulation and, in particular, greater utilisation of forest products is increasing the drain on the nutrient reserve. Our knowledge of the long-term effects of more intensive management practices on nutrient circulation and capital is limited, and detailed studies of the dynamics of nutrient circulation in relation to the maintenance of site productivity are urgently needed.

In the past, research into nutrient circulation in woodlands has been too fragmentary, and little effort has been made to bring together diverse scientific disciplines in order to obtain a comprehensive and balanced picture of the nutrient cycle and its modification by silvicultural practices. At present, silviculture is at the turning point where the forest crop is no longer being regarded as a wild crop and, with increasing domestication, silviculture must be placed on a more scientific basis. Scientific silviculture would benefit greatly if research into nutrient dynamics was concentrated on a few well-defined woodland types for which complete nutrient balance sheets could be prepared to show both the annual circulation of nutrients and the long-term changes that are taking place in the distribution and amount of nutrient capital in the ecosystems.

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RESUMES

Le cycle de nutrition et sa modification par des méthodes de sylviculture

Une des caractéristiques des peuplements forestiers est le degré élevé de circulation annuelle d'éléments nutritifs qui s'effectue entre les plantes et le sol. Ces éléments nutritifs sont transférés par toute une variété d'opérations, et le processus général du flux nutricier, à l'intérieur de chaque écosystème forestier, est fonction d'un certain nombre de facteurs, notamment de la fertilité inhérente du sol et du type et de l'âge du peuplement forestier. Dans les forêts bien peuplées, la contribution du sous-bois au cycle de nutrition est faible, mais dans les forêts claires, la contribution du sous-bois peut dépasser celle des arbres.

Le cycle de nutrition n'est pas un système ferme, étant donné que des quantités supplémentaires d'éléments nutritifs sont fournis naturellement par les précipitations, les matières étrangères prises dans la voûte de feuillage et aussi et par la désagrégation du sol et des roches; mais y a en revanche déperdition par l'effet du ruissellement.

La circulation naturelle des éléments nutritifs est modifiée par les diverses méthodes de sylviculture qui sont examinées sous les trois rubriques suivantes: (1) opérations d'implantation (défrichement, drainage, labour, protection contre le gibier, plantation de jeunes sujets issus de pépinières et application d'engrais minéraux aux jeunes plants); (2) opérations d'aménagement (éclaircies, élagage, emploi de produits chimiques toxiques et du feu); (3) opérations de récolte (gibier, litière du sol, bois d'oeuvre, pâturage des animaux domestiques, construction de routes et utilisation de machines lourdes).

Le présent rapport examine le danger que présentent, pour la fertilité du sol et la productivité de l'emplacement choisi, de mauvaises méthodes de sylviculture et une récolte intensive, ainsi que la possibilité d'appliquer des engrais minéraux aux peuplements forestiers établis, afin d'améliorer les conditions du sol et la croissance des arbres.

Le rapport souligne enfin l'importance qu'il y a à ce que l'on entreprenne des recherches détaillées sur les différents processus contrôlant le cycle de la nutrition, et indique qu'il conviendrait de limiter ces recherches à quelques types forestiers bien définis, de façon à permettre la préparation de diagrammes indiquant, d'une part, la circulation annuelle des éléments nutritifs et, d'autre part, les changements qui se produisent dans la distribution et le volume du capital nutricier.

El Ciclo de Nutrición y su Modificación Mediante Prácticas Silvícolas

Una característica de los bosques es la gran circulación anual de materias nutritivas entre las plantas y el suelo. Estas materias pasan de un medio a otro a través de variados procesos y la circulación general de ellas, dentro del ecosistema forestal, depende de diversos factores, particularmente de la fertilidad inherente del suelo y del tipo y edad del bosque. En los bosques densamente poblados, la vegetación del subestrato que cubre el suelo contribuye muy poco a la circulación nutrimental, no así en los abiertos, en que la contribución de la flora del suelo suele exceder a veces a la de los árboles.

El ciclo de nutrición no es un sistema preciso, ya que siempre hay cierta cantidad de materias nutritivas que suministra la naturaleza en la lluvia, en las substancias externas que se quedan en las copas de los árboles así como en el desgaste del suelo y de las rocas. Pero, a su vez, extrae también otras en los desagües de las áreas forestales.

La circulación natural de las materias nutritivas puede modificarse como resultado de diversos tratamientos forestales que se examinan en este trabajo bajo tres títulos: (1) métodos para el establecimiento, tales como limpia de maleza, avenamiento, labranza, regulación de la fauna, plantación de árboles de semillero y empleo de abonos minerales en éstos; (2) métodos administrativos, esto es, cortes de entresaca, podas, empleo de materias tóxicas químicas y quema; y (3) prácticas de aprovechamiento, o sea, disminución de la fauna, limpieza de despojos y troncos caídos, apacentamiento de animales domésticos, construcción de caminos y el uso de maquinaria pesada.

Se menciona el peligro de desminuir la fertilidad del suelo y la productividad del sitio con prácticas silvícolas desacertadas y de explotaciones intensivas y se trata la posibilidad de emplear abonos minerales en sitios forestales establecidos para mejorar las condiciones del suelo y el crecimiento de los árboles.

Finalmente, se pide la realización de estudios de investigación sobre los diferentes fenómenos naturales que regulan la circulación de las materias nutritivas y se sugieren las ventajas que reportaría concentrar estas investigaciones en unos cuantos tipos de bosques bien definidos de manera que pueda llegar a hacerse una especie de balance en el cual aparezca la circulación anual de materias nutrimentales y los cambios que se efectuan en la distribución y cantidad de nutrición.

SPECIAL PAPERS

The Mineral Nutrition of Canadian Pulpwood Species

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The Influence of Nitrogen, Phosphorus, Potassium and Magnesium Deficiencies on the Growth and Development of Jack Pine (*Pinus banksiana* Lamb.) Seedlings Grown in a Controlled Environment

Introduction

The scientific use of fertilizers appears to be one of the most promising ways of increasing productivity economically in forestry. Recent experience has shown that the *rate of growth* of forest stands, plantations and nursery stock, like that of any other crop, is directly dependent upon an adequate supply of all the thirteen elements[1] which are known to be essential for plant growth. There is reason to believe that growth in many nurseries, plantations and natural stands is being seriously retarded by soil mineral deficiencies. Evidence of the benefits obtainable by the correction of mineral deficiencies is now widespread (5)[2], but little factual data are available regarding responses in Canadian forestry.

In order to use fertilizers scientifically and economically, one must be able to diagnose soil deficiencies correctly, so that appropriate corrective measures may be taken. It is now generally recognized that two of the best diagnostic tools for use in the determination of mineral deficiencies are visual symptoms and foliar analyses. This paper describes the laboratory methods being used and some of the results obtained in a study of the influence of nitrogen, phosphorus, potassium and magnesium deficiencies on the growth and development of white spruce (*Picea glauca* (Moench) Voss), black spruce (*Picea mariana* (Mill.) B. S. P.), jack pine (*Pinus banksiana* Lamb.) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) seedlings grown in a controlled environment.

As space does not permit presentation of all the results obtained, the main emphasis in this paper will be placed on the jack pine data.

Experimental

The controlled environment required for the induction of deficiency symptoms in the tree seedlings was provided by means of an automatically heated and ventilated greenhouse and an automatic sub-irrigation sand culture apparatus, which was devised and tested during a preliminary experiment carried out, indoors, in 1958. Full details of the apparatus, the nutrient solutions used and the treatments applied are given in reference (4).

The basic principle of the sand culture technique is, of course, that the crop is grown in a substrate of pure silica sand, from which it receives no nutrients, and is fed by means of nutrient solutions of known chemical composition.

The control ("complete solution") pots received a nutrient solution containing all the thirteen elements known to be essential for plant growth; the other pots in each series received all the essential elements, in quasi-optimal concentrations, *except* the particular element being studied, which was supplied (i) not at all, or (ii) at approximately 1/100 or (iii) at approximately 1/10 of the concentration of that element in the control ("complete") solution.

In order to protect the seedlings from excessive insolation, and to moderate temperatures within the greenhouse, slatted wooden shades (painted with aluminum paint) were fitted on the outside of the glass. These shades were kept in position throughout the normal growing season, and the light intensity at the top of the pots was found to be approximately 20 to 25% that of full sunlight.

The pots were seeded on May 28, 1959, with jack pine seed (approximately 150 seeds per pot, obtained from the Petawawa Forest Experiment Station, Canada Forestry Branch).

By June 3, germination was well advanced. On June 16, the distilled water in the carboys was replaced by the appropriate nutrient solutions. These solutions were changed once a week, and at each solution change the pH's of the old and the new solutions were determined. The pH's of the *new* solutions were in the 4.8 to 4.95 range for all solutions except those of the phosphorus series which were in the 5.3 to 5.6 range. The pH of the distilled water used ranged from 5.80 to 6.05. During the week, pH's went *down* in the potassium, magnesium and phosphorus series but *up* in the nitrogen series. The pH of the "Distilled H_2O Only" pots (included to test

[1] Nitrogen, phosphorus, potassium, magnesium, calcium, sulphur, copper, zinc, boron, manganese, iron, molybdenum and chlorine.

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

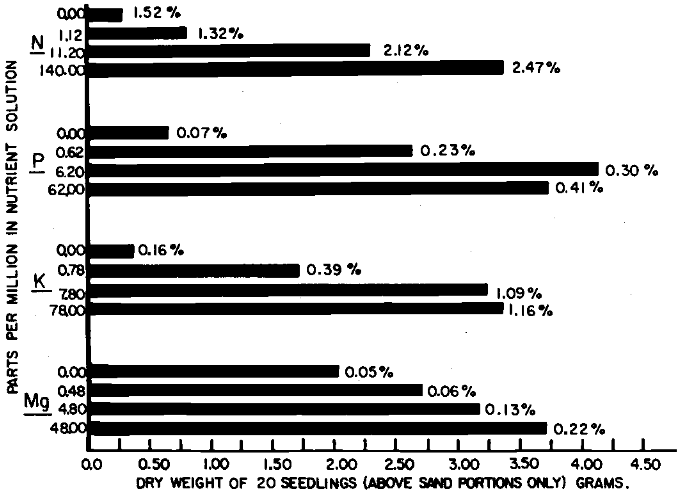

Figure 1. Dry weights of jack pine seedlings versus concentrations of N, P, K, and Mg in nutrient solutions. Percentage figures show the concentration of the element, percent dry weight basis, in the above-sand portions of the seedlings.

the purity of both the sand and the distilled water supply) usually went up to around 6.70 during the course of the week. This may be explained by the fact that the sand used contained a very small amount (0.006%) of calcium as CaO.

On September 2, the western hemlock pots were rotated 180° to counteract the pronounced phototropism which had developed with this species. On September 10 and 11 all the pots were photographed in colour, both singly and in specific and treatment groups, using a Leica M.3 camera, Kodacolour film and daylight or electronic flash lighting. On September 14, the above-sand portions of twenty seedlings were harvested from each pot for dry weight determinations and chemical analyses.

Methods of Analysis

Dry weights were determined by drying for 16 hours at 105°C. and weighing in aluminum cans.

Nitrogen contents were determined by conventional micro-Kjeldahl procedures. Phosphorus and magnesium contents were determined colorimetrically, using a Coleman Universal spectrophotometer (Model 14). Potassium and sodium contents were determined by flame, using a Coleman flame photometer (Model 21).

Discussion

General

Results obtained to date support the contention that specific mineral deficiencies produce recognizable, and more or less clearly defined, visual symptoms. It is not suggested, however, that visual symptoms can invariably be used to diagnose mineral deficiencies correctly. Such diagnoses are not always easy, even when the trees have been grown in a controlled environment which lacks but a single essential element, and in the field more complicated situations, in which more than one element is deficient, are frequently encountered. It is nevertheless suggested that, if some experience has been gained in this field, one can frequently arrive at a reasonably accurate preliminary diagnosis using visual symptoms. It is also suggested that, at least until studies of symptomology are much further advanced, diagnoses based on visual symptoms should, whenever possible, be checked by analytical methods. It is, after all, the concentrations of the essential elements *within the plant* that are all-important and these can be accurately and rapidly determined by modern analytical methods.

The present study is proceeding on the hypothesis that both diagnostic tools (visual symptoms and chemical analyses) will be required and should be developed simultaneously. It would, perhaps, not be inappropriate to point out that there is still a great deal to be learned about the normal or optimum concentrations of essential elements in the foliage of Canadian pulpwood species; until these norms have been established for each species, with some degree of confidence, we shall be severely handicapped in interpreting analytical data.

Optimum Phosphorus Concentration in Nutrient Solutions

Growth was depressed by the highest level of phosphorus (62 ppm), and it is interesting to note that the concentrations of phosphorus in the seedlings were highest in these pots. This could, therefore, seem to be a case of excess consumption which had reached the point of mild toxicity. Fowells and Krauss (2), working with loblolly pine and Virginia pine, obtained greatest height with only 1 ppm of phosphorus in the nutrient solution—their other levels being 0, 0.1, 0.5 and 5.0 ppm. They point out, however, that their data are not in agreement with results obtained by Mitchell (3) which indicated that for white pine, phosphorus was deficient at levels less than 50 ppm. On the other hand, Arnon (1) has shown that some agricultural crops, such as corn, barley and tomatoes grow very well with phosphorus levels below 1 ppm, provided the level is constantly maintained. More work is required to determine the optimum nutrient solution phosphorus concentration for the pulpwood species being studied in the present experiments, but it would appear to lie between 0.62 and 62 ppm and may be close to 6.2 ppm.

Growth Potential of Jack Pine

One of the most striking results of the present experiments is the way in which the jack pine seedlings have out-grown the seedlings of the other three species. With all treatments, the jack pine seedlings are the tallest and, on a dry weight basis, differences in growth are even more pronounced. Considering the complete solution pots only, the jack pine seedlings were approximately 6 times as heavy as the western hemlock, 4½ times as heavy as the black spruce, and 3½ times as heavy as the white spruce. These figures demonstrate the high growth potential of jack pine seedlings.

It was also noticeable that, in the present experiments, the jack pine seedlings were invariably the first to show deficiency symptoms in the various *incomplete* cultures; this may perhaps be partly explained by their higher rate of growth which, presumably, depleted their endospermic supplies of mineral nutrients more rapidly.

Presence in Seedlings of Elements Absent From the Nutrient Solutions

The analytical data show that the seedlings invariably contained a small amount of the element omitted from the nutrient solution in question. Most of this came, presumably, from the endosperm of the seed but, in the case of magnesium, some of it could have come from the sand —which is known to contain 0.031%, by weight, of magnesium as MgO. The small quantities of endospermic nutrients involved were clearly insufficient to maintain adequate growth and may, therefore, for all practical purposes, be left out of account.

"Hidden Hunger"

The term "hidden hunger" is used to describe the situation in which growth is depressed by a mineral deficiency which is not so severe as to induce a distinct visual symptom. In this situation, one has to rely on data obtained from foliar or soil analyses for the detection of the deficiency. Some good examples of "hidden hunger" developed during the course of the present experiment; e.g., the low-nitrogen jack pines were considerably less heavy than the controls but showed no sign of the typical nitrogen deficiency symptom.

It may be anticipated that "hidden hunger" will be encountered in the field and, since there will be no visual symptoms to observe, diagnosis will have to be based on the results of foliar or soil analyses or both.

Conclusions

1. Laboratory (greenhouse) studies have an essential part to play in the scientific study of the mineral nutrition of pulpwood species; many problems, such as inter-element interactions, can be solved with confidence and within a reasonable period of time (especially when working with long-lived tree species) only by the use of a suitable, controlled environment.
2. The automatic sub-irrigation sand culture apparatus, developed for use in this project, is a satisfactory piece of equipment for the induction of visual deficiency symptoms and for the laboratory study of the mineral nutrition of tree species in the seedling to sapling stages of growth.
3. The concentrations of the various elements in the nutrient solutions were reflected in the data obtained by analyzing the above-sand portions of the seedlings. Data obtained in this way will be of value in determining the nutrient concentrations within the seedling which should be regarded as deficient, optimum and excessive.
4. Results obtained to date support the contention that specific mineral deficiencies produce recognizable, and more or less clearly defined, visual symptoms.
5. The development of accurate and reliable methods of diagnosing mineral deficiencies is a prerequisite to the scientific and economic use of fertilizers in forestry; visual symptoms and foliar analyses can both be used with advantage in solving the diagnostic problem. The further development of symptomology and the necessary analytical techniques and foliar data should be given high priority.

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RESUMES

La nutrition minérale des essences canadiennes utilisées pour la fabrication de pâte à papier

Influence des déficiences en azote, phosphore, potasse et magnésium sur la croissance et le développement de jeunes plants de pin de Banks (*Pinus banksiana* Lamb.) cultivés en milieu contrôlé.

Les jeunes plants de pins de Banks ont été cultivés en sol sableux et avec un système de sous-irrigation automatique. L'influence des déficiences en azote, phosphore, potasse et magnésium sur leur croissance et sur leur développement a été étudiée. On a provoqué des symptômes visuels distincts et plus ou moins clairement définis; ces symptômes ont été photographiés en couleur. A la mi-septembre 1959 (15 semaines après l'ensemencement), on a prélevé sur chaque pot vingt plants qui ont été pesés et analysés.

Les résultats obtenus révèlent que les concentrations nutritives trouvées chez ces jeunes plants (dans la partie émergeant du sable seule) et leur poids à sec dépendent l'un et l'autre dans une large mesure de la concentration des matières nutritives dans les solutions alimentaires. Les résultats obtenus font clairement apparaitre le rôle essentiel d'une administration adéquate d'azote, de phosphore, de potasse et de magnésium si l'on veut réaliser une croissance optimum de cette essence importante pour la fabrication de pâte à papier; ils contribuent en même temps à définir la concentration de ces éléments trouvée dans les jeunes plants et qui révèle si l'apport de matière nutritive est insuffisant, optimum ou excessif.

La Nutrición Mineral de las Especies Canadienses Productoras de Pulpa de Madera

La Influencia de la Deficiencia de Nitrógeno, Fósforo, Potasio y Magnesio en el Crecimiento y Desarrollo de Semillones de Pino de Banks (*Pinus banksiana* Lamb.) en un Ambiente Regulado.

Se sembraron y cultivaron semillones de *Pinus banksiana* Lamb. en un suelo arenoso, empleando un aparato automático de subriego, con el objeto de estudiar la influencia de la deficiencia de nitrógeno, fósforo, potasio y magnesio en su crecimiento y desarrollo. A simple vista se observaron diversos síntomas más o menos claramente definidos. A mediados de septiembre de 1959, quince semanas después de sembrados, se tomaron veinte semillones de cada tiesto y se cortaron, pesaron y analizaron.

Los datos obtenidos demuestran que las concentraciones nutritivas que se encontraron en dichos semillones (en la parte fuera del suelo arenoso solamente) y su peso en seco dependían del grado de concentración nutritiva contenida en la solución regada. Los datos también comprobaron la necesidad esencial de una cantidad adecuada de nitrógeno, fósforo, potasio y magnesio para el crecimiento óptimo de esta importante especie productora de pulpa de madera. A la vez, los estudios contribuyeron a determinar las concentraciones de estos elementos dentro del semillón que son indicación de un suministro deficiente, óptimo y excesivo de materias nutritivas.

The Soil-Vegetation Survey As a Means of Classifying Land for Multiple-Use Forestry

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A soil-vegetation survey is an inventory of the soil and the vegetation of an area. The survey as conducted in California takes the form of a map characterizing land units as to their soil and vegetation. This characterization is accomplished by applying a classification of the soil and the vegetation to homogeneous units of the landscape. The soil classification is based upon characteristics of the soil profiles. The vegetation classification is based upon canopy density, form of plant cover (shrub, tree, grass, etc.), and species composition. The soil-vegetation survey is an application of a classification of the soil and vegetation to the landscape by establishing map boundaries delineating land units or types which are homogeneous in regard to soil and vegetation within the limits of the classification units.

Development of Soil-Vegetation Survey Techniques

The California Soil-Vegetation Survey evolved from the combination of separate soil and vegetation surveys which were made prior to 1946 in the wildland areas of California. These wildland areas, including the forests, woodlands, chaparral and grasslands, were mapped with a vegetation classification that included a listing of dominant plant species in order of abundance. The separate soil classification and maps were made at a soil series level. The soil series is a classification unit based upon soil profiles similar in the properties of pH, organic matter, color, structure, drainage, parent rock, degree of profile development, and topographic position. The wildlands of Santa Cruz County in the southern portion of the redwood region were mapped independently by separate organizations for soil and for vegetation types. It was noted upon combining the maps that the majority of the soil type and vegetation type boundaries coincided on the maps when they were superimposed. This gave rise to the suggestion that the soil and vegetation would best be mapped together. The present California Soil-Vegetation Survey[1] was begun in 1946, and since then, 7.5 million acres have been mapped with the combined soil and vegetation classification. The work is conducted by the U.S. Forest Service, Pacific Southwest Forest and Range Experiment Station, cooperating with the University of California. The work is financed by the California State Division of Forestry.

The first step in the method of soil-vegetation mapping is to delineate, on aerial photographs, the boundaries of vegetation types which are homogeneous with regard to density; vegetation elements of conifer, shrub, hardwood, grass, rock, etc.; and broad age classes of the coniferous vegetation. These criteria have been chosen on the basis of how easily they can be interpreted and delineated on aerial photographs. These elements, when delineated on the aerial photographs, result in a map as in Figure 1. This delineation is a first approximation to the likely soil boundaries and vegetation species type boundaries which are to be mapped in the field.

The second step in the method is field mapping carried out on the delineated photographs. For each of the delineated areas, species are listed in order of abundance, site quality is determined, and the soil occuring in the type is classified as to series based upon profile characteris-

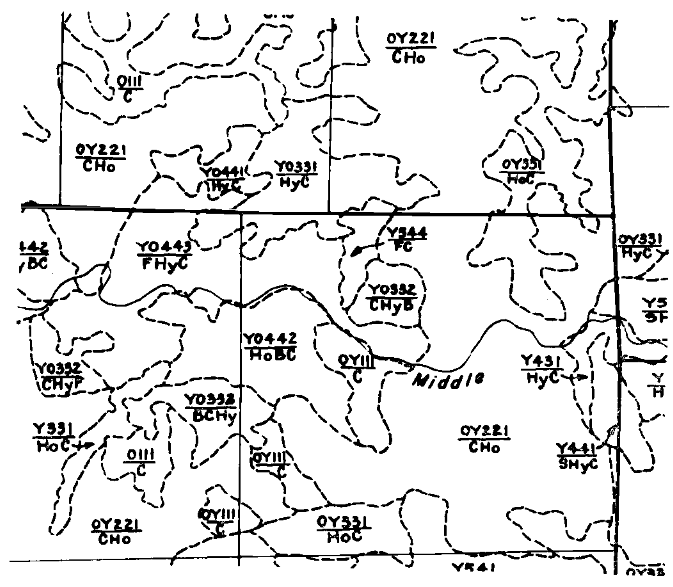

Figure 1. The age-density, vegetation element map obtained by aerial photograph delineation for an area on the Middle Fork of the Ten Mile river near Fort Bragg, California. The symbols in the numerator refer to mature commercial O; young conifers, commercial conifer Y; and density symbols in the order sawtimber-size trees, total commercial timber, and total woody vegetation. The density classes are 0-5 percent, *5*; 5-20 percent, *4*; 20-50 percent, *3*; 50-80 percent, *2*; and 80-100 percent, *1*. The symbols in the denominator refer to vegetation elements present in order of abundance. They are: bare ground, B; conifers, C; ferns and herbs, F; mature hardwoods, Ho; immature hardwoods, Hy; and shrubs, S. Each square is one square mile or approximately 257 hectares.

[1] California, State Division of Natural Resources. Soil-vegetation surveys in California. 1958.

tics. In addition, soil depth, stoniness, and slope classes are determined. Boundaries additional to those already delineated on the aerial photographs are located and added in the course of the field mapping. Changes in the topography, geology, and other soil-forming factors aid in the location of these additional boundaries.

The maps resulting from this procedure now have information for each homogeneous landscape area which includes: vegetation elements (conifer, shrub, hardwood, grass, etc.); density of woody vegetation; list of dominant species present; timber site quality classification; and soil classification, including soil series, soil depth, slope, and stoniness. The site quality classification is made by frequent site tree measurements using height-age relationships. Figure 2 is an example of the soil-vegetation map.

Laboratory analyses and fertility studies are run on the soils to further characterize their properties. Soil samples representative of the various soil profiles classified in the field are collected and analyses are made of their physical and chemical properties. Field tests are made on the grassland soils of the effect of various fertilizer applications on forage productivity and species composition. Small-scale pot tests are made in which soil fertility is determined by growing plants with various rates of application of nitrogen, phosphorus, and potassium in a standardized test.

Thus the soil-vegetation survey provides the forester and wildland manager much of the information he needs to plan the various aspects of multiple-use management of these lands for forestry, range management, watershed management, and recreation and park management. Examples of the application of these maps to some aspects of multiple-use management will be shown.

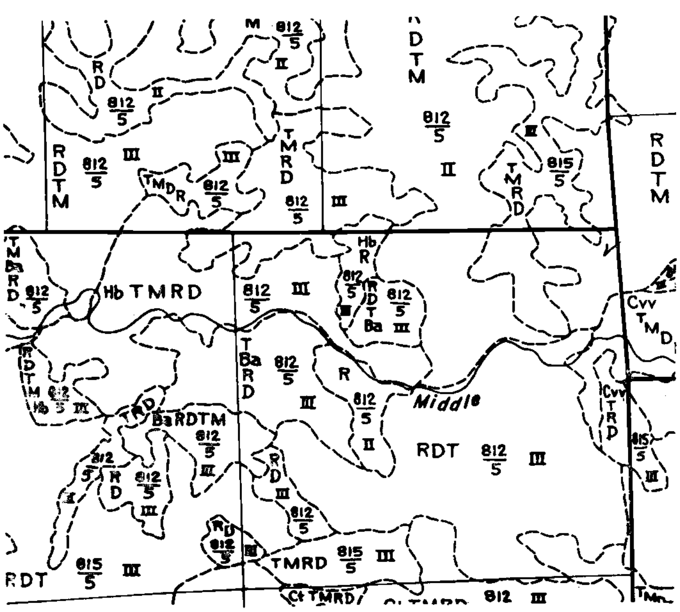

Figure 2. The soil-vegetation map for the area shown in Figure 1. Vegetation is listed by species abbreviation as cited in text. The soils are designated by the fractional symbols: 812, Hugo soil series; 815, Josephine soil series; demominators indicating depths, all being 5, or over 48 inches deep. Site quality based on Douglas-fir site trees designated by III, SI at 100 years, 140'; II, SI at 100 years, 170' (Cvv is *Ceanothus velutinus*).

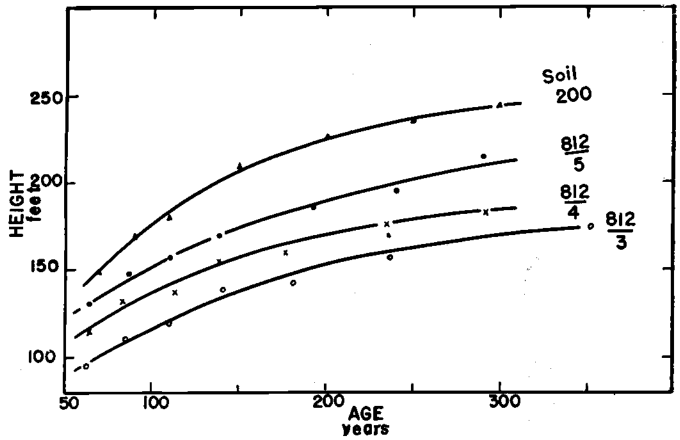

Figure 3. Height-age relationships for *Pseudotsuga menziesii* as arithmitic mean heights for age class intervals for several soil types: *200*, recent alluvial soils (31 trees); and *812*, Hugo soils of various depths, 812/5, greater than 48 inches (379 trees); *812/4*, 76-98 inches (316 trees); and 812/3 (69 trees). Rainfall, 50.1-65 inches per year.

Application to Multiple-Use Wildland Management

FORESTRY

Forest Site Classification

Soil-vegetation maps categorize the main landscape elements related to site quality. Indications of site quality are inherent in the species composition of the vegetation and the soil data presented. By relating site tree measurements to the soil and vegetation units mapped it is possible to make predictions of site quality on similar land units having no site trees. For example, in the course of the soil-vegetation survey in northwestern California, over 3,000 site tree measurements have been made. Many of these occured on one soil series, the Hugo soil series, a gray-brown podzolic soil derived from a graywacke sandstone. Figure 3 shows the height-age relationships of these site tree data for three depth classes of the Hugo soil series (812) in the rainfall range of 50.1″-65.0″. It is seen that the height growth curves are distinctly separate for each of the soil depth categories listed. The height-age relationship for the soil mapping category of recent alluvial soils (200) is much better than that for the Hugo soil series. The recent alluvial soils include the soil series Corralitos, Soquel, and Ferndale, all soils usually silt loam in texture, 5 to 10 feet deep, and having very little soil profile development. The conclusion is that knowing the soil series, soil depth and stoniness, and climate, one can adequately define the site classification for an area. These data are included on each mapping unit, and with a knowledge of these relationships it is possible to assess the productivity of the site.

Succession Following Silvicultural Treatments

The soil-vegetation maps provide a framework of reference against which an assessment can be made of the effect of silvicultural practices on species composition and the succession in species composition that will occur. The following sequence is observable on the mapping units on the Middle Fork of the Ten Mile River near Fort Bragg, California. The soils are the same on each type, a Hugo soil series which is a gray-brown podzolic soil five feet in depth. The vegetation sequence which followed a harvest of old-growth timber was as follows:

$$\text{R D T M} \xrightarrow{\substack{\text{Harvest} \\ \text{(commercial} \\ \text{selection)}}} \text{Hb T M R D} \xrightarrow{\text{4-8 yrs.}} \text{T M Ba R D}$$
$$\xrightarrow{\text{15 yrs.}} \text{T M R D} \xrightarrow{\text{60 yrs.}} \text{R D T M.}$$

Symbols listed are: R, *Sequoia sempervirens;* D, *Pseudotsuga menziesii;* T, *Lithocarpus densiflora;* M, *Arbutus menziesii;* Hb, miscellaneous herbaceous species, i.e., *Erechtites arguta* and *Whipplea modesta;* and Ba, bare ground. T, M, and R return by coppice growth, and D reseeds itself. R and D finally regain their dominance, and the stand returns to its original condition if the above sequence is not disturbed. However, if fire enters into the sequence, another sequence in the mapping of the vegetation types has been observed as follows:

$$\text{R D T M} \xrightarrow{\text{Harvest}} \text{Hb T M R D} \xrightarrow{\text{Fire}}$$
$$\text{Ct T M R D} \xrightarrow{\text{25 yrs.}} \text{T M R D}$$

The symbols refer to the species mentioned earlier, and Ct is *Ceanothus thyrsiflorus,* this sequence again occurring on Hugo soils. Similar sequences occur on similar soils in the same climate. Sequences will vary with widely different soils and with different vegetation types. The soil-vegetation survey maps have indicated that there are consistent sequences of vegetation types following similar treatments on similar soil types in the same climatic conditions. The landscape types as mapped allow a prediction to be made of the effect of a given treatment on the vegetation sequence.

Miscellaneous Applications to Forestry

There are many other applications of the maps which can be made to forestry. The land units, when classified as to both soil and vegetation, offer logical stratification of the major variables influencing growth and productivity of the forest. Plots evaluating growth rates can be related to these types, and a reasonable basis is provided for their extension to other areas of similar soil and vegetation characteristics. Mechanical properties of the soils as mapped can be related to the problems of forest road construction. Successful establishment of plantations is aided by avoidance of poor soil conditions indicated by the maps.

FOREST INFLUENCES AND WATERSHED MANAGEMENT

The information contained on soil-vegetation maps of a watershed can be used in an evaluation of the hydrologic cycle (the water balance), or in the evaluation of the sedimentation processes occuring on the watershed.

Derivation of a Water Balance

The water balance is the calculation of the disposition of precipitation on a watershed. In its basic form, the water yield from a watershed is computed as the difference between the supply (precipitation) and the losses (interception and evapo-transpiration). The soil-vegetation survey furnishes information which aids in the evaluation of the losses. For example, the interception loss is a function of the species present and the canopy density, information which is contained on the maps. The evapo-transpiration loss is dependent upon the supply of water available to satisfy the loss potential induced by the effects of solar energy and the atmospheric saturation deficit. This supply comes from stored soil moisture and is replenished by rainfall and by seepage from riparian areas or from ground water. The soil series, depth, and stoniness characteristics, as mapped in the soil-vegetation survey, allow the determination of soil moisture storage capacity of the various soil mapping units when use is made of the laboratory analyses of field capacity, permanent wilting point, bulk density, and stone content of the soils. The map can be converted into a soil moisture storage map of the watershed, and a weighted areal soil moisture storage determined for the watershed. The extent to which this stored soil moisture is utilized depends upon the species present as indicated also by the map and the extent to which their normal depths of rooting tap the stored soil moisture. Thus, as is usually observed, the woody vegetation uses the entire depth of soil moisture storage, and herbaceous vegetation uses only a fractional part of the stored soil moisture depending upon its depths of rooting. The water balance for a given period of time can be determined by combining the climatic data for the area with the information contained in the soil-vegetation survey of the watershed. Table 1 presents such a water balance for the Castle Creek Watershed in the California Sierra Nevada.

Table 1. Water balance, 1946-1947, Castle Creek

	Inches of water
Precipitation (gross)	47.8
Interception loss	3.5
Precipitation (net)	44.3
Evapo-transpiration loss	10.7
Yield (calculated)	33.6

The interception loss was calculated as a percentage loss from investigation into losses associated with the type of vegetation indicated on the maps. This loss amount was then adjusted proportional to the woody vegetation density for the watershed determined from a weighted area average (36.7%). The evapo-transpiration losses were determined by computing a potential loss based upon temperature, and meeting this loss from either current precipitation or areal soil moisture storage (2.7″), computed for the entire watershed. The areal soil moisture storage is determined as the sum of the weighted area soil moisture storage amounts in the soils associated with each of the major forms of vegetation. Thus, water losses would be much greater from a watershed in which the area is covered with a 90% density of coniferous vegetation on deep soils, than from a watershed that is bare rock, or from another having herbaceous vegetation on deep soils.

Sedimentation

The soil-vegetation survey information aids the identification of sediment source areas on the watershed. If a stream begins to be loaded with sediment after a disturbance, the location of this disturbance can be identified by properties of the sediment related to the properties of the soils on the watershed. Thus, taking an extreme case, a watershed mapped on the soil vegetation survey has soils classified as the Hugo soil series and the Cornutt soil series. The first of these is a grey brown podsol and the second a lateritic soil bright red in color. If a red sediment is found in the stream it is apparent that the sediment source is in a Cornutt soil area. Type of rock in the sediment bed load of the stream, color of the sediment, clay composition of the suspended sediments, all may be related to similar properties of soils mapped on the watershed. Predictions may also be made concerning sedimentation to be expected from soil-vegetation types following vegetation removal, as in timber harvest for forestry purposes, by observing past effects of such operations on similar soil-vegetation types.

RECREATION AREA MANAGEMENT

The objective of park and recreation area management is often to maintain vegetation in "natural" condition on an area. The soil-vegetation maps present an inventory of the natural soil and vegetation relationships that occur in undisturbed areas and allow the prediction to be made of the effect of management on the natural vegetation. This may be a climax forest in some areas, or in others it may be a sub-climax forest or a temporary vegetation type. In the redwood region there are parks set aside to preserve the large *Sequoia sempervirens* forests in a natural state because of their uniqueness and their beauty. Problems in maintaining these groves in their natural state with little deterioration arise partly due to their relationships to the soils on which they form. The pure old-growth stands of redwood are mapped as occurring on the recent alluvial soils along the river. The local hill slopes with the Hugo soil series have vegetation types containing a mixture of redwood, tanoak, Douglas-fir, and madrone. The park management problems in the pure redwood type on the alluvial soils revolve around maintaining soil conditions undisturbed to the extent that the soil is not compacted by visitor use or altered by excessive sedimentation, either of which will result in damage to the shallow-rooted redwood. The mixed redwood forest on the Hugo soils can withstand a heavier degree of use, as the soil is stony and is less subject to compaction from visitor use or to damaging sedimentation due to floods.

RANGE MANAGEMENT

The multiple-use management of wildland and forest areas frequently involves a decision based upon the comparison of the relative yields between different types of management. For example, the alternative of management for timber production or for forage production for grazing animals may be available for a given tract of land. The soil-vegetation types provide a basis for the assessment of range carrying capacities.

The carrying capacities of some of the wildland soils in California as shown in Table 2, range from 4-5 acres per cow per year to more than 160 acres. It has been of interest to observe that these carrying capacities can be related to the total nitrogen content of the soil on the site as determined in the analyses made of the soils mapped in the survey. Thus, as is seen in Table 2, these contents (lbs. per acre to a two-foot depth) range from nearly 17,000 pounds per acre to 2,970 pounds per acre. The conversion of forested areas to range is a frequent question in multiple-use management. The decision should be partly based on the carrying capacity of the soil for livestock. As is seen in Table 2, two forest soils listed have carrying capacities estimated at intermediate to low and have corresponding nitrogen contents. The forest soil usually tends to have its nitrogen content concentrated near the surface, due to leaf litter return. When conversion is accomplished and the leaf litter return interrupted a loss in nitrogen usually occurs, and there is a corresponding drop in range carrying capacity within a few years. These factors should be considered in decisions regarding alternatives of growing timber or forage on a soil. The soil-vegetation survey offers information basic to these decisions. A rough evaluation of fertility value of the upland soil is possible, since nitrogen in fertilizers costs approximately ten cents per pound. The comparison of value of a given soil-vegetation type for either range or timber production allows the wildland or forest manager to make decisions as to the type of management which will yield the greatest return in the multiple use of an area.

Table 2. The range carrying capacities of wildland soils used for range management, and their nitrogen contents

Soil series	Est. carrying capacity (Acres/cow/year)	Nitrogen	content*
		Lbs./acre 2ft. depth	*Grams/m² 60cm. depth*
Grassland soils			
Mattole	5	16,950	1,908
Zanone	5	15,680	1,763
Kneeland	10	9,860	1,110
Yorkville	25	8,820	992
Nacimiento	25	8,900	1,001
Newville	30	4,050	455
Henneke	70	3,670	413
Lodo	70	2,970	334
Forest soils			
Musick	30	5,290	595
Josephine	25	3,970	447

* Total nitrogen content determined by Kjehldahl method on fine earth fraction of soil, and adjusted for bulk density and stone content to an area basis.

Summary

The California Soil-Vegetation Survey provides a method of classifying and mapping the soil and vegetation characteristics on the same map. This combination of information is particularly adaptable to multiple-use management of forest and wildland areas in that it describes the major land resources that are subject to management; the soil and the vegetation. The general principles of the method and some applications are presented in this paper.

RESUMES

L'étude du sol et de la végétation considérée comme moyen de classement de la terre pour la sylviculture à usages multiples

Les Services d'Etudes du Sol et de la Végétation de Californie ont terminé le levé de 3 millions d'hectares de terres en forêts, pacages et bassins hydrographiques. L'enquête se propose de mettre au point une nomenclature des sols et de la végétation,

et de l'appliquer à des unités homogènes de paysage tracées selon une superficie minima de 4 hectares. Les unités de paysage sont portées sur des photographies aériennes en utilisant l'âge, la densité et les éléments structurels de la végétation visibles sur les photographies. On procède à un classement des sols et de la végétation sur le terrain en observant ces limites. On décrit les sols par séries, profondeur, nature pierreuse, et degré de pente. On classe la végétation d'après les espèces dominantes par ordre d'abondance, et l'on indique les qualités d'un site pour la production d'espèces forestières commerciales. Les sols sont en outre définis par des analyses de laboratoire portant sur leurs propriétés physiques et chimiques, et par des essais de fertilité sur le terrain. L'auteur explique comment, l'étude terminée, on l'utilise comme source d'information pour l'application d'un régime à usages multiples dans les forêts et autres terres non cultivées, et il donne des exemples. Le document fournit le rapport hauteur/âge du *Pseudotsuga menziesii* en fonction des phases de profondeur des séries de sol *Hugo* dans un sol podzolique brun gris. L'évolution de la végétation en fonction des diverses méthodes d'exploitation forestière se confirme dans le cas de nombreuses combinaisons sol/végétation. L'auteur en fournit des exemples. Il explique la manière de parvenir à un équilibre des eaux en décrivant les formes de précipitation dans un bassin hydrographique en tant qu'interception et évaporation/transpiration en utilisant des renseignements sur le sol et la végétation. Il décrit l'application de ces données aux problèmes de gestion des parcs et installations touristiques qui soulèvent la question du maintien des conditions naturelles de la végétation. Les séries de sols des régions étudiées, si on les examine du point de vue de l'exploitation des pâturages, peuvent être classées d'après leurs possibilités de pacage, et des séries de sols allant de 2 à 28 hectares par tête de bétail et par an révèlent une teneur totale en azote correspondant à une série allant de 1.908 gr./m² à 334 gr./m² pour les premiers 60 cms de profondeur du sol selon les renseignements fournis par l'étude.

El Estudio de Suelos y Vegetación como Medio de Clasificación de Tierras Destinadas a Usos Forestales Múltiples

La oficina de Estudios de Suelos y Vegetación de California tiene investigadas actualmente 3 millones de hectáreas de regiones silvestres, integradas por bosques, pastizales y cuencas hidrográficas. El estudio se está llevando a cabo con el objeto de formular un sistema de clasificación de suelos y vegetación aplicable a unidades homogéneas de tierra, con mapas que incluyan un mínimo de 4 hectáreas. Las unidades de tierra se delinean en fotografías aéreas, usando como guía la edad, densidad y elementos estructurales de la vegetación observables en las fotografías. Se hace una clasificación de los suelos y la vegetación dentro de estas delineaciones de tipo en el campo. Los suelos se describen en series, profundidad, contenido de piedras y pendiente. La vegetación se describe de acuerdo con las especies dominantes y el orden de abundancia de éstas y, en el caso de las especies forestales comerciales, se indica la calidad del sitio. Los suelos más tarde se caracterizan también por las propiedades químicas y físicas observadas en los análisis de laboratorio y por pruebas de fertilidad hechas en el mismo campo. A continuación se explica y se dan ejemplos del estudio como fuente de datos para aplicar la administración de uso múltiple a los bosques y a otras zonas silvestres. Se dan también los términos de relación de la altura y edad de *Pseudotsuga menziesii* con las fases de profundidad de un suelo pardo-gris podzólico, delineadas en las series sobre suelos de *Hugo*. Las sucesiones de vegetación establecidas de acuerdo con diversas prácticas de administración forestal son convenientes para muchas combinaciones de suelo y vegetación. Se dan ejemplos específicos. Se aportan datos sobre la derivación o cómputo del ciclo hidrológico, el cual se obtiene calculando la diferencia entre el suministro (la lluvia caída en la cuenca hidrográfica) y las pérdidas (por intercepción y evapo-transpiración), valiéndose de los informes sobre suelos y vegetación para el cálculo de estas últimas. Se describe también la aplicación de los citados informes a los problemas de actividades recreativas y de administración de parques inherentes al mantenimiento de las condiciones naturales de vegetación. Las series de suelos en las superficies que ya tienen mapa, cuando se avalúan como posibles terrenos de pasto, pueden considerarse en términos de su capacidad para sostener reses. Las series de suelos varían de 2 a 28 hectáreas por res al año y muestran entre sí una variación en contenido total de nitrógeno, en los 60 centímetros de la capa superior del suelo, de 1908 gramos por m² a 334 gramos por m², según los datos recogidos en este estudio.

Natural and Conventional Height-Age Curves for Douglas-Fir and Some Limits to Their Refinement

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Introduction

For several decades in North America little effort has been devoted to the improvement of height-age curves. Although H. A. Meyer (1953), Davis (1954) and many others have concluded that height-age curves are the most useful indicators of productivity, considerable research has been centered on alternative approaches to the study of site.

Factors that have diverted study from conventional "site index" curves include: (1) difficulty in determining the true curve form; (2) the need to classify productivity of deforested areas; (3) the desire to provide a means of stratification that is independent of height-age; (4) insistence upon supposed "total," "absolute," or "independent" approaches; and (5) the advent of physiographic site classification, based upon aerial photographs, which is useful for engineering as well as biological purposes.

Recently, however, Spurr (1952) suggested the construction of polymorphic or natural height-age curves by means of stem analysis, and Turnbull (1958) reviewed thoroughly the literature on stem analysis techniques.

Both stem analyses and successive measurements of height on permanent sample plots can be used to improve conventional height-age relationships. These techniques have been applied in the present study to determine advantages and disadvantages and to assess the limitations of conventional height-age curves. Site-index curves with reference ages of 50 and 100 years respectively are developed and compared with others available for Douglas-fir.

Collection of Data

The data were collected on the U.B.C. Research Forest at Haney in 1958 and 1959. The 1958 data were taken from Douglas-fir 60-85 years old felled on plots 1, 4, 5, 7, and 8 of those studied by Griffith (1960). Their respective site indices (S.I.) are 180, 85, 160, 150, and 140 feet at 100 years. Plot size was 0.1 acres. The 1959 data were taken from 150-year-old Douglas-firs felled on a plot comparable to Griffith's 1 and 5. Stump ages were corrected to total ages by adding the appropriate number of years from McArdle, Meyer, and Bruce (1949). Cumulated total height was plotted over age at each section (average length was 16 feet) to estimate height by decades for each tree. The wide range in age means that cyclical variations in climate are averaged. Height-age curves for each of the trees studied in 1958 were projected to the reference age of 100 years. Actual height was used for the 50-year reference age. All data are summarized in Table 1. The error of estimate from stem analysis probably is about half that of accurate determinations of height and age of standing trees.

Table 1. Average height, standard deviation, and coefficient of variation of 132 Douglas-firs at Haney

Total age (years)	10	20	30	40	50	60	70	100p	100t
Av. Height (ft.)	12	32	56	78	93	105	116	145	147
St. Dev. Ht. (ft.)	5	12	17	22	25	27	28	29	34
Coeff. of Var. (%)	44	36	30	28	27	26	24	20	23

The difference in Table 1 between plot (p) and tree (t) values at age 100 represents the discrepancy resulting from use of plot averages instead of projected or actual height (H) of each tree.

Table 2 contains top heights and standard deviations at age 100 for five plots. The overlap between plots 5 and 8 up to age 40 suggests the presence of a factor limiting growth on plot 8 after age 40.

Table 2. Average height and standard deviation of 10 tallest trees on each plot

		Height (feet) at total age (years)—							
Plot No.		10	20	30	40	50	60	70	80
4	Av. Ht.	7	21	34	45	54	64	—	—
	St. Dev.	2	3	5	4	5	5	—	—
1	Av. Ht.	17	47	80	107	128	145	155	167
	St. Dev.	3	5	4	4	3	4	4	6
5	Av. Ht.	13	33	63	87	110	127	142	152
	St. Dev.	2	6	7	8	5	6	5	8
7	Av. Ht.	16	45	72	96	113	128	136	144
	St. Dev.	4	4	5	6	6	4	4	4
8	Av. Ht.	12	36	66	88	104	119	127	134
	St. Dev.	1	4	3	6	5	5	8	8

Methods of Constructing Height-Age Curves

The data of Tables 1 and 2 show an increase of standard deviation with age (A) and a decrease of coefficient of variation with age. Therefore in construction of height-age (H/A) curves by conventional methods it would be necessary at least to modify the dispersion about the average or guiding curve by reference to a curve of coefficients of variation over total age, thereby accounting for the change of coefficient of variation with age.

In constructing the first sets of height-age curves based on these data, Heger (1959) used the technique of Ker (1957). Ker constructed natural height-age curves for several species by determining equations in the form H = a + b (S.I.) for each 20-year age class and harmonizing both intercept and slope.

Later, difficulties of harmonization, and the desire for simple comparisons of many H/A curves suggested the need to transform them into straight lines. The following transformations were tried: H/A, H/A^2, $\frac{H/1}{A}$, H/logA, logH/A, $\frac{\log H/1}{A}$, log H/log A, $\frac{S.I.}{H}/A$, and $\frac{S.I.}{H}/\frac{1}{A}$. None would convert the data to acceptable straight lines, largely because the 10-year class was included. But the ratio of S.I. to H for each age class proved exceptionally valuable for construction and comparison of H/A curves.

Use of S.I./H automatically harmonizes the data for intercept or "a" values, and "b" coefficients can be effectively harmonized by graphing S.I./H for each age class. Averages of S.I./H define any group of H/A curves and are as simple to use as similar equations developed by Bishop, Johnson, and Staebler (1958) for alder.

Forcing the H/A curve to originate at O, as it does in nature, causes a small increase in standard error of estimate, (SE_E) in comparison with determination of equations of the form H = a + b (S.I.) for each age class. In separate analyses of H/A data on dominant and codominant crown classes using a reference age of 100 years, all "a" values were minus and reached a maximum of —30 feet at 40 years. Standard errors of estimate were largest at this age, 8 feet in comparison with the average of 4 feet. Agreement between ratio and regression approaches was much better for top heights, using 50 years as the reference age. Up to the reference age, the maximum "a" was 3.0 feet. Standard errors of estimate were almost identical, reaching a maximum of 5 feet at 20 years and averaging 3 feet. The conclusion was reached that either method may be used to develop a satisfactory sheaf of polymorphic height-age curves.

Factors Influencing Height-Age Curves

S.I./H for each tree and age class will be used to show the influence of several variables on height-age curves.

Portion of Stand Sampled

Although the height curve for intermediate (I) trees is erratic, the ratios of Table 3 demonstrate a significant change in form of H/A curve, especially for very young (10) and older (70) classes of total age. Fifty years was

Table 3. Influence of portion of stand sampled on S.I./H on five 0.1-acre plots

	Total age in years						Age 50	
	10	20	30	40	60	70	Ht.	St.Dev.
	- - -	- - -	(S.I./H)	- - -	- - -	- - -	(feet)	
Tallest 10 per acre (5)[1]	6.20	2.50	1.67	1.19	0.89	0.82	113	0
Tallest 20 per acre (10)	6.50	2.51	1.55	1.19	0.88	0.81	111	3
Tallest 40 per acre (20)	6.90	2.55	1.57	1.19	0.88	0.81	109	4
Tallest 100 per acre (40)	7.65	2.75	1.60	1.20	0.87	0.81	102	5
All dominants (56)	8.68	3.06	1.69	1.22	0.87	0.80	106	6
All codominants (46)	9.16	3.08	1.71	1.23	0.87	0.79	90	7
All intermediates (16)	9.45	2.99	1.51	1.18	0.87	0.78	68	7

[1] Number of trees measured.

used as the reference age in order that H_{50} be without error. Analyses of variance showed no significant differences among ratios of S.I./H for dominant (D), codominant (CD), or 100 tallest trees per acre (top height, TH).

The ratios of S.I./H are 1.00 at age 50, the reference age. Average heights and average plot standard deviations are given in Table 3 for each portion of the stand sampled.

The influence of portion of stand sampled on the position of H/A curves at various ages is shown in Table 4.

Table 4. Heights of various portions of the stand expressed as percentages of average heights of the 100 tallest trees per acre

Total age in years	10	20	30	40	50	60	70
	- - - - (Percentages of Top Height) - - - -						
Tallest 10 per acre	134	119	115	110	109	108	108
Tallest 20 per acre	127	117	111	109	108	107	107
Tallest 40 per acre	116	112	107	107	105	105	105
Tallest 100 per acre	100	100	100	100	100	100	100
All dominants	89	91	94	97	98	98	101
Av. D and CD	85	88	91	94	96	96	98
All codominants	78	82	85	88	90	91	91

Some of the differences in average heights of trees in various crown classes result from differences in age. Dominants averaged 82.6, codominants 81.3, and intermediates 74.1 years in total age. There was much variation about these averages and, in fact, codominants were somewhat older than dominants on plots 1 and 5.

Conversion From H_{50} to H_{100}

Heights of individual trees at 50 years may be converted to plot heights at 100 years by the expression $H_{100p} = 54.8 + 0.966\ H_{50}$. This is modified by crown classes with D as 1, CD as 2, and I as 3 to $H_{100p} = 14.5 + 1.16\ H_{50} + 13.8\ (1, 2 \text{ or } 3)$.

Heights of individual trees at 50 years may be converted to individual tree heights at 100 years by the expression $H_{100t} = 35.8 + 1.20\ H_{50}$. This is slightly modified by crown classes to $H_{100t} = 35.7 + 1.20\ H_{50} + 0.01\ (1, 2, \text{ or } 3)$.

Years to Reach Breast Height

Agreement is becoming more general that the numbers of years suggested by McArdle, Meyer, and Bruce (1949) to convert boring age to total age are conservative (Becking, 1954; Smith and Ker, 1956; Mueller-Dombois, 1959). On the average, two years should be deducted from the number of years to reach breast height suggested by McArdle, Meyer, and Bruce (1949).

Age of Stand When Sampled

Regressions of total decadal heights on heights at reference ages 50 and 100 years were calculated, using each of the 132 trees in all crown classes. All regressions were statistically significant. To facilitate comparison, correlation coefficients are given in Table 5 for each decade and reference age. Both plot and tree averages are given for age 100. All show that the shorter the period of prediction, and the closer it is to reference age, the higher will be the probable degree of success.

Further evidence of the difficulties of estimating S.I. in very young stands (Smith and Ker, 1956) was provided

Table 5. Degree of association among reference height and decadal height

Total age in years	10	20	30	40	50	60	70	100p	100t
			(Simple correlation coefficients, r)						
H_{50}/H_A	.71	.82	.93	.98	1.0	.99	.98	.85	.91
H_{100}plot/H_A	.60	.70	.81	.84	.85	.87	.88	1.0	.88
H_{100}tree/H_A	.62	.69	.81	.87	.91	.94	.96	.88	1.0

by analysis of the regressions of heights at 50 and 100 years on juvenile height growth. For 43 trees, data were available on the length of each of the first five nodes above breast height. Table 6 shows that although averages of four or five nodes ensure statistical significance, their potential for predicting future height is lower than that of total heights at age 10.

Table 6. Relationships among juvenile height growth and heights of 43 individual Douglas-firs at ages 50 and 100 years

Nodes above B.H.	1	2	3	4	5	1,2	1,2 3	1,2 3,4	1,2,3 4,5	H_{50}	H_{100}
	(Simple correlation coefficients, r)										
H_{50}/node length	.29	.03	.28	.42	.30	.14	.31	.32	.38	1.00	0.89
H_{100}/node length	.31	.03	.25	.35	.25	.15	.30	.28	.34	0.89	1.00
	Mean node length in inches									Mean ht. in ft.	
	18	19	20	23	24	18	18	19	20	91	150
	Standard deviation in inches									S.D. in ft.	
	5	5	7	6	5	4	4	4	4	22	29

Table 7. Comparisons of U.B.C. curves with other height-age curves for Douglas-fir

Source	10	20	30	40	50	60	70	80	100
	Stand age in years								
			(Averages S.I./H; H_{100}/H_A)						(Av.H_{100})
U.B.C. TH	11.84	4.24	2.67	1.88	1.56	1.37	1.26	1.17	145
McArdle, Meyer and Bruce (1949)		3.84	2.18	1.67	1.43	1.28		1.10	140
Barnes (1947)		5.00	2.66	1.78	1.38	1.21		1.07	110
B.C.F.S. (1956)		4.73	2.65	1.84	1.43	1.24		1.07	110
Spurr (1952)		3.62	2.43	1.86	1.56	1.36		1.13	150
Hanzlick (1914)		4.21	2.39	1.74	1.45	1.28		1.10	128
Spilsbury Smith (1947)			3.00	1.88	1.47	1.28		1.08	124
Carmean (1956)		1.60	1.35	1.21	1.12	1.07		1.02	110
Carmean (1956)		3.77	2.62	1.97	1.61	1.38		1.13	160
Schumacher (1930)			2.42	1.82	1.54	1.34		1.12	139
			(Average S.I./H; H_{50}/H_A)						(Av.H_{50})
U.B.C. TH	7.65	2.75	1.60	1.20	1.00	0.87	0.81	0.75	93
For. Com. Gr. Br.		2.28	1.49	1.16	1.00				90
Grandjean (1953) TH	6.70	2.40	1.50	1.20	1.00	0.90	0.83		75
Grandjean Av. Ht.	7.20	2.50	1.50	1.20	1.00	0.89	0.82		70

Recent height growth on the study plots (Griffith, 1960, Tables 18 and 29) was closely associated with estimated site index and is a much better indicator of S.I. than is juvenile height growth. Estimates of S.I. without age (Stoate and Crossin, 1959) are no better than the best juvenile estimates of Table 6 and are much worse than 10-year heights as shown in Table 5.

These data on stand age illustrate the difficulties involved in predicting growth in height for long periods and at very young ages.

Change in Crown Class

On the five plots studied, from 1 to 4 and an average of 2 of the 10 tallest trees on a plot representing each 10-year-age class were finally classed as codominant. These trees were presumably in the dominant group at early ages. Only one tree of the 132 studied grew out of what appeared to be an initially codominant height class. Warrack (1952) showed that 15 per cent of the dominants decreased in crown class between ages 19 and 39 in an unthinned stand at Cowichan Lake.

Influence of Site Index on Curve Shape

Analyses of variance of S.I./H by plots and crown classes for each plot and age showed no influence of crown class, but plot differences provided a significant amount of variation, especially in the younger age classes. The variation could not be explained consistently by site index, lesser vegetation, or by any of the soil or moisture variables studied by Griffith (1960), and therefore must be considered as essentially random in nature. Part of the decrease in height growth after age 40 years on plot 8 can be explained by its lower soil moisture and fewer dominant trees sampled in comparison with plot 5.

Influence of Stocking on Curve Shape

It was not possible to detect any influence of stocking on shape of the H/A curves. However, total stem analyses of 30 Douglas-firs planted 22 years ago at a spacing of 6 feet by 6 feet in the U.B.C. Campus Forest showed an apparent increase in site index from 160 to 180.

Comparison With Other Height-Age Curves

The S.I./H ratios for the U.B.C. Research Forest data are compared in Table 7 with those published for Douglas-fir grown in other regions (Heger, 1959).

With the exception of part of the data of Carmean (1956), which represent implausible growth rates, the ratios of Table 7 are in general agreement, although average heights differ. The ratios differ much less than those of Table 3, which are based upon different portions of the U.B.C. stands. The differences within Table 7 can be explained in terms of variations in correction of boring age to total age, in portion of stand sampled, in calculation of average height of trees sampled, and in method of curve construction.

Comparison With Forest Association or Site-Type Data

Ecologists have collected many data on the influence of soil, climatic, and physiographic factors on the growth of Douglas-fir, but have failed to provide convincing evidence on the existence of absolute sites. The best published data on Douglas-fir forest site-types are those of Spilsbury and Smith (1947). These are summarized in Table 8. Since stands sampled were more than 30 years old, the variation cannot be attributed to extreme youth of the sample trees.

Table 8. Summary of data on Douglas-fir site-types collected by Spilsbury and Smith (1947)

Site type	P	P-G	G	GPA	GU
No. of plots	47	70	62	42	9
Min. S.I. (ft.)	124	122	84	70	67
Max. S.I. (ft.)	190	190	160	120	104
Av. S.I. (ft.)	161	151	127	93	80
Curve S.I. (ft.)	169	151	124	94	70
S.D. S.I. (ft.)	14	15	18	12	15

In all but the G type, two-thirds of the plots are likely to fall within plus or minus 15 feet (one 30-foot S.I. Class) of the average site index for the type. Another 30 per cent of the plots will be one site-index class too high or low, and about 3 per cent will be two site-index classes too high or low.

Becking (1954) divided the above types into 15 with a range in S.I. of from 70 to 212 feet. Within each type the number of plots averaged 18, the standard deviation 17 feet, and the average range in S.I. was 53 feet at 100 years. Krajina and Spilsbury reduced the number of types to four, estimating the S.I. of Salal-lichen to be 70 feet or less, of Salal 115, of Moss 150, and of Swordfern 180 feet. Schmidt (1954) estimated a S.I. of 97 feet for Salal, 135 for Moss, and 174 feet for Swordfern. Mueller-Dombois (1959) took an intermediate position, estimating S.I. 80 or less for Salal-lichen, 110 for Salal, 140 for Moss, and 170 or more for Swordfern.

Realizing that the plots used to define these site-types were purposefully selected to represent very small and specific plant communities, the range in site index and the variety of estimates within each supposedly "absolute" type are discouraging.

Concluding Discussion

Height-age curves may incorrectly assume a similar shape for good and poor sites. They may be based upon data that are not representative of the range in productivity. They may use incorrect data for converting age at height or boring to total age (Smith and Ker, 1956). Proportions of dominant and codominant crown classes may have been inadequately defined, and heights of these might have been averaged for diameter in one of several ways (Ker, 1952). Current growth in height may not have been used as a check on total height and age in an attempt to discover the presence of any substantially limiting factors (Ker and Smith, 1957). Most of these faults can be overcome by adequate sampling, and correct curve shapes can be determined by stem analysis and successive measurements of heights as reported herein.

Nothing can be done, however, to foretell accurately the effect of changing methods of management or genetically different stock on the growth characteristics in a particular locality. No method of classification, only time, can provide answers to such problems.

Since all approaches are applied by designation of similar units or strata we should continue to use the trees themselves as the best measures of productivity. Certainly, successful application in forestry of classification systems independent of tree species depends upon the degree to which such systems can be correlated with growth in height and age.

Arguments against the use of height and age hinge on the incompleteness with which growth in height expresses productivity, on the desire for a measure that is independent of height and age, or on the supposed difference between "apparent" and "absolute" site.

We can dismiss the first by suggesting that no approach can provide a total measure and that statistically significant and important correlations must suffice. Even the best of site measures are relatively poor estimators of present or past yield (Smith and Ker, 1959), yet we can find no good substitute for site and age in predicting future growth.

The second argument involving independence fails to recognize the ease and accuracy with which growth of one tree species may be correlated with another, and the simplicity of providing independence by subjectively designating site quality classes from "very good" to "very poor." The extreme variation in published values of so-called absolute sites cannot be justified on the basis that height and age together allegedly express tree growth poorly.

The advantages of the height-age approach are its simplicity, the possibility of recognizing any reasonable number of quality classes, and the ease of conversion to any units of measurement. Height-age curves can be developed with a nominal amount of field work for a single species or a group of species. These can be used to provide an index of quality within any forest strata, giving individual or average estimates for any size of unit or desired degree of precision.

Limitations to the height-age approach are being overcome by studies such as that by Ker (1957), who determined site indices for all species in a mixed stand, by Lynch (1958), who corrected for extremes in density, and by Stage (1959), who developed a method of determining site index in uneven-aged grand fir. Although further studies are required to define and refine height-age relationships, our analyses show that those presently available provide adequate estimates of productivity.

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RESUMES

Courbes hauteur-âge naturelles et conventionnelles pour le sapin de Douglas—Obstacles à leur amélioration

Nous examinons, dans le présent rapport, les défauts présentés par les courbes hauteur-âge, et nous montrons comment il est possible de remédier à la plupart de ces défauts à l'aide des techniques dont on dispose à l'heure actuelle, la plus importante étant la mise au point de courbes hauteur-âge basées sur l'analyse des fûts. Nous donnons un résumé de l'analyse des fûts de 132 sapins de Douglas pour illustrer l'influence de certains facteurs tels que portion du peuplement analysée, âges de référence de 50 et de 100 ans, nombre d'années pour atteindre la hauteur de poitrine, moyenne de la parcelle et de chaque arbre, mensurations à un jeune âge de la croissance en hauteur sur les courbes hauteur-âge et estimations de l'indice du site. Des expressions hauteur-âge sont établies pour 50 et 100 ans et des équations sont données pour la conversion de l'une à l'autre. L'estimation perd de son exactitude lorsque la période de prédiction s'accroît et lorsque l'âge auquel le peuplement est étudié diminue.

Les courbes hauteur-âge disponibles pour le sapin de Douglas sont ramenées à une base commune par l'utilisation des rapports de l'indice du site et de la hauteur par décades. Ces différences entre les courbes hauteur-âge publiées proviennent en majeure partie des variations dans la méthode appliquée dans la construction de ces courbes. Les données hauteur-âge relatives à certaines associations forestières présentent une gamme très large d'indices de site au sein de phyto-sociétés déterminées. Nous résumons les avantages des courbes hauteur-âge et concluons que celles dont on dispose à l'heure actuelle fournissent des estimations adéquates de productivité.

Curvas Estadísticas, Naturales y Convencionales, sobre la Altura y Edad del Abeto Rojo y Algunas Observaciones sobre sus Límites de Exactitud

Este trabajo trata sobre los defectos de las curvas de altura y edad y demuestra que la mayoría de ellos pueden rectificarse mediante el empleo de métodos actualmente en existencia, el más importante de los cuales es el que basa dichas curvas en un

análisis del tronco. Asimismo, se hace un resumen del análisis de troncos de 132 abetos rojos (*Pseudotsuga menziesii*) para ilustrar la influencia de la porción de bosque examinada, con edades referenciales de 50 a 100 años, tiempo necesario para llegar a la altura del pecho de un hombre, promedios de parcela y de árboles, medidas de crecimiento juvenil en curvas de altura y edad y cálculos sobre el índice del medio estacional. La exactitud del cálculo disminuye cuando se aumenta el período de predicción y se disminuye la edad en la cual se estudia el grupo de árboles.

Las curvas de altura y edad planteadas para estos abetos rojos fueron reducidas a bases comunes mediante el establecimiento de la proporción por décadas entre el índice del medio estacional y la altura. La mayor parte de las diferencias entre las curvas de altura y edad publicadas son resultado de variaciones en el método de computación. Los datos aportados por las asociaciones forestales suelen tener un amplio límite en cuanto al índice del medio estacional dentro de grupos de plantas específicas. Al final, se resumen las ventajas que resultan de las curvas de altura y edad y se llega a la conclusión de que las que existen actualmente proveen cálculos adecuados sobre la productividad.

Soil Improvement by Cultivation and the Use of Fertilizers

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Improvement of the soil by cultivation and manuring is of great importance in preparation of bare land for afforestation in the United Kingdom, and the present paper gives a brief outline of the main considerations and methods involved in present-day practices. Considerable experience on the cultivation and fertiliser needs of poor quality sites has been gained in recent years, particularly in connection with the large extension of moorland afforestation since the formation of the Forestry Commission in 1919. The need for the best soils being retained for agriculture has resulted in a concentration of afforestation work on degraded grazing land, consisting mainly of unimproved peat and heather moorland. The diversity of these difficult land types is exemplified by the acid peat bogs of north and west Scotland, the hill peats of the Scottish Border and Pennine regions, the dry upland heaths of northeast England and east Scotland, and the lowland heaths of east and south England. To these may be added badly drained clays, and shallow dry soils over chalk in the Midlands and south of England.

When large-scale planting first started on these sites in the early 1920's, there was little practical experience on which to draw, and questions of choice of species, cultivation, drainage, manuring, etc., had to be answered by trial and error and by a large programme of field experimental work. Despite the many different sites, it soon became apparent that the main factors limiting tree survival and growth were poor aeration and drainage on waterlogged peats and compacted mineral soils, low levels of major nutrients, and intense competition of the natural heath or grass vegetation. After early attempts to establish crops on "unimproved" moorland sites, it became obvious that drastic preparatory treatments to improve the soil conditions were essential if economic crops were to be produced.

The total productivity or fertility of a site may be related to the volume of soil suitable for unhindered root development, as well as to the inherent fertility in terms of the levels of available nutrients in the soil. The effects of cultivation and manuring methods on these characteristics of site are discussed below.

Soil Improvement by Cultivation

Most of the poor quality sites available for afforestation have undisturbed soils characterised by inadequate drainage and aeration. On such soils, the early practice of planting trees directly into the undisturbed natural surface was a failure, and it was found that growth could be greatly improved on wet peat by planting on upturned turfs cut from drains, or on dry heaths by planting on mounds of mineral soil. The success of such "turfing" and "mounding" techniques led directly to the development of the ploughing methods in use today, which are little more than the mechanisation of these operations.

The present methods of cultivation in preparation for planting usually involve single-furrow ploughing at a spacing and depth varying with soil conditions; planting is then done on the inverted plough ridge (in wet areas) or in the furrow bottom (in dry areas). There are many effects influencing tree growth, and these may be grouped broadly as follows:

Improved drainage and aeration. Cultivation of undisturbed soils improves drainage and aeration, thereby increasing the amount of soil which can be exploited by tree roots. Drainage impedence and anaerobic conditions are encountered on water-logged peat, and ploughing gives drainage to carry off excess water, and also provides peat ridges on which trees may be planted free of waterlogging. On mineral soils, impedence and anaerobic conditions are frequently associated with soil compaction or the presence of a hard iron or humus pan as in many podsolized heath soils. On these sites, shattering the compaction by cultivation provides vertical drainage and improved conditions for root growth.

Nutrient Mobilisation and Reduction of Vegetation Competition

Soil disturbance and improved aeration facilitate weathering of minerals and accelerate microbiological activity for the breakdown of organic matter and the mobilisation of nutrients. In addition, ploughing results in effective local suppression of vegetation and reduction of competition from weeds, particularly for nitrogen and water, in the early years of the life of the plantation.

The benefits of ploughing may be summarised as follows: First, the reduction of losses and the more uniform early growth due to the ironing out of minor differences between poorer and better planting spots. Second, and most important, the more rapid early growth, which reduces the period the trees spend in the weeding—and most frost-susceptible—phase and results in quicker establishment. Third, increse in quality class of crop. Fourth, the task of planting is made easier and quicker, since smaller and therefore cheaper plants may be used, and sometimes no weeding at all is required.

Against these advantages must be placed the future extraction difficulties imposed by the plough ridges, a possible increase in the susceptibility to windblow, owing to the roots tending to run along the ridges or furrows rather than in other directions, and the greater initial expense. On balance, however, it is believed that on most workable sites the benefits far outweigh the disadvantages.

There are three main types of land on which ploughing is normally done—wet sites (mainly peat), dry heaths and grassy sites. On the first of these, the wet sites, draining is the most obvious requirement, but it is quite clear that raising up the plant out of the vegetation is also essential. These two needs are well met by turf ploughs such as the Cuthbertson single mouldboard model, which cuts a fairly deep drain and at the same time inverts a turf ridge which may be planted as it lies; or else thick slices may be cut from it and spread on the surface of the ground at the required planting spacing, and the trees planted in these turfs. Opinions differ as to which is the better of these two practices, but as a rule the furrows are usually spaced seventeen to twenty-two feet apart, to allow for two or three rows of turfs to be spread between furrows. But on the very poorest deep acid peat, the furrows are spaced five to six feet apart and all planting is done on the turf ridges.

Other types of ploughs are also used, but most provide only turf ridges, and normally they need to be used in conjunction with a draining plough. For example, a Cuthbertson double mouldboard plough, which provides two slices of turf from one furrow, may be used at appropriate spacings between drains made by a single mouldboard model. The alignment of the drains made by a draining plough needs the most careful forethought.

On the dry heaths, ploughing has two main objects: first, to break up the shallow layer of surface peat, and second, to reduce the compaction in the underlying mineral soil, breaking up the pan where this exists. Such work can be done with relatively simple but necessarily robust ploughs. The commonest type in use is the "tine" plough which can be used either with or without a mouldboard. Ploughs on heathland are used to give furrows at intervals of about five feet, and the furrows usually run round the contour, rather than up and down the hill, as in this way moisture is conserved and any tendency towards erosion is lessened.

The third main type of ground might be defined as sites where it is important to secure freedom from competing vegetation. Examples are grasslands on mineral soil and chalk downland. Various types of ploughs are used on these sites, including strengthened agricultural ploughs; ploughing is generally at 5-foot intervals, but occasionally complete surface ploughing is needed.

All ploughing as a preparation for planting requires a powerful tractor, and normal practice is to use standard commercial makes of about thirty to forty horsepower. On very soft peatland, tractors with specially wide tracks are required.

As explained above, single furrow, that is, partial ploughing with furrows spaced at five feet or more is the general rule, and there has been relatively little experience of more intensive cultivation. The risks of windblow with single-furrow ploughing, and the possibility of better growth where a large proportion of the soil volume is cultivated, have stimulated interest in complete cultivation on certain sites. Trials of multiple-disc ploughs for complete ploughing of heaths have proved disappointing, owing to the limited depth of cultivation achieved, especially in compacted soil or stony ground. Similarly, the use of heavy rotovators has proved impractical in all except the easiest conditions. The alternative of complete ploughing with single mouldboard subsoiler ploughs is slow and costly, but it may be that the results of such drastic soil disturbance on crop stability and long-term increment may justify the development of special equipment. This question cannot be answered until existing experiments have run their course.

Soil Improvement by the Use of Fertilisers

The effect of cultivation on the mobilisation and availability of nutrients has already been mentioned. Nevertheless, even after ploughing, certain heath and peat sites have a nutrient status which is inadequate to support vigorous tree growth. On these soils application of fertilisers at the time of planting is an essential adjunct to proper cultivation. Thus, on the poorest types of wet peat moorland and on dry upland heath, normal growth of conifers is impossible without the addition of phosphate fertilisers. Experiments over 30 years have shown that on the acid peats typified by *Scirpus* vegetation, phosphate manuring is highly beneficial and often essential to the survival of the crop. On poor peat in general, phosphate is the main requirement at planting, and in trials other nutrients, including nitrogen, potassium, calcium and magnesium, have had little effect.

On these poor soils, placed dressing of ground rock phosphate or superphosphate at 1½-2 ozs. per tree at planting is now general practice. The fertiliser is usually spread by hand around the base of each tree, but trials are now under way to cheapen the operation by mechanical drilling of the fertiliser beneath the plough ridge at the time of ploughing. There is little doubt about the economics of phosphate dressings at planting on poor soils, as in most cases the plants without treatment fail to grow at all, or at best, pass through a prolonged period of slow growth before canopy closure.

Fertilisers have been found of value in connection with the problem of improving "checked" or slow-growing plantations which have failed to close canopy. The majority of such crops are the result of inadequate preparatory cultivation or failure to apply phosphate at the time of planting. The result has been a slow-growing or totally checked crop. Experiments have shown that in some circumstances fertiliser top-dressing of such crops can produce a dramatic growth improvement in spruce or pine on poor sites. Once again, phosphate is a key element.

Large-scale top dressing of forest crops presents problems, but recent experience indicates that the use of aircraft for application at rates up to 3-4 cwt. per acre may be an economic proposition.

Improvement of soil productivity by the use of fertilisers in the crop phase has, so far, received relatively little attention in Britain. However, a large number of the earlier plantations have now reached the canopy stage, and more attention is being paid to the possible value of fertiliser top-dressings as a means of increasing crop increment. Manuring of crops after canopy closure is a new field of research in Britain, but there is a considerable background of experience in Europe and elsewhere, indicating that nitrogen, calcium and potassium may be limiting factors at this stage. There is clear evidence too, that in some older plantations on deep acid peat potash, deficiencies arise after the crops close canopy (Wright, 1956). To provide first-hand evidence, an extensive series of factorial N, P, K, Ca, Mg fertiliser trials are now being observed in "pole-stage" crops of pine, spruce and Douglas-fir on a wide variety of sites in Britain. These studies will be continued to provide data on the reaction of established crops to these nutrients and the possibility of diagnosis of deficiencies by soil and foliage analyses. At present, no top-dressings on other than an experimental scale have been applied to crops in the pole stage.

The foregoing account gives some impression of the practical value of adequate cultivation and manuring in preparing impoverished soils for afforestation. In Britain, amelioration of sites by these means has resulted in successful establishment of crops on large areas of land which would otherwise be incapable of supporting tree crops. Under more favourable conditions, proper site preparation has resulted in a marked increase in productivity as indicated by the quality class of crops. There still remains considerable scope for improvement, and the possible value of more intensive methods of cultivation and manuring than practised hitherto warrants full investigation.

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RESUMES

Amélioration du sol par le labourage et l'utilisation d'engrais

Le labourage et l'utilisation d'engrais sont indispensables pour établir de façon satisfaisante des peuplements sylvestres dans la plupart des régions d'Angleterre aux sols les plus pauvres. Le labourage consiste généralement à creuser á la charrue un sillon doublé d'un billon, l'espace entre chaque sillon étant d'au moins 5 pieds. Dans un terrain humide, les plants sont disposés dans le billon surélevé, et dans les terrains secs, au fond du sillon. Nous indiquons les avantages et les désavantages que présente le labourage, mais les premiers l'emportent de beaucoup sur les derniers, du moins pendant les premières années. Nous examinons également la question de l'utilisation des engrais, d'abord au moment de la plantation, puis dans des plantations dont la croissance s'est "arrêtée" ou ne se développant que très lentement, et enfin dans des plantations ayant atteint un stade assez avancé de développement. L'élément indispensable au moment de la plantation ainsi que pour l'amélioration des plantations "arrêtées" est le phosphore, mais pour les peuplements âgés, d'autres éléments peuvent être nécessaires dans certains terrains pauvres; c'est un fait maintenant connu que certaines tourbes acides sont déficientes en potasse.

Mejoramiento de Suelos por Medio del Cultivo y del Uso de Abonos

El cultivo y el uso de abonos son técnicas necesarias para establecer en las tierras menos fértiles de Gran Bretaña existencias provechosas de árboles. El cultivo por lo general consiste del arado de la tierra formando lomos y surcos en hileras separadas no menos de 5 pies una de otra. En tierras húmedas las plantas se colocan en el lomo y en zonas secas las plantas se colocan en los surcos. Se señalan las ventajas y las desventajas del arado; por lo menos durante los primeros años, las ventajas son mayores que las desventajas. Se analiza el uso de abonos al plantarse, en cultivos "regulados" o de crecimiento muy lento y durante las etapas del crecimiento. El fósforo es el elemento esencial al plantarse y para los cultivos de crecimiento lento, pero durante la fase del desarrollo pueden resultar necesarios otros elementos en lugares menos fértiles; se ha podido establecer que el potasio es deficiente en algunas turberas ácidas.

Evaluation of Chemical Analyses of Soils and Plants As Aids in Intensive Soil Management

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The intensification of silvicultural practice throughout the world has brought to the notice of foresters many areas in which forest growth, or the success of forestation, is limited by a deficiency of one or more plant nutrients (White and Leaf, 1957). If the future of forestry includes a wider use of fertilizers, and if the use of these amendments is not to be just on a trial-and-error basis, then it is imperative that adequate means be developed for detecting areas of poor nutrient status.

In the past, soil and plant analyses have been used to indicate nutrient deficiencies (White, 1958; Wilde, 1958), but neither method is wholly satisfactory; thus, an objective assessment of the merits and difficulties of both methods should be helpful to research workers and practicing foresters.

Techniques of soil and plant analysis attempt to indicate the level of availability of nutrients in soil to plants. Soil analysis attempts a direct measure of the soil nutrient supply and an indirect measure of plant nutrient uptake. The converse is true for plant analysis.

Field Sampling

Due to the impossibility of measuring the nutrient content of the entire soil or vegetation on a given area, it is necessary to collect relatively small samples for analysis. This imposes immediate problems, since both the soil and vegetation are heterogeneous (Jackson, 1958; Leyton, 1948).

Sampling position. In soil, considerable variations in nutrient contents occur with depth and location. Not enough is known about the uptake of nutrients from different parts of the soil to determine the best sampling technique. Thus, some advocate the use of a surface sample including, or as well as, the litter layers, while others sample by horizons or fixed depth intervals. Samples from a number of profiles may be composited or kept separate for laboratory analysis.

Plant analysis is believed to overcome the difficulties of heterogeneity of soils. However, there is an uneven distribution of nutrients in plants. Sampling of agricultural plants is usually restricted to a single part which shows a close relation to nutrient supply and less variation due to other, unrelated, factors. In trees with uneven vertical and lateral distribution of nutrients in crowns and boles sampling has usually been restricted to the current year's near-terminal foliage.

Sampling time. Seasonal variations in nutrient content are less important in soils than in litter and plants. For trees in temperate climates, it is usually recommended that sampling be restricted to the dormant season for evergreens and just prior to leaf discoloration for deciduous species.

Yearly variations in nutrient content are of importance in soils as well as in plants. For soils, this variation is due to the modifying influence of vegetation on the soil. For plants, the variation is due to growing season conditions, including length of frost-free period, temperature, and total amount and distribution of precipitation.

Plant analysis assumes the presence of the plant on the site, but the use of bio-assays by advocates of soil analysis suggests that one species may be used as an indicator for others.

Laboratory Analyses

The samples of soils and plants may be analyzed with precision in the laboratory, but the results are applicable to the samples and may not truly reflect field conditions unless the samples are representative. In the laboratory, soils pose more problems than plant material.

Sample preparation. The handling of samples can make considerable differences as to the results obtained from analyses. Some suggest that foliage samples should be washed to remove dust prior to analysis. This may be possible for large-leaved species, but becomes increasingly difficult with small leaves or needles.

Soil and plant samples are usually dried prior to analysis at temperatures ranging from 60° to 105° C. The lower temperatures are necessary to reduce volitalization of nitrogen. Drying soil samples may also affect the results of analyses for other elements, especially potassium. Drying plant samples is especially important soon after collection in order to stop metabolic activities which alter their weights.

Following drying, the soils are sieved, usually through a 2 mm. mesh, to remove stones. Care is used to destroy aggregates but not break up mineral particles. The plant tissue is ground to pass a fine mesh sieve, but this may cause differential loss of tissue as well as contamination.

Sample treatment. Chemical analyses involve aliquots of homogenized samples. Plant samples are usually analyzed for their total contents of various elements, whereas for soils this is generally true only for nitrogen. For the other soil nutrients, an attempt is made to measure the so called "available to plants" fraction by leaching with various extractants. Thus, plant analysis has the advantage that all the elements except nitrogen may be determined from a single aliquot. With soils, different extractants are often used, depending on the element investigated. Extractants range from distilled water to boiling, concentrated acids. The use of these extractants attempts to remove a quantity of the various nutrients available for uptake by plants. In the past, most effort has been devoted to the development of analytical techniques for phosphorus and potassium, while the other elements have received relatively little consideration. Some extraction methods are more successful than others, though most of the data refers to agricultural crops and may not be applicable to forestry, where effects of mycorrhizae may be of considerable importance. Although it is known that extracting solutions have different efficiencies in leaching nutrients from mineral soil and organic matter, it is not known to what extent trees obtain nutrients from these two sources or how much the results of analyses are affected by the relative amounts of these two constituents in the soil.

Interpretation

Careful interpretation is absolutely essential to make the best use of soil and plant analyses. The ability to interpret results is dependent on the knowledge of the factors which govern growth and nutrient uptake by plants (Kozlowski, 1956; Leyton, 1957).

Soil analyses. Results from soil analyses are usually reported on a concentration basis, e.g., percent, parts per million, or milliequivalents per 100 grams. Except for nitrogen, the analytical results are often reported as oxides. This multiplicity adds to the difficulty of comparing data and may lead to confusion.

To properly interpret analytical data it is necessary to convert results from concentrations to contents on an area basis. To make this conversion, weight per unit volume and stoniness must be known. This is obvious if the range of soils is from organic through alluvium to talus origin, especially when it is remembered that samples are sieved to remove stones prior to analysis.

In the past, foresters who have attempted to relate tree growth to soil characteristics have most frequently measured tree growth in terms of height over age. The following data have been compiled to show how, in agriculture, the method of assessing the reliability of soil analyses markedly affects the result:

Significance of correlations between plant characteristics and soil analyses

Plant characteristics	Significant at 5% level	Not significant	Total
Total chemical content	76	3	79
Total yield	73	27	100
Response to fertilizers	5	9	14
Total	154	39	193

Thus, soil analyses are more frequently related to nutrient uptake than to dry matter production, a conclusion which is not particularly surprising. The fact that soil analyses are least successful in predicting response to fertilizers only emphasises our lack of knowledge on the fate of applied fertilizers and the relationship between growth and the relative availability of all the elements necessary to plant growth.

Plant analyses. Results from plant analyses are usually reported on a concentration basis and relate to a specific portion of the plant. A serious problem is that it is not known how the percentage nutrient content of different parts of the tree is related to the total uptake by the tree. However, relationships have been found between height growth and concentration of nutrients in a near-terminal foliage, but these relationships may be expected to break down in cases of luxury consumption.

Establishment and use of standards. In the past, attempts have been made to establish standards for adequate or deficient nutrient levels in soils and plants. However, these attempts raise many problems and may be of questionable value. Variations in analyses related to sampling position, seasonal and long time changes, and sample treatment increase the difficulty of establishing standards. For example, extrapolation of greenhouse data to the forest is unwise until more is known about the effects of age and environmental factors, other than soil nutrients, on the growth and mineral nutrition of trees. Additional difficulties result from the interaction between nutrients, since unbalance as well as deficiencies may affect growth, e.g., ion antagonism.

To use standards, it is necessary to work under the same conditions so that comparisons may be made.

Conclusions

It should be clear from this review of soil and plant analysis that considerably more information on many aspects of growth and mineral nutrition of trees and on aspects of soils and fertilizers is necessary before an adequate method is found for predicting response to fertilizers. At the moment it can only be said that, below certain levels of soil and plant nutrients, deficiencies may be present.

Foresters have to rely on agriculture for much of their knowledge, and even with much larger resources for research, agriculturists are far from an adequate knowledge of plant growth and nutrition. In forestry, several studies were made of nutrient uptake by various species in the 19th century, and these have been summarized in an attempt to obtain an idea of the nutrient requirements of timber crops (Rennie, 1955). However, it is only in recent years that a vigorous attempt has been made to work out some of the details of growth and mineral nutrition of different species (Ovington and Madgwick, 1959). Analyses of complete trees allow an estimation of the total uptake and distribution of nutrients within tree stands and overcome the problems of selecting sampling positions and expressing plant analyses purely on a concentration basis.

Unfortunately, interpretation of studies of complete trees is subject to many of the difficulties associated with plant analysis. There is no known way of differentiating between luxury consumption and uptake necessary for tree growth. Variability between trees is great, so that adequate sampling of a stand requires analysis of several trees. The effect of species, soil characteristics, sampling season, translocation of nutrients and washing of leaves by precipitation, on the nutrient cycle are practically unknown.

The need for fundamental research on all aspects of tree nutrition is obvious. Perhaps for several years to come the most effective way to determine nutrient deficiencies will be through fertilizer trials, but a judicious use of both soil and plant analyses prior to the establishment of such trials might well save foresters a considerable amount of time and effort.

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RESUMES

Evaluation des analyses chimiques des sols et des plantes en tant que moyens d'aménagement intensif des sols

L'analyse des sols et celle des plantes ont été utilisées pour indiquer l'insuffisances d'éléments nutritifs, mais ni l'une ni l'autre de ces méthodes ne s'est avérée entièrement satisfaisante. Il serait donc indiqué d'arriver à une évaluation objective des mérites et difficultés des deux méthodes.

Les méthodes utilisées dans l'analyse des sols et des plantes visent à déterminer le niveau d'éléments nutritifs disponibles dans le sol pour les plantes. La valeur des résultats analytiques ainsi obtenus est modifiée par des problèmes d'échantillonnage (y compris celui de la position et du temps de collecte de l'échantillon), des analyses de laboratoire, de préparation et de traitement de l'échantillon et de l'interprétation des résultats. Et dans cette dernière, il faut inclure le problème de l'établissement et de l'utilisation d'étalons.

Etant donné qu'il est impossible de mesurer le contenu nutritif du sol ou de la couverture végétale d'une zone entière, il est nécessaire de recueillir un nombre relativement restreint d'échantillons. Ceci pose immédiatement des problèmes puisque le sol aussi bien que la végétation sont hétérogènes.

Ces échantillons de sols et de plantes peuvent être analysé avec précision dans les laboratoires, mais les résultats ne sont applicables qu'aux échantillons eux-mêmes et ne reflètent pas les conditions actuelles à moins qu'il n'y ait certitude que les échantillons soient vraiment représentatifs. En laboratoire, les sols posent un problème plus ardu que les végétaux parce que l'on s'efforce de mesurer la fraction des éléments nutritifs du sol qui est vraiment assimilable par les plantes.

Une interprétation minutieuse est absolument essentielle pour l'utilisation optima des analyses de sols et de plantes. La capacité d'interpréter les résultats des analyses dépend de la connaissance des facteurs qui régissent la croissance des plantes et leur capacité d'absorption nutritive.

L'analyse d'arbres entiers ne résout que partiellement quelques-unes des difficultés d'analyses de parties spécifiques d'un arbre.

La nécessité d'étendre les recherches de base à tous les aspects de la nutrition des arbres est évidente. Il se peut que pendant soit celle qui plusieurs années encore la méthode la plus efficace de déterminer des insuffisances nutritives comporte des essais d'engrais; mais une utilisation judicieuse d'analyses du sol aussi bien que de plantes avant le début de tels essais pourrait fort bien épargner au forestier une perte de temps et d'efforts considérable.

Evaluación de los Análisis Químicos de Suelos y Plantas como Ayuda para la Administración Intensiva de Suelos

Los análisis de suelos y plantas han solido usarse para determinar las deficiencias de nutrición, pero ninguno de los dos métodos es totalmente satisfactorio; por ello merecen examinarse los méritos e inconvenientes de ambos.

Los métodos de análisis de suelos y plantas tratan de determinar el grado de nutritivos que el suelo tiene a la disposición de las plantas. El valor de los datos analíticos sufre con los problemas del muestreo en el terreno, que incluyen los de tiempo y posición de las muestras, los de los análisis de laboratorio que incluyen los del tratamiento y preparación de muestras y, finalmente, los de interpretación para la determinación y uso y tipos.

Como es imposible evaluar el contenido nutritivo de todo el suelo o la vegetación de un espacio dado, los que se coleccionan para el análisis son muestras relativamente pequeñas. Esto acarrea ensequida problemas porque tanto el suelo como la vegetación son heterogéneos.

Las muestras de suelos y plantas pueden ser analizadas con precisión en el laboratorio, pero los resultados son aplicables sólo a las muestras y quizás no reflejan exactamente las condiciones del campo, a no ser que dichas muestras sean verdaderamente representativas. En el laboratorio, los suelos presentan más problemas que las materias vegetales debido a que lo que se trata de determinar con el análisis es la fracción de sustancias nutritivas del suelo " a la disposición de las plantas."

Para hacer mejor uso de los análisis de suelos y plantas es absolutamente necesario darles cuidadosa interpretación. La habilidad de interpretar los resultados depende de los conocimientos que se tengan de los factores que gobiernan el crecimiento y la absorción de nutritivo en las plantas.

Los análisis de árboles completos vencen solamente algunas de las dificultades de los análisis de partes específicas del árbol.

Es evidente, pues, la necesidad de estudiar básicamente todos los aspectos de la nutrición de los árboles. Quizás, por muchos años más, el medio más eficaz de determinar las deficiencias nutritivas sea por medio del ensayo de abonos, pero un estudio prudente de los análisis de suelos y plantas antes de dichos ensayos quizás ahorre considerable tiempo y esfuerzo a los silvicultores.

Use of Mycorrhizae for Afforestation

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This paper reports the results of research started in 1953 by the Microbiological Laboratory of the Forestry and Game Management Research Institute. Apart from detailed ecological studies on different outstanding forest types, we are working on problems of mortality reduction of plants in the first years after planting. Experiments are carried out on beech, linden (*Tilia parvifolia*), Norway spruce, Scots pine, larch, silver fir and others. The work is in progress.

In 1957, experiments were laid down with mycorrhization of oak acorns stored in low heaps during winter in a forest stand. Inoculation experiments used mycorrhizal soil from oak stands, and 1,242 oak plants were eventually included in the tests. These experiments suggest that mycorrhizated oak acorns may yield about 34 per cent more plants than oak acorns without the mycorrhizae.

In 1953, ameliorating experiments were made by adding diabase into patches under the acorns on degraded soil with ortstein. The results of six years show that diabase addition into patches with raw humus gave about 300 per cent more oak plants than did soils without diabase. The growth of mycorrhizae was stimulated, and there is a clear relationship between the physical-chemical amelioration of soil and the mycorrhizae on the one hand and plant growth on the other. These ameliorating experiments include 533 oak plants. Other experiments with inoculation of oak acorns include 6,400 oak plants. Inoculation was made at the time of sowing into patches on a fertile agricultural soil. The following effects were shown: addition of pure mycelia gave an increase in increment of about 8 per cent, addition of mycorrhizal soil, 5 per cent—when compared with oak acorns without mycorrhizae—after five years' observation. Other experiments on 390 oak plants can be summarized in the results of 1955. The addition of mycorrhizal soil increased the height of inoculated seedlings by about 52 per cent.

It is interesting to note that experiments with inoculation of oak acorns in furrows gave no positive results. Further detailed examination of 485 oak plants revealed that plants with mycorrhizae grew better than plants without mycorrhizae.

To sum up, in twenty experiments with mycorrhizae, I found the following principal results: physical-chemical properties of soil are the main factors for plant growing; and variability and frequence of the mycorrhizae are symptoms of soil conditions. For this reason, further work of the Microbiological Laboratory is the initiation of experiments with the main object of finding such symbiotic fungi of tree species as can also produce effective mycorrhizae in unsuitable site conditions.

RESUMES

Emploi de la mycorhize dans le reboisement

Ce document résume les travaux de recherche poursuivis par le laboratoire microbiologique de l'Institut de Recherche de Zbraslav Strnady en matière de sylviculture et d'aménagement du gibier. Les essais réalisés démontrent clairement la stimulation de croissance produite chez différentes espèces d'arbres. Les essais d'amélioration devraient être orientés vers la recherche de champignons symbiotiques susceptibles de produire des mycorhizes efficaces dans des milieux défavorables. Les travaux de recherche sur les mycorhizes entrepris en 1953 se poursuivent.

Empleo de Mycorrhizae para el Embosquecimiento

Este trabajo resume las actividades de investigación del Departamento Microbiológico del Instituto de Investigaciones de Administración de Bosques y Fauna, en Zbraslav Strnady. Los experimentos realizados dieron prueba de la eficacia del método para estimular el crecimiento de diversas especies de árboles. Los experimentos de mejoramiento deben concentrarse en la búsqueda de hongos simbióticos, capaces de producir mycorrhizae eficaces en suelos desfavorables. Los trabajos de investigación con las mycorrhizae se iniciaron en 1953 y continúan en la actualidad.

Recent Results of Fertilizer Experiments in Swedish Forests

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Although experiments with addition of plant nutrients to forest soils have been carried out for more than 50 years in Europe and some 25 years in the United States, our knowledge is still very incomplete regarding the possibilities for a lasting improvement of the nutrient cycle of the forest. It has been shown that a deficiency in mineral nutrients, e.g., K or P, on peaty or sandy soils can be cured for a long time by a single application of fertilizer. Several cases have been reported from middle Europe, where addition of mineral nutrients and/or lime has improved the forest yield over a long period, although the main deficiency was in nitrogen. Often the effect may be explained by intensified biotic nitrogen fixation, but sometimes it is ascribed to accelerated decomposition of the organic matter in the soil, followed by an increase in nitrogen mobilization. This increase in turnover is expected to produce but temporary growth improvement, however. A more lasting effect may be obtained in cases where the treatment leads to a change of the humus layer from mor to mull. While it seems doubtful whether the nutrition of a stand growing on mull is always superior to that of a stand growing on a similar site with mor, certain advantages of the mull site do exist—superior moisture conditions and deeper root penetration.

According to the evidence of field experiments, foliar analyses, and soil analyses, a deficiency in nitrogen appears to be widespread in the northern coniferous forests. In fact, the normal state of a coniferous forest with mor cover and podzol profile is characterized by a keen competition for nitrogen (cf. Romell, 1935). Only clear-fellings and burnt sites *may* have an ample supply of soluble nitrogen for a limited period.

Several questions remain to be answered in this context:

1. How long is a single application of nitrogeneous fertilizer effective?
2. Do stands from different sites and of different tree species respond in the same way to the same treatment?
3. Is it possible in Sweden to improve the nitrogen status indirectly, and hence the growth, by application of minerals and lime, as in some southern countries?

It would also be of great interest to know:

4. What is the effect of fertilizer application on the wood quality?
5. What is the fate of the plant nutrients supplied; viz, the amount used by the stand?

Several series of experiments have been laid out in Sweden with the primary intention of answering the questions 1-3. Since most of the experiments started in the fifties, only a few results are available. However, we have additional data from an experiment started by Romell in 1935 and 1936, where the measurements cover a considerably longer period than that in most other experiments (Fig. 1 from Romell, MS). In this case the experimental plots were located in a slow-growing 250-year-old spruce stand at relatively high altitude (450 m. or 1,470 feet above sea level) in middle Sweden. Save for the nitrogen application, which consisted in sprinkling a weak aqueous solution of ammonium nitrate every other week during the summers of 1936, 1937 and 1938, the treatments were given in 1935 and 1936. The total amount of N added was equivalent to 420 kgs. per hectare. Also, the applications of other fertilizers were rather heavy. Per hectare, plot IV ("Minerals") thus

Figure 1

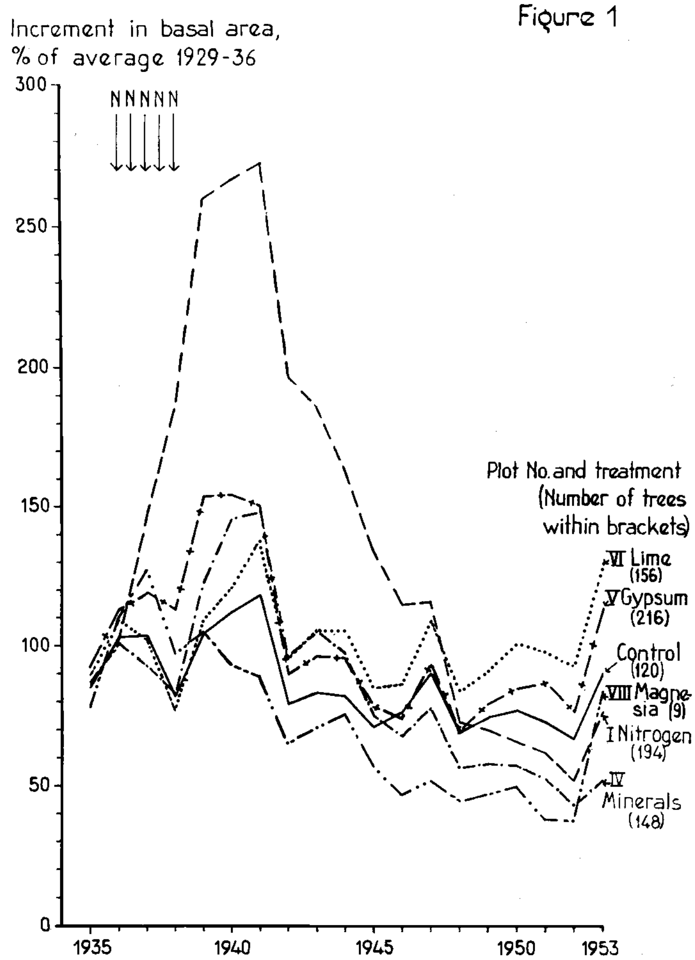

Table 1. Data on the experimental plots

Expt. No.	Lat. N.	Long. E.	Status of the growing stock on the control plots at the start of the experiment: Species	Age (yrs.)	Height[a] (m.)	Basal area (m.²/ha.)	Volume (m.³/ha.)	Mean annual growth during the experimental period — Control plots: Basal area (m.²/ha.)	Control plots: Volume (m.³/ha.)	Fertilized plots: Range of volume growth variation (m.³/ha.)
870	59°50′	15°50′	0,57 Pine	50	17,4	25,8	169	0,75	6,7	8,4–11,6
			0,43 Spruce	60	17,0					
871	59°30′	13°40′	0,08 Pine	59	21,2	21,5	187	0,58	7,9	8,1–12,2
			0,92 Spruce							
877	56°40′	16°10′	1,00 Pine	42	11,9	15,7	76	0,61	4,2	4,8– 5,5
883	56°50′	12°50′	1,00 Spruce	49	21,4	26,3	232	1,02	13,5	13,1–15,3
884	56°50′	12°50′	1,00 Beech	40	11,8[b]	16,1	91	1,35	12,2	12,0–16,4

[a] Upper height, i.e., mean height of largest trees.
[b] Mean height of all trees.

received 3,200 kgs. of rock phosphate and 4,000 kgs. of mica (phlogopite), and plot VI ("Lime"), 6,400 kgs. of ground limestone.

As shown in Figure 1, a clear growth response was obtained only in the case of ammonium nitrate application. Raising the annual basal area increment from about 1 per cent to between 1.5 and 2 per cent, the effect lasted for about ten years. Corresponding increase in volume growth was between 1 and 2 m³. per hectare and year. Thus, the strong relative growth response was not equal to a very great increase in absolute increment; of course, the high age and poor state of the stand at the start of the experiment was the reason.

Recent experiments have been laid out in younger stands. Table 1 presents data from five experiments revised in 1958 and 1959. Experiment No. 870 is situated in middle Sweden on a rather normal moraine soil with mor cover and podzol profile-conditions characteristic of a large part of the forest soils in Sweden. Experiment No. 871 has superior soil (silty and clayey) and more favourable moisture conditions. Experiment No. 877 represents a pine stand on dry sandy soil in the part of the country which has the lowest humidity. Experiments Nos. 883 and 884, on the other hand, are situated in humid southwestern Sweden on a moraine soil with low stone content. Experiments Nos. 871 and 884 are located on gentle slopes; all the others on level sites. Experiment No. 883 consists of a spruce stand planted on old farm land; all the other stands grow on forest land.

The species Scots pine, Norway spruce, and European beech are listed with their volume proportions in Table 1.

Essentially similar in all five experiments (and in several other experiments not yet revised), the experimental plan comprises: one control plot, one plot with two separate additions of 100 kgs. of nitrogen per hectare (as nitrochalk), one plot with minerals (usually about 100 kgs. of potassium as sulphate and 50 kgs. of phosphorus as basic slag, with or without some lime), and one plot with both nitrogen and minerals. A plot with 10,000 kgs. per hectare of ground limestone, too, has been included, where possible, and in experiments Nos. 871 and 883, also a plot with both lime and nitrogen. (The so-called lime plot in experiment No. 871, however, also received one nitrogen application in 1957.) All fertilizers were spread by hand.

Small differences in stand structure between the plots occur in each experiment. These differences presumably are responsible for some of the irregularities obtained when the growth response is measured as increase in volume growth per unit area. The group occurrence of trees affected by root rot within experiments Nos. 871 and 883 may also contribute.

The most consistent results are those representing the relative growth within the various plots in each series. Increment cores were extracted from a considerable number of sample trees in all experiments except No. 884 (with beech). The length of the terminal leader during periods before and after the treatment was also measured. This, however, could be made on felled trees only. The averages of the height growth and the radial growth for a particular plot in a particular year were then expressed in per cent of the corresponding figure for the year before the treatment. The values calculated in this way were then divided by the value for the same year in the corresponding control plot to give the relative growth values plotted in Figures 2 and 3 (growth of control plot = 100).

It can be concluded from Figures 2 and 3 that application of ammonium nitrate increased the radial growth at least in three of the experiments (Nos. 870, 871, and 877). The height growth response is not so clear, perhaps because of the small number of trees measured, but there is a tendency to improved growth in fertilized plots. It seems doubtful whether there is any effect of minerals only.

Experiment No. 877 is of particular interest regarding the duration of the nitrogen response, because here the effect has evidently disappeared already after six years. At present, it is not clear whether this rapid culmination of the fertilizer effect is caused by the dry site or the species (cf. Tamm, 1956). It is also possible that the occurrence of two extremely dry summers since the start of the experiment (1955 and 1959) would contribute.

The absence of strong response in experiment No. 883 is another remarkable feature in the diagrams. Yet, the volume increment recorded in all three of the nitrogen fertilized plots is higher than that in any of the other

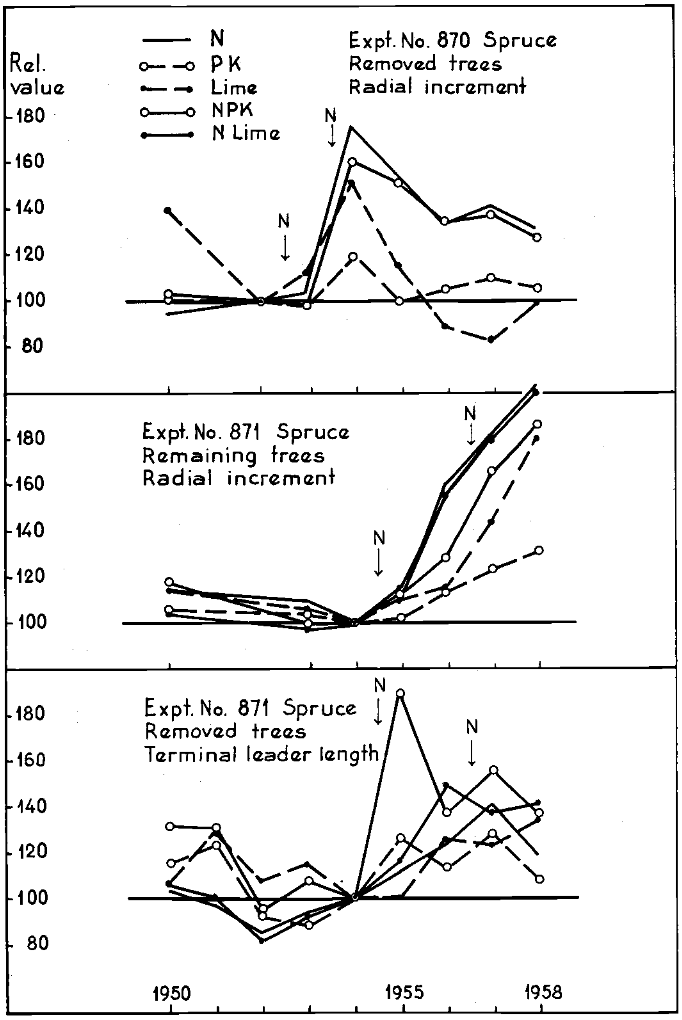

Figure 2

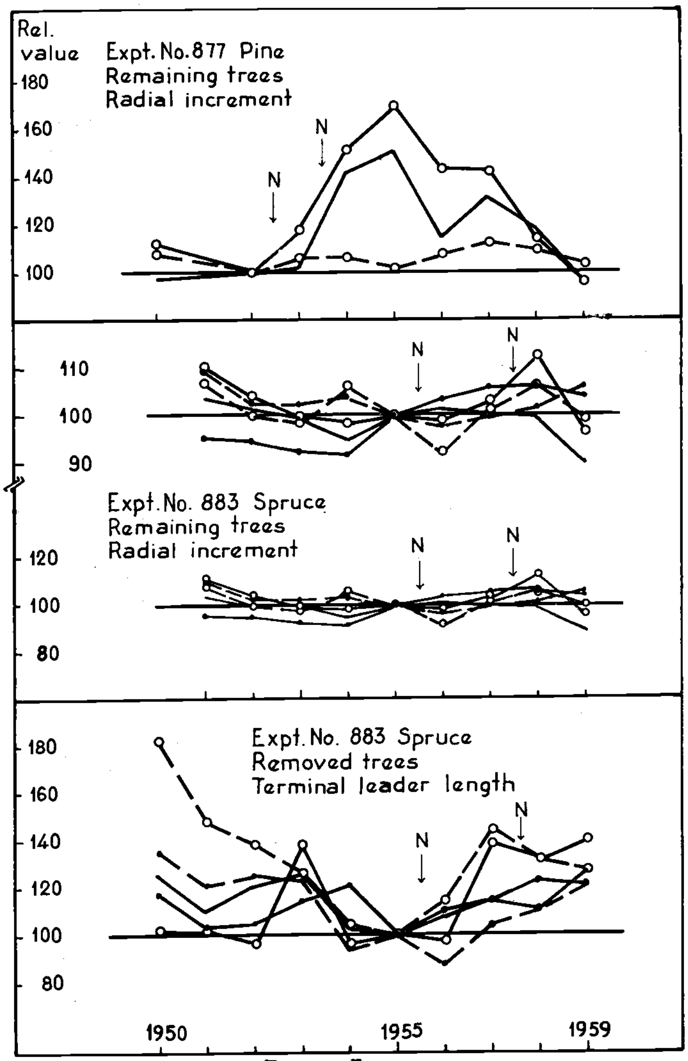

Figure 3

plots, but the difference is small. It seems natural to infer that the growth of this excellent spruce stand would be less favoured by artificial supply of plant nutrient than the growth of poor stands. The beech stand in the neighbourhood, experiment No. 884, may grow on a site superior to that of the spruce stand, middle of a long slope versus plateau No. 883. The growth measurements seem to indicate that beech has reacted better than spruce. The site of these two experiments, although not very rich from the geological point of view, must be classified as most favourable to the spruce but only moderate to the beech, which is here growing not far from the northern limit of its geographical range. The results can be compared with those of Mitscherlich and Wittich (1958), who found good growth responses on most of their plots in the Black Forest, also when the site was good.

It is not possible to discuss here in detail the results of the soil and foliar analyses carried out in most plots. It can only be mentioned that so far there is no indication of a positive effect of the lime application on the nitrogen content of the needles during the first five years. The phosphate applications, however, have generally resulted in an increase in foliar phosphate, while the increase in foliar potassium is less. A relationship between foliar phosphate and the amount of easily soluble soil phosphate, too, seems to exist.

In two of the experiments, Nos. 871 and 883, an attempt has been made to estimate the total nutrient uptake of the trees. Only a relatively small part of the added plant nutrients can be accounted for in the standing trees (less than 15 per cent of the nitrogen added in experiment No. 871, still less in other cases).

On the basis of increment cores, the wood formed after fertilization has been compared with that formed in the control plots and with that formed in the same plot before treatment, also with respect to late-wood content and density (Ericson, 1959, 1960). The potential changes in wood quality after fertilization have received very little attention in most earlier investigations (cf., however, Erickson and Lambert, 1958).

Rather definite answers to the questions listed above can now be given:

1. Not even the effect of a heavy application of ammonium nitrate can be expected to last longer than 10-12 years; under unfavourable conditions, only half that time.

It would be interesting, however, to make new long-term experiments with gaseous ammonia or other fertilizers producing similar effects.

2. A strong growth response can be expected on most sites after the addition of soluble nitrogen, the effect probably being smaller if the site index is very high.

3. The present results do not support the assumption that liming or mineral fertilization should increase the turnover in the soil, increase the nitrogen supply and improve the forest growth on Swedish moraine sites. However, it is not excluded that the effect exists, though it is very slow. The fact that the limed plot showed the highest basal area increment in Romell's experiment 18 years after treatment is suggestive.

4. In the slow-growing pine stand in experiment No. 877, wood density and late-wood content were not affected by the increase of annual ring width caused by artificial nutrient supply.

In other cases the growth increase was followed by a moderate decrease in wood density. Thus, the growth effect measured in kgs. of wood produced per unit area is slightly lower than its expression in volume per unit area.

5. Although the foliar analyses show definite changes in needle composition after fertilization, relatively little of the added plant nutrients are utilized by the stands. Much of added nitrates is presumably leached out, and this probably holds true also for a part of the other soluble salts. Phosphates and lime are better retained.

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RESUMES

Résultats de récentes expériences faites avec des engrais dans les forêts de la Suède

Des expériences très complètes ont été faites en Suède au cours des six dernières années dans le but de réunir de plus amples renseignements sur l'action des engrais azotés et minéraux dans différentes localités. Certaines de ces expériences ont fait l'objet de révisions et les résultats sont examinés ici en même temps que les nouvelles données obtenues à la suite d'une expérience déjà entreprise en 1935 et 1936 par Romell.

Ces expériences confirment l'opinion générale selon laquelle les forêts de Suède souffrent d'une déficience en azote générale dans les terrains riches en minéraux, et qu'on n'obtient que des résultats négligeables ou nuls en appliquant des engrais minéraux sans azote, du moins pendant une courte période. L'application de nitrate d'ammonium (comme la nitrocraie dans les nouvelles expériences) a intensifié la croissance dans tous les cas: l'effet a été limité dans le cas d'un peuplement d'épicéas ayant un indice de station élevé, et extrêmement marqué dans le cas d'un vieux peuplement d'épicéas à croissance lente et dont la croissance semble avoir été gênée à l'origine par un manque d'azote assimilable. L'augmentation de croissance a persisté pendant 5 à 6 ans dans un peuplement de pins en sol sableux sec et deux fois plus longtemps dans la vieille forêt d'épicéas. En ce qui concerne le reste des expériences, la croissance était encore plus marquée sur les parcelles "N" que sur les parcelles témoin au moment des révisions.

L'application de nitrate d'ammonium a fait diminuer légèrement le poids du bois par unité de volume dans certaines des expériences, mais est resté sans effet dans d'autres. Une fraction relativement réduite des substances nutritives semble avoir été utilisée par les peuplements et au bout de cinq ans, seuls le phosphore et la chaux apparaissaient encore en quantités mesurables dans la couche végétale du sol.

Resultados Recientes de los Ensayos de Abonos en los Bosques de Suecia

Durante los últimos seis años se han realizado en Suecia extensos ensayos con el fin de obtener mayor información sobre los efectos de abonos nitrogénicos y minerales en diferentes sitios. En este trabajo se estudian algunos de estos experimentos y se discuten sus resultados, conjuntamente con los nuevos datos aportados por los ensayos hechos en 1935 y 1936 por Romell.

Queda confirmada la opinión corriente de que en Suecia la deficiencia de nitrógeno es muy común en los bosques de suelos minerales y de que poco o nada se obtiene con aplicar fertilizantes minerales sin nitrógeno, al menos durante un período relativamente corto. El empleo de nitrato de amonio (como nitrocarbonato de cal en los nuevos ensayos) aumentó el crecimiento en todos los casos: el efecto fue ligero en el de un abetal con un elevado índice de medio estacional y extremadamente eficaz en el de un abetal de desarrollo lento, impedido en su creciemiento, al parecer, por una deficiencia de nitrógeno. La duración del nuevo impulso de crecimiento fue de cinco a seis años en una pinar de terreno arenoso seco y el doble de años en el viejo abetal. En el resto de los ensayos, el creciemiento fue aún mayor en parcelas con nitrógeno (N) que en las parcelas utilizadas como control.

El suministro de nitrato de amonio disminuyó ligeramente el volumen depeso de la madera en algunos experimentos, pero no tuvo efecto en otros. La cantidad del alimento nutritivo adicional usada por los rodales fue relativamente pequeña y después de cinco años sólo quedaban en la capa superior del suelo pequeñas cantidades de fósforo y cal.

Forest Fertilization in Eastern North America

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The abandonment of vast acreages from agriculture since the turn of the century and the increasing demands upon the forests for lumber and pulp have inspired concern for intensifying forest management in Eastern North America. Since cellulose production is enhanced by nutrient fertilization of such fibrous crops as cotton and flax, it seems possible that forest trees, too, may benefit from supplements of inorganic materials. Within the past decade much effort has been expended to test this hypothesis in the region.

Generally, where particular nutrient deficiencies are unknown, high-analysis complete fertilizers, such as 12-12-12, are being tested. While, for the present, experimental applications are made by hand, in at least two tests pelleted materials have been applied by fixed-wing aircraft (White, 1956). It appears probable that, if fertilizers are employed in practice, aerial applications will be used. In a New York test in which 200 pounds per acre* of KC1 was applied, total cost for the treatment was $13.00 per acre.

The North

A discussion of forest fertilization in Eastern North America should properly begin, it seems, with the monumental work of Heiberg and White (1951) in the Adirondack sand plains of northern New York. In those soils of glacial outwash origin, red pine (*Pinus resinosa* Ait.), white pine (*P. strobus* L.), white spruce (*Picea glauca* (Moench) Voss), and Norway spruce (*P. abies* (L.) Karst.) responded to 200 ppa of KC1 (60% K_2O). Annual height growth increased from 46% to 104% over non-fertilized plots, and the effect of treatment lasted for at least six years.

Symptoms accompany K deficiency of these soils which were intensively farmed for about 100 years prior to the agricultural depression of the 1920's. The abnormal characteristics are (1) needle chlorosis, (2) stunted seedlings and saplings, (3) short needles, and (4) persistance of needles on branches for less than the usual number of years. Lafond (1950) notes similar symptoms in Canada.

Soils derived under similar conditions of climate and geology also become Mg deficient for the growth of red pine, white pine, and jack pine (*Pinus banksiana* Lamb.) (Stone, 1953). The most conspicuous symptom of this malnutrition is bright yellow discoloration of tips of the current year's needles. Only under extreme Mg deficiency is growth seriously affected. Treatment with $MgSO_4$ (20-50 ppa Mg) alleviated symptoms and resulted in increased height growth for at least three years. A recent report by Swan of Canada verifies the occurrence of this symptom for jack pine. However the symptom was not apparent for white spruce, black spruce, and western hemlock. Swan worked with environment-controlled seedlings.

With the background of Heiberg and White (1951) and Stone (1953), we endeavored to relate the amount of K in foliage of naturally occurring vegetation to availability of K in the soil and to observe deficiency symptoms in native trees, shrubs, and herbs. To do so would supply diagnostic aid in selecting tree species for planting on these adverse sites—so adverse that frequently a retrogression in quality of vegetation is apparent: abandoned hay field to poverty grass to *Polytrichum* moss to less demanding mosses and lichens to no vegetation and erosion. The most notable foliar-soil K relationship was for white pine (Fig. 1). K in chokecherry (*Prunus virginiana* L.) and trembling aspen (*Populus tremuloides* Michx.) foliage also appeared to be related to exchangeable K in the soil (Walker, 1955a).

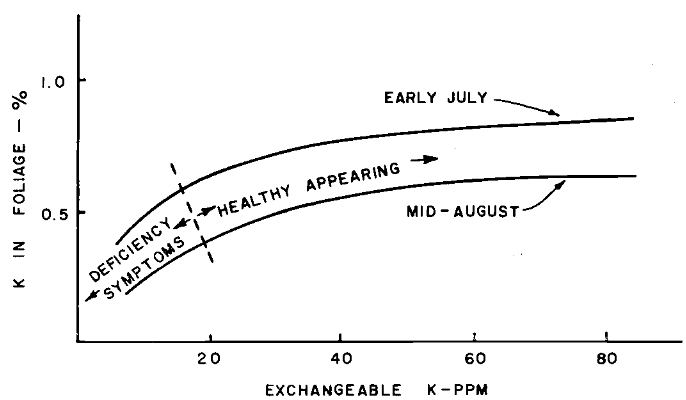

Figure 1. Exchangeable K in the soil plow horizon and in foliage of white pine. Note the decrease in needle K during the 6-week interval.

Abnormal colorations indicative of K-deficient soils were observed in foliage of black cherry (*Prunus serotina* Ehrh.), gray birch (*Betula populifolia* Marsh.), red maple (*Acer rubrum* L.), and blackberry bushes (*Rubus* subgenus *Eubatus*). For black cherry, bright red pigmentation occurred at leaf margins (Fig. 2), and gray birch had chlorotic margins sharply delineated from normal tissue. Red maple leaves were evenly chlorotic, and blackberry leaves displayed marginal browning. All of these symptoms were removed by fertilizing with 200

* Hereinafter referred to as ppa.
1 pound per acre = 1.1 kilograms per hectare.
1 kilogram per hectare =0.89 pounds per acre.

ppa of KC1 (Walker, 1956). On sites displaying these abnormalities, K must be applied in, perhaps, the third or fourth year, if suitable growth of demanding species is to be obtained.

Growth of poplar trees in Quebec, Canada, has been substantially increased by applications of 300-500 ppa of 10-10-10. There, method of placement is deemed important, as materials applied deep in the soil gave better results than broadcast applications. Elsewhere in Canada, in the province of Ontario, lime is being used in tests to improve growth of hardwoods. Applications of ten tons per acre of dolomitic limestone resulted in increased exchangeable Ca in *F* and *H* layers, but no downward movement in mineral soil was noted, nor was the Ca content of maple (*Acer* sp.) seedlings improved (Armson, 1959).

Recently Heiberg, Leyton, and Loewenstein (1959) related total yield to uptake of N, P, and K by tree parts in K-deficient sites for red pine of deep outwash sands. They noted the substantially greater height growth and amount of K taken up by trees planted at 6x6 foot spacing than by those at 4x4 foot spacing when from 50 to 150 ppa of K was applied. It was suggested that the total K uptake in plots given 150 ppa of K was 70 pounds higher than controls. Assuming the fertilizer provided all of the extra K, the efficiency of utilization was about 50 percent. The influence of the fertilizer was evident almost 10 years after treatment.

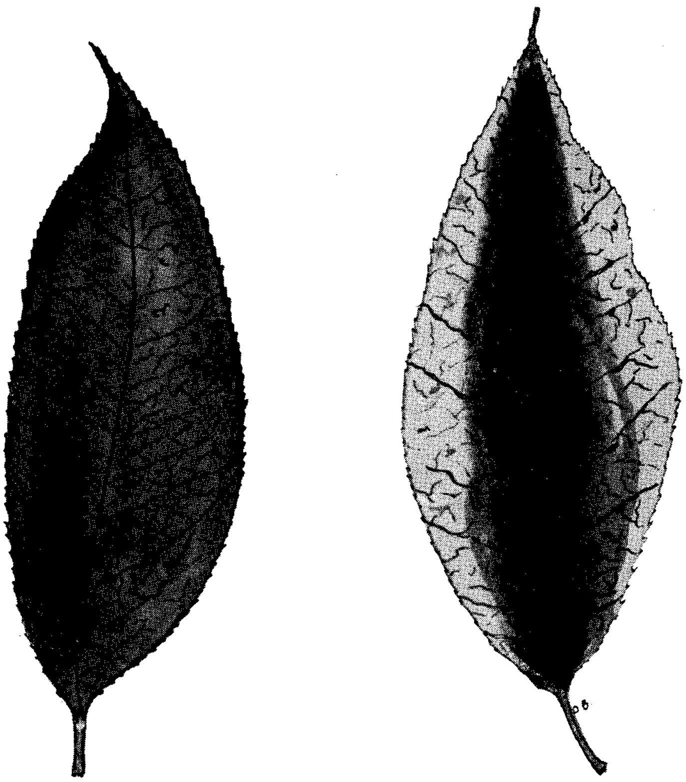

Figure 2. Abnormal coloration (red) at margins of K-deficient black cherry leaf (right), normal (left).

North-Central Region

Boggess and Gilmore (1959) obtained a significant increase in diameter growth of shortleaf pine (*Pinus echinata* Mill.) using 100 ppa each of N and P in a loess silt loam soil of Illinois. The stand contained 775 trees per acre and was 22 years old at time of treatment. After two years, the average diameter growth for treated trees was 4–6%, in contrast to 3–5% for check plots. Nitrogen alone produced a slightly smaller response (Gilmore and Boggess, 1960).

Treating red pine plantations in sites of low fertility with complete fertilizers provided a response by the end of the first growing season. Highly significant differences were observed for needle length, needle weight, and needle weight per unit of length. Two- and three-year-old needles were also retained better on trees given N-P-K than on those without added nutrients (White and Lowry, 1959).

The South

In the South, mineral deficiencies and results of fertilization have been less dramatic than in the Northeast. Many experiments have produced negative results, but those with affirmative conclusions are promising leads to conditions under which trees may respond to fertilization. An exhaustive review of literature on forest fertilization in the region, as of December 1959, is in *Forest Fertilization Research in the South* by Walker and Tisdale (1959). Throughout the Southern United States, it appears that water is more critical to tree growth than nutrients, even when the latter may be in short supply. The low nutritional demand of southern pines is also evidenced in the small amount of essential elements found in foliage—considerably less than in common hardwood species (Metz, 1952).

In the Florida peninsula of the Southeastern United States, 12-year-old slash pine (*Pinus elliottii* Engelm.) stands have responded to 500 ppa of N, along with P, K, and minor elements (McGregor, 1957). This species also responded to 200 ppa, equivalent to 1-5-4, in Alabama (Boggess and Stahelin, 1948), to 50 ppa of NH_4NO in Georgia (Jackson and Cloud, 1958), and to 1 ton per acre of colloidal phosphate in Florida (Barnes and Ralston, 1953). Other slash pine studies by the author indicate a significant response to fertilization one and two years after treatment at age 10 with 200 ppa of N. Diameter growth the first year was significant at the 10% level and for the second year at the 1% level. Accumulated growth for the two-year period was significant at the 5% level. However, differences in growth between treated and untreated plots was not great—.45 and .36 inches, respectively, for the two-year period. No differences were noted in height growth. N in foliage of treated trees was 1.04% one year after treatment in contrast to 0.96% for untreated trees (Table 1).

A sapling-size loblolly pine (*Pinus taeda* L.) plantation showed a 40 percent increase in wood production in North Carolina eight years after receiving 160 ppa of N (Maki, 1958). In southern Arkansas, height growth was not affected by fertilization of this species, but diameter growth was stimulated for two growing seasons by 100 ppa of N, and more so by 300 ppa of N. Foliar analyses showed N, P, and K were absorbed from fertilizers (Zahner, 1959). Young loblolly pine plantations in the Georgia Piedmont region suffered from various fertilizer treatments. This was probably from applying the nutrients too soon after planting and, thereby, causing rapid growth

Table 1. Growth of slash pine in south Georgia during two growing seasons following fertilization [1]

	No. trees	Average d.b.h. - - - - inches - - - -			Increase in d.b.h. - - - - inches - - - -			- - - - percent - - - -		
	1960	1958	1959	1960	58–59	59–60	58–60	58–59	59–60	58–60
60# NH_4NO_3	185	4.31	4.60	4.79	.27	.19	.45	6.3	4.1	10.4
60# NH_4NO_3+ 50# 20% superphosphate	154	4.50	4.76	4.97	.26	.21	.47	5.8	4.4	10.4
50# 20% superphosphate	156	4.49	4.71	4.86	.18	.15	.34	4.0	3.2	7.5
check	158	4.44	4.67	4.83	.20	.16	.36	4.5	3.4	8.1

[1] All trees on 0.1 acre plots.

of competing weeds which consumed available soil moisture to the detriment of the seedlings (Walker, 1958b). In the Coastal Plain of the United States' mid-south, the favorable effects of high N treatments in loblolly pine nurseries were carried over into out-plantings (Switzer and Nelson, 1956). Those trees given highest dosage rates in the nursery grew fastest following transplanting.

Longleaf pine (*Pinus palustris* Mill.) growth response has been noted by Bateman and Roark (1957) in the lower Mississippi Valley and by Paul and Marts (1931) in deep sands of the lower Coastal Plain "sandhills" for N-P-K applications. In the latter study, water was deemed

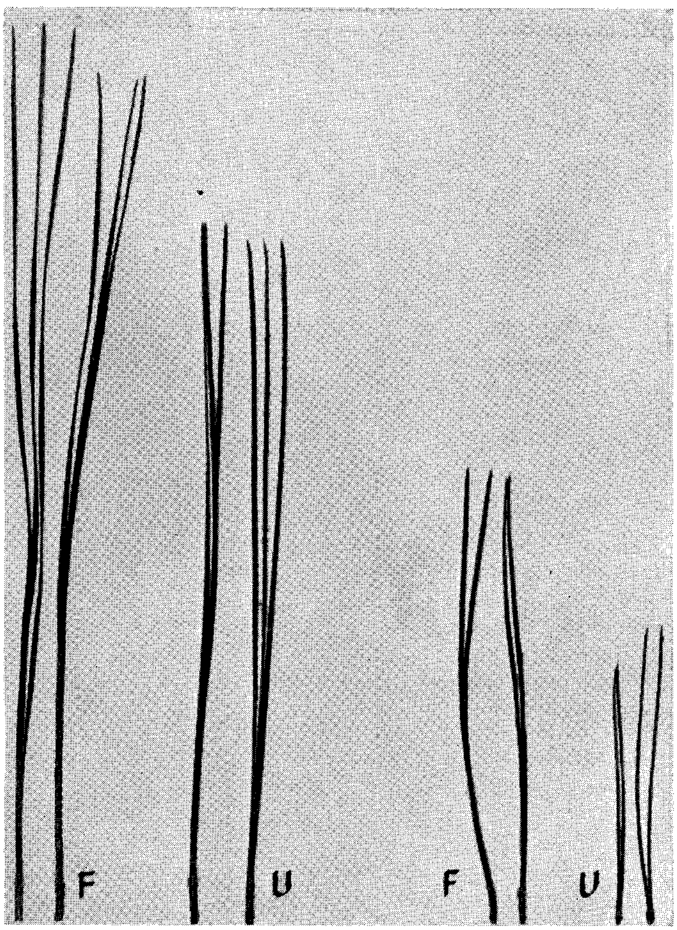

Figure 3. Fertilizers stimulate needle growth of loblolly (left) and shortleaf (right) pines.

the most important factor in tree development, and dosage rates were high: up to 270 pounds per tree of $NaNO_3$ +245 pounds of superphosphate +190 pounds of K_2SO_4, applied over a three-year period to trees from 100 to 150 years old.

Flowering and cone production have been increased by fertilization of slash pine (Hoekstra and Mergen, 1957), loblolly pine (Wenger, 1953), and longleaf pine (Allen, 1953). N, P, and K are involved, but it cannot be said to which element the stimulus is most attributable.

A virtually untapped forest resource in the southern United States is the desirable hardwood species on sites other than the typical "delta-like" hardwood bottomlands. With these deciduous trees, response to fertilizer amendments appear greater than for pines. Second-year observations for a yellow-poplar stand in the Georgia Piedmont province showed increasing height growth with increasing fertilizer rates—from 0 to 1,000 ppa of (20-52-0) (McAlpine, 1959). Black locust (*Robinia pseudoacacia* L.) and Japanese chestnut (*Castanea crenata* Sieb. & Zucc.) also respond to fertilization (N. Walker, 1955; Diller, Whittaker, and Anderson, 1957).

From radioactive isotope studies, it is apparent that uptake of at least one nutrient, phosphorus, by loblolly pine occurs shortly after treatment with $H_3P^{32}O_4$.

Two days after treatment, more P was found in low-positioned needles—both current whorl and older needles—than at higher positions and later periods (Fig. 4) (Walker, 1958). Appreciable radioactive phosphorus is also absorbed in the normally dormant winter season.

Considerable apprehension prevails as to the influence of fertilization on insect and disease manifestations among southern pines, namely Nantucket tip moth (*Rhyacionia frustrana* Comst.) and fusiform rust (*Cronartium fusiforme* (Pk.) Hedgc. and Hunt.). Several workers note this trend with the rust (Gilmore and Livingston, 1958). It is hypothesized that supplemental nutrients encourage early breaking of dormancy and, thereby, provide succulent needle tissue through which fungus spores enter at the time when spore dissemination is most prolific.

On the other hand, N fertilization induces an improvement among some shortleaf pine trees affected by little-leaf malady (Roth, Toole, and Hepting, 1948). This disease is associated with the fungus *Phytophthora cinnamomi* on severely eroded sites which were once in row-crop agriculture.

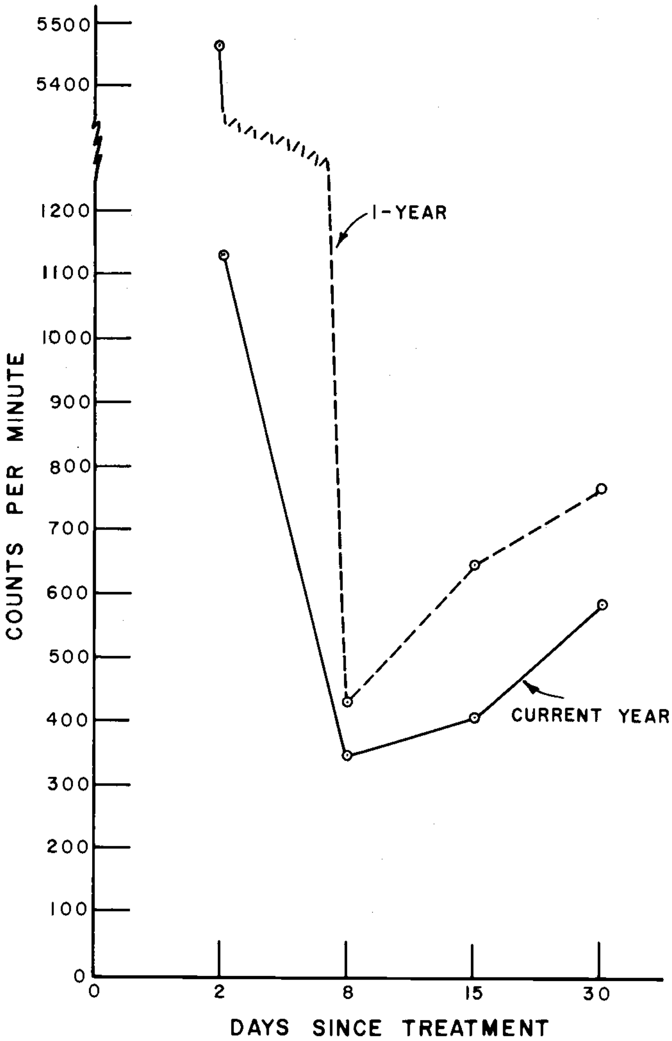

Figure 4. Phosphorous 32 uptake of loblolly pine in the Georgia Piedmont province of the Southeastern United States.

Vegetation Influences on Fertility

It is evident that certain species of vegetation appreciably influence nutrient element availability in the soil and, hence, the growth of trees. This, of course, is obvious over long periods of time—hundreds of years. But it is generally not reckoned as taking place over relatively short spans—several years.

In the Adirondack Mountain "sand plains" of the Northeast, previously described, white birch (*Betula papyrifera* Marsh.) trees are apparently able to obtain K even on soils extremely low in this element. As a result, release of K when foliage decomposes is sufficient for increasing K content of the surface soil. White pines growing under the crowns of the birch have superior vigor and color to those growing in the open, and also have significantly higher amounts of K in needles (Table 2) (Walker, 1956b).

The chemical composition of eastern redcedar foliage is, likewise, associated with chemical properties of the soil. Calcium content and pH are influenced by the rapid decomposition and incorporation of redcedar foliage. High nutrient levels encourage earthworm activity in the surface horizon, according to studies made on sandy loam, well-drained, brown podzolic soils of the Northeastern United States (Read and Walker, 1950) (Table 3).

Conclusion

Throughout Eastern North America, it is apparent that foresters are giving much consideration to the possibility of fertilizing forests. Only on a single site type and for just a few species is the desirability of treatment firmly established. As research progresses, confirmation will follow as to whether it is worthwhile to provide nutritional amendments for stimulating tree growth, seed production, gum flow, and rehabilitation of denuded sites.

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Table 2. Foliar and soil analyses for potassium

Sample pair No.	K in foliage[1]			Exch. K in surface soils[2]	
	White pine[2]				
	Under crowns	In open	White birch	Under crowns	In open
	Percent	*Percent*	*Percent*	*PPM*	*PPM*
1	0.55	0.28	0.85	18.5	6.2
2	.48	.28	.58	14.6	4.7
3	.43	.26	.63	18.2	3.8
Average	.49	.27	.69	17.1	4.9

[1] Dry weight basis, August foliage.
[2] Differences significant at 1% level.

Table 3. Calcium (1%) under eastern redcedar and red pine in two Connecticut plantations

Plantation	Redcedar	Pine
A	0.11	0.01
B	.19	.04

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RESUMES

Méthodes de fertilisation des forêts dans l'est de l'Amérique du Nord

Les méthodes de fertilisation des forêts dans l'est de l'Amérique du Nord se trouvent encore à un stade expérimental; toutefois, les nombreuses données recueillies sur cette question permettent d'être optimiste. L'auteur décrit les conditions de déficience en matières nutritives et les symptômes de déficience du système foliaire. En ce qui concerne les cas connus de malnutrition, l'auteur propose des remèdes appropriés. Dans les plaines du nord-est, lavées par les eaux de fonte des glaciers, l'application de 200 livres de KC1 (60% K_2O) par acre a une influence favorable sur les pins et les épicéas. Dans d'autres régions, les applications de Mg augmentent la vigueur des résineux. L'auteur se réfère à ses travaux dans le sud où l'application de 200 livres d'azote par acre au cours d'une période de deux ans a permis d'obtenir des résultats importants en ce qui concerne la croissance en diamètre du *Pinus elliottii*. Il signale également l'emploi de phosphore radioactif pour étudier l'assimilation des matières nutritives, qui sont absorbées rapidement. En outre, il est fait mention de l'influence du bouleau blanc et du cèdre rouge oriental sur la fertilité des sols forestiers.

Métodos para el Abono de Bosques en el Este de la América del Norte

Los métodos para el abono de bosques en el Este de la América del Norte aún se hallan en un estado experimental, pero ha sido posible reunir mucha información al respecto que justifica un punto de vista optimista. En este trabajo se describen condiciones de deficiencias de nutrición y síntomas de deficiencias en el follaje. Para los casos de desnutrición conocidos, se ofrecen los remedios pertinentes. En las llanuras del Noreste, lavadas por los glaciares, 200 libras por acre de KC1 (60% K_2O) resultan de beneficio para pinos y píceas. En otras partes, la aplicación de Mg aumenta la fortaleza de las coníferas. El autor informa sobre su labor en el Sur donde con 200 libras de N por acre, durante un período de 2 años, se han obtenido resultados favorables y ha resultado en el aumento del diámetro de los pinos de pantano (*Pinus elliottii*). Se informa sobre el uso del fósforo radioactivo como medio para estudiar la asimilación de nutrientes. Los nutrientes son absorbidos con rapidez. Se señala la influencia del abedul blanco y del cedro rojo del Este sobre la fertilidad de los suelos forestales.

Classification, Mapping, and Interpretation of Soils With Special Reference to Forestry

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Soils of a region often show marked variations in many fundamental characteristics such as depth, texture, porosity, water storage capacity, nutrient availability, etc., all of which greatly influence plant growth. Each soil has a definite range of performance and potentiality, and in dealing with any problem having a bearing on soil conditions, it is an essential pre-requisite to recognize the kind of soil involved. In order to make full use of the data on soils for achieving maximum production, their proper classification, mapping, and interpretation are the basic requirements.

The intimate relationship that exists between soil and vegetation and the profound influence that each has on the physical and morphological characteristics of the other have long been recognized. In recent years much attention has, therefore, been paid to the edaphic factors in the delineation of plant communities within a homogeneous climatic region. It has been shown that different silvicultural methods and management practices should be employed in different areas in view of the great diversity in soil characteristics and moisture conditions within short distances.

Purpose of Soil Classification

A classification of soils into proper soil types and a thorough understanding of their nature, like any other scientific classification, represents in a systematic form our knowledge about soils and serves as a basis for a judicious utilization of different soils. Soil classification is, in fact, both a fundamental and a purposeful investigation of the soil resources. The soil type in a region is now considered as a sound unit for the application of the results of research over large areas.

A classification of forest soils assists in assessing the capabilities of soils in relation to silviculture and forest management in the interest of increased production. It offers valuable information on many problems which often confront the foresters, including failure of natural regeneration in certain areas, incidence of diseases and pests, large-scale mortality, fire hazards, etc. The widest application lies in defining the soils that are best suited to planting with exacting species, so that every type of land can be utilized for its maximum production.

System of Soil Classification

The idea of soil classification appears to be as old as the very art of agriculture, although many developments have taken place in the basic principles from time to time with advancement in the field of soil science. In Europe and the U.S., texture or geology was used for a long time as the sole criterion of soil classification. It was only after the Russian scientists had enunciated the idea of soil as a natural body with a well-defined morphology that soil profiles dominated all work on soil survey and soil classification in these and other countries.

The most common method of soil classification followed in the U. S. is that of classifying primarily into the great soil groups and then into categories, series, types and phases. In certain countries, the term "association" is used, which consists of a number of series derived from the same parent material in any given physiographic region, but which differ in drainage conditions as a result of varied topography. Milne, in Africa, put forward the concept of soil catena for the regular recurrence of a topographical sequence of soils, and this concept has been adopted extensively, especially in the United States.

The basic idea of soil classification is not new to India. There is evidence on record to show that the system existed as early as 3000 B.C. The earliest soil classification, which was undertaken in agriculture for the assessment of land revenue, was based mainly on colour, texture, availability of water, level of the land, and productive capacity in terms of agricultural crops. A systematic approach to the study of Indian soils and their classification was first made by Leather (1898), who distinguished four major soil groups, viz (1) Indo-Gangetic alluvium, (2) Black cotton or regur soils, (3) Red soils lying on metamorphic rocks, and (4) Laterites and Lateritic soils. Genetic soil studies and classification of soils are, however, comparatively recent developments in this country. Most of the previous work was related to specific purposes from a utilitarian standpoint such as soil fertility, irrigation, and reclamation, until 1938, when Basu and Sirur published the results of their investigations on the survey and classification of the black soil area of the Nira left bank and Pravara canals in the Deccan, following the modern genetic methods. These and other subsequent profile studies have furnished detailed scientific information on the main broad groups of Indian soils. Very recently, an all-India soil survey on a soil region basis has been started to study and classify the soils of the country.

According to the soil map of India (1954), soils of the country have been broadly classified into the following 20 groups: (1) Alluvial soils (undifferentiated); (2) Coastal alluvium (New); (3) Grey and brown soils of the Indus, Jamuna and Gangetic basins, impregnated with salts; (4) Gangetic alluvium (calcareous); (5) Saline and Deltaic soils; (6) Deep black or regur soils of valleys; (7) Medium black soil of Trap and Gneissic origin (Plateau); (8) Shallow black soils; (9) Mixed red and black soils; (10) Red loam; (11) Red gravelly soils; (12) Red and yellow soils; (13) Laterites (high and low level); (14) Laterite soil (old alluvium); (15) Desert soils; (16) Skeletal soils; (17) Forest and hill soils (undifferentiated); (18) Sub-montane regional soils (undifferentiated); (19) Foot-hill swampy soils (undifferentiated); and (20) Peat soils. It will appear from the above that no definite system of classification has so far been followed for the forest soils of the country.

Under humid tropical conditions, leaching of silica predominates in contrast to that of sesquioxides in the temperate climate, the laterite soil being the most characteristic soil type. The humid tropical soils are further characterized by a rapid decomposition of organic matter and extensive turnover of the plant nutrients. The soils of dry zones, however, differ in many respects from those of the humid regions by having higher pH values, greater amounts of bases, and poor status of organic matter.

Mapping

The ultimate purpose of soil classification lies in the preparation of accurate maps, showing type and distribution. Such a map contains all the relevant information on the main soil types found in the various forest regions and serves as an inventory of the soil resources of the area. Mapping of vegetation and soil together increases the value of both and endeavours to depict their reciprocal relations. It is of most importance to map the basic soil characters, thereby making the soil maps more objective, so that the map can be interpreted for any purpose. From such maps, single-purpose maps can be easily derived.

The scale of the map usually varies with the purpose for which it is prepared. In general, the scale should be larger for showing detailed information about a small area (detailed survey), and smaller for showing broad characteristic of a large area (reconnaissance survey). Besides, different scales are used for the maps meant for field work and for final publication. Kellogg (1958) recommended that for agricultural lands in India the scale for field work should be 16″ or 8″ = 1 mile, according to the details required, whereas for the forest areas, a field map of a scale smaller than 4″ = 1 mile can be used. Regarding publication, he suggested a scale between 2″ = 1 mile and 4″ = 1 mile for agricultural lands, and somewhat smaller for the woodland areas. For a systematic survey of forest soils in India, Seth and Yadav (1956) suggested a procedure for the preparation of a base map, according to which three up-to-date maps, showing separately the different broad types of soils, vegetation, and climate, should be superimposed on a single map, and the areas having apparently more or less uniform conditions of soil, climate, and forest composition should be demarcated. These areas should be designated as Basic Soil Regions and should be used as the unit of survey. The same authors (1957) have described in detail the two soil forms "A and B" for recording data on soil and vegetation *in situ*. In many countries, especially in the U.S., soil mapping is done directly on aerial photographs.

Several workers have attempted to prepare soil maps of India, but all these maps were based on rather scanty data available to them. The latest soil map of the country was prepared in 1954 by the Indian Agricultural Research Institute, New Delhi. Champion (1936) prepared a map of the country showing the distribution of the climatic types of forests with due regard to climate and soil. Besides, many soil maps have recently been prepared in the States by the respective Agricultural Departments.

Interpretation

Owing to relatively long periods of tree growth, the large volume of soil exploited during such periods, the great struggle for competition under mixed forests, and many other factors, the forest trees have soil requirements much different from those of agricultural crops. The effects of the soil disorders caused by deficiencies and excesses of the nutrient elements appear to be more deleterious on the forest trees on account of their long growth period than on the agricultural crops, most of which complete their entire growth cycle within one season. An appreciable portion of the tree remains below the ground, and, therefore, to know the actual environment of the underground part it is necessary to examine the soil to greater depths, where wide differences in soil conditions caused by compaction, cementation, alluviation, and other factors are usually found. The effects of these differences on the development of the root system are ultimately reflected in the growth behaviour of the trees. Consequently, in the case of forest crops, an examination of the subsoil is at least as important as that of the top layer.

While interpreting soil data, a soil scientist is required to have a thorough knowledge of the soil requirements of the different forest trees, their rooting habits, ability to absorb moisture and nutrients, adaptability to changing environments, tolerance limits for various soil changes, etc. He should be aware of the limitations and the range of applicability of a particular method used in the measurement of a soil property under varied conditions of soils, climate, and vegetation. For instance, there is not yet any one method for the determination of "available" phosphorus which is suitable for all soil types and forest crops. Before the soil data can be interpreted correctly, it is advantageous to classify the various soil properties into suitable grades based on an intensive study of the soil-vegetation complex under conditions which are representative of natural environments. Since forest trees grown under tropical conditions are many and varied, they have widely varying soil requirements. Of the various soil properties, depth, texture, structure, drainage, water table, geology, pH, and nutrient status are more important for forest growth. Greater importance should be given to the physical properties than to their chemical composition, although certain poor soils do not contain adequate reserves of nutrients for sustained timber production.

The investigations carried out in India on the growth and regeneration of the important tree species have shown that soil plays a vital role in the realm of forestry. They furnish convincing evidence that different tree species have different soil requirements which necessitate a different interpretation of soil data for each species. The results of a few investigations are summarized in the following paragraphs.

The chief causes responsible for the unsatisfactory regeneration of sal (*Shorea robusta*) are deficient aeration and insufficient moisture supply. A good quality of sal in the Dun valley occurs on deep soils having acidic reaction, while the soils of high pH value support miscellaneous forest communities without sal. Recently, it has been reported that lower levels of organic matter and higher values of moisture equivalent indicate superior condition for sal growth.

From a critical study of teak soils by Seth and Yadav (1959), it appears that the best teak forests tend to develop on well-drained rich alluvium along the river banks, having adequate moisture availability. It thrives well on trap, but often avoids areas where laterite is present. A low SiO_2/R_2O_3 ratio, a low dispersion coefficient, a southerly or westerly aspect, and a very low or extra high water table are unfavourable for the growth of teak and vice versa. Under swampy conditions teak is replaced by *Lagerstroemia flosreginae,* while in shallow soil overlying laterite it is substituted by *Xylia.* An interesting case is found in parts of Madhya Pradesh, Orissa, and Andhra Pradesh where the natural zones of sal and teak overlap to some extent, though the soil requirements of both species are distinct. This differential distribution of the two species in a single region under similar climatic conditions suggests that a change in geology and soil conditions leads to the predominance of a different species.

A large-scale mortality of *Casuarina* plantations in Madras and Orissa has occurred due to excessive or deficient moisture, depending upon the level of the water table and morphology of the soil profile. A significant correlation has been found between the soil texture and the incidence of root disease in shisham (*Dalbergia sissoo*). This species grows healthily on sandy or loamy sand soils, whereas the root diseases begin to affect this species in sandy loam soils and assume high proportions in clayey loam or clay soils. Most of the trees are unable to thrive on alkaline soils, but certain species, namely *Butea monosperma, Acacia arabica, Prosopis spicigera, Azadirachta indica, Capparis* spp., etc., are found to grow well under such conditions.

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RESUMES

Classement, cartographie et interprétation des sols, notamment en ce qui concerne la sylviculture

Le rapport examine le but et le système du classement des sols, et donne un compte rendu succinct des travaux réalisés dans ce domaine en Inde. Il esquisse les principes généraux de la cartographie et renvoie aux cartes des sols dressées dans ce pays. L'auteur s'efforce de mettre en lumière les divers facteurs qui différencient les cultures agricoles et forestières qui leur sont nécessaires du point de vue des sols. Il fait ressortir les considérations dont il faut tenir compte lorsqu'on interprète les sols à des fins sylvicoles. Les résultats de plusieurs enquêtes menées sur les sols de l'Inde indiquent que les différentes essences présentent des différences marquées du point de vue des sols dont ils ont besoin, et qu'une interprétation distincte des données pédologiques est nécessaire pour chaque espèce.

Clasificación, Topografía e Interpretación de Suelos para Fines Forestales

El estudio explica el objeto y sistema de clasificación de suelos e informa brevemente de la labor realizada en la India sobre la materia. Enumera los principios generales de trazar mapas y menciona los mapas para la clasificación de suelos preparados en este país. Trata de aclarar los factores que diferencian a los requisitos del suelo para la producción agrícola y para la forestal. Insiste sobre las consideraciones que deben tenerse en cuenta al interpretar los suelos para fines forestales. Informa sobre los resultados de algunas investigaciones de suelos en la India que indican que los distintos árboles forestales difieren ampliamente en cuanto a los componentes del suelo que requieren y que para cada especie es necesario interpretar separadamente los datos del suelo.

The Ecosystem Concept in Forestry

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Canada

Introduction

The theme of the Forest Ecosystem Symposium held during the Ninth International Botanical Congress in Montreal, Canada, in 1959, was: "Can we find a common platform for the different schools of forest classification?" In spite of the divergent opinions expressed at this symposium, the consensus was that a common platform could and should be found. This view was in keeping with the interest shown at the Fourth World Forestry Congress in India, 1954, in the practical application of the biogeocoenose (ecosystem) concept in forest management. It was considered appropriate to re-emphasize the point and to suggest that, in order to place forestry practice on a fundamental basis, research ought to be oriented to methods of description, investigation and classification of forests as ecosystems. At the suggestion of Prof. I. Hustich, chairman of the symposium, a motion was passed that the results of the deliberations of the symposium group should be presented to the Fifth World Forestry Congress. Accordingly, the present paper was prepared by a group of Canadian participants. It sets forth eight proposals based on opinions expressed at the Botanical Congress.

In order to interpret the meaning of the ecosystem concept in relation to forestry, it has seemed advisable to present with each proposal the underlying considerations on which it is based. Further references to the concept, and to principles dealt with in the proposals, may be found in the symposium papers as listed in the bibliography.

Proposal 1. That a forest ecosystem be conceived as an assemblage of forest organisms and of the soil and climatic features which co-exist and interact at specific locations on the earth's surface. It is a geographic unit.

Basic considerations. The simplest view of the forest is that it is an aggregation of exploitable trees and nothing more. With a little more imagination it includes all stands of trees and associated vegetation which, at some time or other, may have some use, whether it be for timber production, watershed management, wildlife habitat or tourist camp site. Deeper comprehension brings in the soil and the climate—the media from which the forest derives its sustenance and its energy. This leads to a consideration of a geographic entity occupying a certain place on the earth's surface where climate and soil interact with plants and animals to give a particular productivity system. This is, in fact, an ecosystem (see also "biogeocoenosis" of Sukachev (16)*, "total site" of Hills (5)).

Both the terms "site" and "ecosystem" have been used with less comprehensive connotations. Site, as defined by the Society of American Foresters, can be interpreted as synonymous with ecosystem, although frequently used to denote the physical environment only. "Biogeocoenosis"—a unit ecosystem defined with particular reference to vegetational homogeneity—has not been in use long enough to have acquired ambiguity of meaning, though some confusion has already arisen from its equation with "forest type." There is an obvious need to establish reasonable and firm definitions.

Proposal 2. That the value of the ecosystem concept be recognized as bringing a comprehensive viewpoint to bear on the forest, focussing attention on those biophysical relationships which direct the formation, development, perpetuation and productive capacity of forests.

Basic considerations. In the ecosystem concept the forest community is integrated with environment; it is placed as a functional part of the landscape rather than a separate object. This wider viewpoint does not necessarily replace the study of the forest as a botanical entity, nor substitute for the analysis of stands in terms of their parts: the individual trees, the vegetational strata and phases 1–17. Its importance lies in the provision of an objective basis for the study of circulation, transformation, accumulation and loss of matter and energy in productivity systems.

Proposal 3. That study and analysis of forest ecosystems be directed to their functional processes as productivity systems, with attention to the quantitative aspects of the flow of energy and the circulation and accumulation of materials. Only to the degree that there is an understanding of dynamic processes will the relationships of the parts within the ecosystem be fully understood.

Basic considerations. As a field wherein there is continual cycling of energy and matter, resulting in the accumulation of organic materials (wood, for example),

* Numbers in parentheses denote the references listed at the end of this paper.

each ecosystem is characterized by function, i.e., by the form and intensity of its own processes (12). Since forest management deals with the control of these processes, the dynamics of the ecosystem must be understood. Such understanding will also refine classification and assist in the definition of types which are of maximum use for forestry.

Proposal 4. That for forestry purposes, ecosystem units be identified as significant segments of the forest-land spectrum.

Basic considerations. Existing patterns of vegetation will be used in forested areas for the selection of useful ecosystem units. However, the status of each such unit can be determined only by taking into account the coinciding patterns of the physiographic features of the land. Thus, a particular forest stand is always seen as in at least momentary equilibrium with a certain ecosystem of which it is one expression. It needs to be recognized, however, that floristic composition and structure of the forest community are governed also by historical factors.

Proposal 5. That the description and classification of ecosystem units be based on significant features of both forest and land, as neither forest vegetation nor physical environment alone can indicate unequivocally the nature of the ecosystem.

Basic considerations. The forest ecosystem may be divided into two main components: (a) the living organisms of the forest; and (b) the non-living physical environment. The non-living environment may for convenience be called physiography (physiographic site). Biologists (4, 7 and 14) frequently refer to these two parts as the biocoenose (the community of living organisms) and the ecotope (physiography). For forestry purposes it would seem desirable to establish the class concepts of "forest type" (type of forest or plant association) for the former, and "physiographic (site) type" (type of physical environment, including climate) for the latter. The forest community is not an ecosystem, neither is physiographic site a productivity system. The assumption that similar vegetation communities are similar ecosystems is true only under some circumstances (i.e., when the ecotopes are similar). In other cases, two communities may appear similar from the standpoint of species composition and even from the standpoint of forest production for a given production period. However, the type and range of the processes responsible for this production may differ widely in the two systems. In such cases there are two ecosystems, not one. Unfortunately, the worker who assumes that similar forests mean similar ecosystems frequently fails, because of this assumption, to discover the true differences in the ecosystem, even though he may describe the climate and soil features as well as those of the forest community.

As the impact of climate is closely tied to geographic location, land type and vegetation type, its application to the definition of ecosystems is mainly limited to a descriptive role. Detailed vegetational and soil descriptions find new meaning when applied to ecosystem units rather than to forest stands. Such data serve to indicate the functions and processes that are going on.

Proposal 6. That the boundaries of useful ecosystem units be established by the mutual and reciprocal use of both forest features and land features.

Basic considerations. Unit forest ecosystems can be delimited spatially and temporally in various ways (7, 16), but the most important criteria are significant changes in ecological relationships between forest and land. Thus, ecosystem boundaries represent also coincident changes in both types of forest (as plant communities) and types of physiography. Similarities and differences in the dynamics of different ecosystems can be determined only where boundaries are well defined in terms of both forest and land features. Once the ecological relationships have been established, the potential of areas can be inferred from and mapped by the physiography alone. As features of vegetation and soil are seldom static, particular attention is necessarily directed to the land or the landform (surface relief plus materials which constitute it).

Proposal 7. That forest ecosystems be identified and studied within a geographic framework defined with due regard to regional differences of biota, landform and climate. This will give precision to description and classification, and will facilitate the development and application of general principles.

Basic considerations. Ecosystems are geographic entities and are not readily systematized without reference to the earth's surface. A system of regions or zones, selected on the basis of related vegetational and landscape features (reflecting relatively homogeneous relationships between these two visible components of ecosystems), will provide a frame of reference for classification.

Proposal 8. That an acceptable system of concepts and an appropriate terminology be formulated in order that methods and results may be readily understood by workers in the fields of forestry research and practice. This is also the necessary basis for international cooperative research.

Basic considerations. There will doubtless be differences in the approach to a study of forest ecosystems from area to area, due to geographic individuality and to differences in objectives and in available knowledge.

These differences will not however, necessitate differences in basic concepts. In fact, it is only by maintaining a fundamentally uniform approach in this field that the differences between regions will be fully recognized.

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(3) Daubenmire, R. Some major problems in vegetation classification.

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RESUMES

Le concept de l'écosystème en sylviculture

La question de la classification des forêts sur une base écologique a fait l'objet d'une séance spéciale du Neuvième Congrès de Botanique qui s'est tenu au Canada en 1959.

Le présent rapport, dans lequel sont exposés les résultats des délibérations de cette séance, a été préparé par un groupe de participants canadiens. Huit propositions ayant trait aux aspects importants du concept de l'écosystème appliqué à la sylviculture y sont présentées. Nous avons mis en lumière le fait que le sylviculteur a affaire à un système de productivité dont le peuplement forestier est une partie. Pour le comprendre et en assurer le contrôle, il faut en conséquence qu'il tienne compte des processus auxquels participe la forêt à l'intérieur de l'écosystème. L'utilisation mutuelle et réciproque des caractéristiques de la végétation comme de celles de la terre, et de leurs rapports écologiques, est indispensable pour définir et classer chaque groupe d'écosystème forestier utile. Dans ce domaine relativement nouveau, il est nécessaire de formuler des concepts clairs et une terminologie appropriée pour faciliter la recherche et les échanges d'idées sur le plan international.

El Concepto del Ecosistema en la Silvicultura

El Noveno Congreso Botánico de Canadá, celebrado en 1959, dedicó toda una sesión a la discusión de la clasificación forestal basada en el ecosistema. El presente trabajo ha sido preparado por un grupo de funcionarios canadienses que participaron en el citado Congreso y tiene como base la citada discusión. Se consignan ocho propuestas relacionadas con importantes aspectos del concepto del ecosistema en su aplicación a la silvicultura. Se señala que el silvicultor tiene que administrar un sistema de productividad, del cual el bosque es una parte. Por lo tanto, para entenderlo y regularlo han de tomarse en consideración los procesos internos del ecosistema en los cuales participa el bosque. Se llama la atención a la necesidad de usar mutua y recíprocamente tanto la vegetación como los suelos, en todas sus características, y tomar en cuenta las relaciones ecológicas al definir y clasificar las unidades útiles del ecosistema forestal. En este campo de estudios, que es relativamente nuevo, se necesita formular conceptos claros y una terminología apropiada para facilitar las investigaciones y el canje internacional de ideas.

The Classification of Forest Productivity Systems

(Site, Ecosystem, Biogeocoenose)

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The Nature of Forest Productivity Systems

Forest production is dependent upon processes which transform and transmit energy and matter within and between forest organisms and their environment. Trees and other green plants synthesize organic matter from the energy and matter transmitted to them by the atmosphere and the soil. Other organisms consume and reduce organic matter, thus transforming and releasing energy and matter for another cycle of forest growth. Soil, in its true sense, is the activated portion of the surface geological materials which releases the energy and matter of the non-living organic and inorganic materials and transfers these to the plant roots. The atmosphere transfers the solar energy of the sun to the organisms and facilitates the exchange of energy and matter within the forest and the soil.

The forest production is a complex of interdependent processes operating within an assemblage of living organisms and their non-living environment. Such assemblages of forest organisms and of soil and atmosphere features, occupying specific portions of the earth's surface and unified by the processes of forest production, are termed *forest productivity systems* (6, 7, 15, 18, 23).[1]

Neither forest nor physiographic features (i.e., the combination of soil and atmosphere) are, in themselves, productivity systems. Certain physiographic features—namely, regional combinations of geological materials—relief and climate constitute the potential control of the kind and rates of biological activity. The actual biological production of an area, however, is dependent upon the capacity of the organisms, which have successively estab-

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

lished themselves upon it, to develop the potential inherent in the above-mentioned physiographic features (8).

Changes in the vegetation features of an area result in changes in certain physiographic features, notably changes in the soil profile and local effective climate. Broad changes in vegetation reflecting changes in macroclimate[2] are responsible for major changes in soil profiles. The changes in vegetation, recognized as "forest succession," are usually responsible for minor changes in soil horizons only, but, in certain cases, they are associated with major profile changes.

Thus, forest productivity systems are dynamic systems in which both forest and physiographic features are changing within the limits imposed by the "matter-and-energy" potential of the land and the "genetic" potential of the forest organisms.

All the components of the ecosystem which play a direct role in forest production are interactive, mutually influencing one another. For example, vegetation, in its broad aspect, depends on regional climate and regional landform (geological materials, relief and ground water). In its local aspect, vegetation depends upon local combinations of landform, climate and soil profile, and upon the historical development of the vegetation of the area. The historical development of vegetation is dependent upon the genetic potential of organisms to develop biotic communities adjusted to the changes of climate and landform which take place over long periods of time. That is, the present vegetation is dependent upon the potential of those organisms which were available to colonize the area within each period of change.

Furthermore, soil profile, in turn, depends upon the interrelationships of the vegetation and climate which now exist on the local area, and, in many cases, also those which have existed in the past on this same area.

Local climate depends upon the control exercised by landform and present vegetation on the effectiveness of the regional macroclimate.

Thus, in the forest productivity system, its non-living components (the land) and its living components (the forest community) are so intimately associated that they cannot be considered separate or *apart* from one another, yet so fundamentally different that they cannot be considered *a part* of one another (6).

Some Essential Definitions of Forest Productivity Systems and Their Component Parts

It is not the purpose of the writer to discuss, at this time, the many terms which have been introduced to connote biological productivity systems. However, it would seem appropriate to make brief reference to three of these, namely, site, ecosystem and biogeocoenose.

According to the Society of American Foresters, forest productivity system may be simply called *site*. The definition of site in their *Forestry Terminology* can be paraphrased thus: "The combination of the biotic, climatic and soil conditions of an area considered with reference to its capacity to produce forests or other vegetation." However, in much of the plant sociology literature (13) and, to some extent, in that of forestry, the term "site" has been used as a synonym of ecotope, referring only to the physiographic or land features. To ensure that site be considered in its totality, with both living and non-living components, this writer (3) in 1952 introduced the term *total site*, but subsequently has dropped the qualifying word "total" in many of his discussions.

The term *ecosystem* was introduced in 1935 by Tansley (26). Unfortunately it, too, has been used with various meanings. However, recently its meaning has been "firmed" to refer to productivity systems (14), including that of the forest ecosystem (17, 18).

In 1944, Sukachev (19) introduced the term *biogeocoenose* to connote the interaction of the living (bio) and the non-living (geo) organized within a common meeting place (coenose). He (22, 25) has taken great pains to develop the concept of biogeocoenose to include both the living and non-living components of the productivity system and to define it so that it unmistakably connotes the total productivity system. Yet he, himself, has already introduced confusion by calling the individual forest biogeocoenoses, a "forest type," identified solely by characteristics of the vegetation (22). Apart from this and the fact that it may sound extremely academic to the practical forester, the term biogeocoenose is not objectionable. However, in the following discussion, forest productivity systems will be called "ecosystems." Whenever the term "site" is used as a synonym of ecosystem, this meaning will be clearly indicated.

A *forest type* is that portion of the ecosystem which consists of the forest and other plants (6). It does not include soil and climate as suggested by Sukachev (22) and others, including the Zürich-Montpellier School (13). The forest community consists of organisms which utilize energy to synthesize and reduce matter. Forest type, therefore, includes only the green plants and the fungi and other reducing organisms which participate in the primary production cycles within the forest ecosystem.

A *physiography type* is that portion of the ecosystem which consists of physiographic features, including (i) geological materials, (ii) ground water, and (iii) local atmosphere. Not only are the geological materials the source of raw materials and of internally-stored energy, but combinations of physiographic features provide the mechanism for the transmission of energy and matter to and from the organisms. A pattern of physiography types is known as a *land type* (6).

The Role of the Concept of Ecosystem (Total Site) In Forest Management

The objective of forest management is to manipulate the various features of the forest ecosystem in order that the potential of each forest area may be as fully utilized as possible within the limits imposed by economic and social conditions. Thus, forest management is concerned not only with the interrelationships between forest and its environment during the existing production period, it is also concerned whether such interrelationships represent the full capacity of the area to produce forests and, if not, how production can be increased economically (4, 6, 12, 21, 22, 23).

Since changes in any one feature of an ecosystem result in changes in the other features, it is only through a knowledge of the dynamics of that specific ecosystem

[2] Macroclimate—the regional climate, not modified by local differences in landform and vegetative cover.

that the trends in the effect of these changes on forest production can be predicted.

Requirements for a Classification of Ecosystems

Only recently has the classification of ecosystems, per se, been given serious consideration. Lying, as it does, in the borderline between the biological and the earth sciences, their classification has been approached from both fields. This has resulted in a strong bias to either the physiographic or biotic aspects. For example, some soil scientists have believed that the soil profile is all that is required to rate productivity, since it reflects the summation of all the features of the productivity system (6). Biological bias has also been very strong. Take, for example, the term "biocoenose," which Möbius introduced to mean the total productivity system, but which has now come to mean only the biotic community.

Sukachev, recognizing that, in view of its derivation, biocoenose should be reserved to connote the living portion only, inserted the syllable "geo" and thus added a new term "biogeocoenose" to scientific terminology. In fact, many terms were added in consequence, since he has developed the science of biogeocoenology (20) in order that the term biogeocoenose retain its full significance.

This pure meaning will not be easily maintained, in view of the biological bias which Sukachev himself has introduced. Not only has he given the local units of forest biogeocoenoses the name of "forest types," but he admits that he uses only gradients of vegetation to define their boundaries. Take the following statement, for example: "It is therefore expedient to primarily use the phytocoenosis (vegetative community) in separating the biogeocoenoses. The boundaries of each biogeocoenosis are primarily defined by the boundaries of the phytocoenosis. This stems from the fact that among the components of a biogeocoenosis the greatest, so-to-speak, biogeocoenotic role, as a rule, falls to the lot of the phytocoenosis" (23). (See also statements concerning the Zürich-Montpellier School (13).)

However, it is not a question of which—the forest or the land—plays the dominant or more important role in forest production. Each forest type, when considered discrete from the land, has a variable role depending upon the specific physiography type with which it is associated. Each physiography type, when considered discrete from the forest, also plays a variable role depending upon the specific forest type with which it is associated. Again let it be stated that it is not a matter of determining, a priori, which is the more important. Rather, it is a matter of establishing a framework within which the specific role of each forest type within each specific productivity system can be determined (12).

This discrepancy between the stated objective of biogeocoenology and the methods which have been set forth for its achievement (23, 24) is but one example of many which could be quoted that suggest the necessity to establish, firmly, the basic principles which govern the classification of productivity systems, whether they are known as "biogeocoenoses," "ecosystems" or "total sites." The required classification of ecosystem units is one which is established through the mutual and reciprocal use of both forest and land features (18). To establish biogeocoenose (ecosystem) units using only the features of the plant community (13, 23) defeats the very purpose of ecosystem studies.

From Sukachev's statement that it is expedient to use vegetation features to "circumscribe" ecosystems (rather than to use the vegetation-physiography relationships to "define" them), it would appear that Sukachev was not aware that at least one method based on the latter criterion was available.

In view of the interest which is being shown in the role of the ecosystem concept in forestry (18) and of the proposals for international cooperative trials under the auspices of the International Union of Forest Research Organizations (16, 22), the objective of this paper is to present those principles on which the classification of ecosystems should be based. These are principles which have become apparent to this writer during his research in total site in Ontario, Canada (6). The methods which he has used are outlined in a paper which is being presented at this Congress (1). They may be found also in greater detail elsewhere (3, 5, 6).

Outline of Principles Used to Classify Forest Ecosystems (Biogeocoenoses or Total Site)

The proposed principles, with corollaries, are enumerated below:

Principle No. 1 and Corollaries

The nature of forest ecosystems requires that their classification be based on the character of the interrelationships between the forest and its physiographic environment. A classification useful in forestry practice requires that these characteristics be observable in the field (6).

Corollary 1a. Ecosystem types are established through combining classes from a number of gradients of both forest and physiographic features (1).

Corollary 1b. Boundaries of ecosystem units are established through the mutual and reciprocal use of both forest and physiographic features (18).

Principle No. 2 and Corollary

The classification of the ecosystem as a complex whole must provide for a classification of its two major parts, namely, the forest and the physiography, as integral parts of the ecosystem. This can be accomplished only through the concurrent establishment of forest and physiography types (6).

Corollary 2a. Physiography types will be defined by gradient classes of those landform and climate features which denote significant differences in the development of vegetation. Although these classes are defined in terms of physiographic features, the limits of the classes are set by ranges in their effectiveness on vegetation development and growth (6).

Principle No. 3 and Corollaries

The dynamic nature of ecosystems requires that their classification provide for changes in the system for both short and relatively long periods of time.

Corollary 3a. The relatively stable landform features, combined with the climatic features associated with them, constitute the physiographic limits within which changes in vegetation and soil can take place. Accordingly, a classification of dynamic ecosystems will be based primarily on those significant features of landform and climate which constitute the matter-and-energy control of vegetation succession and of soil development (6). These landform units constitute the basis for evaluating the biotic potential of the vegetation. (See Corollary 3b.)

Corollary 3b. Within the limits set by a relatively narrow range in landform features, this classification will provide for the use of vegetation and soil features to indicate changes in the ecosystem at three arbitrarily defined levels, namely:

(i) *Within an ecosystem type.* Here the changes in the biotic features will not extend beyond the limits set by the definition of a forest type (10, 11, 12).

(ii) *Within a single series of ecosystems.* Here gradients of biotic features are established which show changes throughout the entire succession, including the climax, on similar landforms. The gradients are divided into classes representing stages in the succession within a period of relatively uniform climate (11).

(iii) *Within a multiple series of ecosystems.* Here the multiple series of ecosystems represent changes which cover a wide range in time during which the climate changes considerably, with consequent changes in vegetation succession. Little change in the landform is apparent, but differences in climate and succession are indicated by differences in soil profile development (6, 11).

Principle No. 4 and Corollary

That the field classification of ecosystems provide a basis for the study and analysis of their function as productivity systems (15).

Corollary 4a. A classification of ecosystems based on combinations of gradients of the significant forest and physiographic features will provide the basis for interpreting significance of a given level of specific features such as "available potassium," "prescribed burn," etc.

Principle No. 5 and Corollaries

The classification of ecosystems should include the establishment of ecosystem regions based on the homogeneity of relationships between vegetation and landform in order to provide areas within which the results of forestry practice may be predicted with a reasonable degree of assurance (6, 7).

Corollary 5a. An ecosystem region will be a relatively broad mosaic of forest types, each specific type having developed under similar biotic and physiographic conditions. It can be assumed, with a reasonable degree of certainty, that the patterns of biotic potential within the region will be similar (6).

Corollary 5b. An ecosystem region will be a region having a relatively narrow range in macroclimate and having a characteristic mosaic of local effective climates which are similar for similar landforms.

Corollary 5c. Ecosystem regions will be mosaics of physiography types which will have similar "matter-and-energy" potential since they are areas in which there is homogeneity of relationships between landform and effective local climate.

Corollary 5d. Ecosystem regions will be regions in which specific soil profiles have developed under specific combinations of environmental conditions, thus rendering it possible to use the character of soil horizons in evaluating forest productivity and forest practice.

Principle No. 6 and Corollary

That a uniform classification of ecosystems within "natural" regions provide for the interpretation of their dynamic characteristics for forestry and other land uses (7), with particular reference to changes in forest productivity resulting from human occupance and attendant differences in objectives and available knowledge.

Corollary 6a. A geographic region will combine the significant features of human controls with those constituting the "matter-and-energy" potential of the physiography and the "genetic" potential of the vegetation.

Principle No. 7 and Corollary

Since forest management plans are related to specific areas, the distribution pattern of ecosystem types and of interpretive types, based on ecosystem types, should be readily mapped at those levels of detail which are convenient for forestry practice (5, 6, 11, 12).

Corollary 7a. A classification of ecosystems which permits the use of aerial photographs expedites mapping. Hence it is desirable that a classification of ecosystems be adaptable to interpretation from aerial photographs (2).

The significance of the principles enumerated above would be greatly clarified if space permitted a comparison of the degree to which they have been applied in the various methods of forest typology (6, 13, 22). Such an analysis is presented in another discussion (9).

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RESUMES

La classification des systèmes de productivité forestière (site, écosystème, biogéocénose)

Les systèmes de productivité forestière (site, écosystème ou biogéocénose) sont des assemblages d'organismes forestiers et de caractéristiques du sol et de l'atmosphère occupant des portions déterminées de la surface de la terre, et unifiés par les divers processus de la production forestière. Ces processus, qui transforment et transmettent l'énergie et la matière à l'intérieur des organismes forestiers et entre ceux-ci et leur milieu, forment un complexe interdépendant d'actions réciproques.

L'auteur du présent rapport estime qu'en raison du fait que les systèmes de productivité sont des complexes de caractéristiques propres à la forêt et à la terre et étroitement reliées entre elles, une telle corrélation doit constituer le critère à choisir pour établir leur classification, au lieu de s'arrêter uniquement à ceux des critères ayant trait soit à la forêt, soit à la physiographie, qui ne constituent qu'une partie de l'ensemble.

Il est fait mention dans ce rapport d'une méthode utilisée pour la classification du site total, dans laquelle des "unités d'écosystème" sont établies par l'utilisation mutuelle et réciproque des caractéristiques d'ordre forestier aussi bien que celles d'ordre physiographique. En prenant note des rapports existant entre la succession et la croissance de la végétation dans des classes déterminées de relief de terrain, on établit des régions d'écosystème (site) à l'intérieur desquelles des résultats similaires peuvent être attendus de méthodes sylviculturales similaires dans le cadre de combinaisons similaires de types forestiers et de types de terrain. Cette classification fournit la base pour la définition du terme "similarité" de conditions.

Les principes requis pour la classification des systèmes de productivité forestière sont énumérés, afin que les méthodes de typologie forestière proposées pour des essais coopératifs internationaux puissent être évaluées dans le cadre de la notion de l'écosystème.

La nature dynamique, à dimensions multiples, des systèmes de productivité forestière exige que leur classification se prête à un certain nombre de moyens d'approche qui, bien que distincts les uns des autres, ne peuvent pas être considérés séparément. Par exemple, lorsqu'on utilise des gradients de caractéristiques d'ordre soit forestier, soit physiographique, pour identifier, décrire, classer et désigner les limites des écosystèmes, ceux-ci doivent être divisés en classes basées sur des rapports significatifs entre la forêt et la terre.

La classification des combinaisons des types forestiers et physiographiques ainsi établie peut alors être utilisée comme un cadre objectif à l'intérieur duquel les processus fonctionnels des systèmes de productivité forestière peuvent être étudiés et analysés.

Clasificación de los Sistemas de Productividad Forestal

Los sistemas de productividad forestal (sitio, ecosistema o biogeocoenosis) son el conjunto de los organismos forestales y de los factores del suelo y de la atmósfera que ocupan partes específicas de la superficie terrestre y están unidos por los procesos de la producción forestal. Estos procesos, que transforman y transmiten energía y materia dentro de los organismos forestales y entre éstos y su ambiente, forman un complejo interdependiente de interacciones recíprocas.

El autor afirma que, como los sistemas de productividad son un complejo de factores terrestres y forestales relacionados entre sí, esta relación misma debería ser el criterio a seguir para su clasificación y no meramente aquellos de bosque o fisiografía que son nada más que parte del conjunto.

En este trabajo se hace referencia a un método de clasificación de "sitio completo" en el cual se establecen "unidades de ecosistema" mediante el uso mutuo y recíproco tanto de los factores forestales como de los fisiográficos. Tomando en cuenta la relación de la sucesión vegetal y del crecimiento en ciertas clases específicas de formación de terreno podrían establecerse ecosistemas regionales dentro de los cuales fuera posible esperar resultados semejantes de prácticas forestales análogas realizadas con combinaciones parecidas de ciertos tipos de bosques y tipos, de suelos. La clasificación proporciona la base para definir el termino "semejanza" de condiciones.

El autor enumera después los principios necesarios para la clasificación de sistemas de productividad forestal, de manera que los métodos de tipología forestal propuestos para los ensayos cooperativos internacionales puedan ser avaluados dentro del concepto del ecosistema.

La naturaleza dinámica y multidimensional de los sistemas de productividad forestal requiere que su clasificación suministre cierto número de normas básicas, las cuales, aunque diferentes entre sí, no pueden ser consideradas separadamente unas de otras. Por ejemplo, cuando se emplean diversos grados de factores forestales o fisiográficos para identificar, describir, clasificar y designar los límites de los ecosistemas, éstos deben dividirse en clases basadas en relaciones de importancia existentes entre el bosque y el suelo.

La clasificación de combinaciones de tipos forestales y fisiográficas establecida en esta forma podrá usarse entonces como un marco objetivo dentro del cual será posible estudiar y analizar los procesos funcionales de los sistemas de productividad forestal.

Studies on Light Intensities Required for Growth of Seedlings of Taiwan Incense-Cedar (Libocedrus formosana, Florin) at Different Altitudes

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Introduction

The light intensity requirement of trees is called "Shade Enduring or Tolerance of Shade." It has intimate influence on the growth and development of trees. The reaction of trees to light varies in different tree species, because each species of tree requires a certain amount of light intensity. Otherwise, it grows poorly and suffers high mortality.

The studies on light intensity of trees began as early as 1852, in Germany, by G. Heyer and were continued by many foresters in other countries. But it is far behind in our country. Research results on this subject were reported by Lin Wei-fang and Liu Yeh-ching of the Institute of Agriculture and Forestry, Fukien Academy, in 1945 and 1947, in their reports entitled "Experiments on requirements of light intensities for the seedlings of China-fir (*Cunninghamia lanceolata* Hook.)" and "Experiments on requirements of light intensities for the coniferous seedlings (*Pinus massoniana* Lamb., *Fokienia hodginsi* Henry and Thomas., and *Keteleeria fortunei* Carr.)". In 1956, they studied in Taiwan the light intensities required for growth of seedlings of Taiwan red cypress (*Chamaecyparis formosensis*, Matsum.), and a report was published in 1958.

Although the method and design of research followed by workers were different, their purposes were the same.

Description of the Experimental Plots

Location

This study was carried out in three regions at different altitudes of 250, 750, and 1,350 meters in the Lu-Kuei Cinchona Experiment Station, Taiwan Forestry Research Institute, Kaohsiung, Taiwan, China. The first experimental region is in Lu-kuei Nursery. It is situated at an altitude of 250 meters and lies at longtitude 120°38′ E. and latitude 23°00′ N. The second experimental region is in Shan-ping Nursery, at an altitude of 750 meters, longtitude 120°41′ E., and latitude 22°58′ N. The third experimental region is in Nan-feng Nursery, at an altitude of 1,350 meters, longtude 120°42′ E. and latitude 23°00′ N.

Climate

The meteorological factors of the experimental regions were recorded in 1957 as follows: At 250 meters, the average air temperature was 23.27° C.; relative humidity, 82%; total sunshine-duration, 1,570 hrs.; and annual rainfall, 2,523 mm. At 750 meters, the average air temperature was 20.27° C.; relative humidity, 85%; total sunshine-duration, 1,149 hrs.; and annual rainfall, 3,171 mm. At 1,350 meters, the average air temperature was 17.22° C.; relative humidity, 89%; total sunshine-duration, 1,136 hrs.; and annual rainfall, 3,384 mm. The above three experimental regions are warm and semi-humid with an alternation of wet and dry seasons, and the rainfall is less in November to April. About 88% of the rainfall is recorded in May to September.

Soil

The characteristics of the soils in the experimental regions were determined as follows: At low altitude (250 meters) the soil is sandy loam with a pH value from 5.18 to 5.39. Total nitrogen content is from 0.0948 to 0.0973%; available-P, 20 to 25 ppm; and available-K, 25 to 63 ppm. At medium altitude (750 meters) it is silty loam with a pH value from 4.95 to 5.00. Total nitrogen content is from 0.0414 to 0.169%; available-P, 21 to 65 ppm; and available-K, 64 to 140 ppm. At high altitude (1,350 meters), the soil is loam with a pH value from 5.22 to 5.65: total nitrogen content is from 0.3269 to 0.3768%; available-P, 30 to 48 ppm; and available-K, 123 to 125 ppm.

Purpose of Study

This study was conducted from October 1956 to February 1958. The major purpose of this study was to determine the optimum requirement of light intensity for the growth of seedlings of Taiwan incense-cedar at various altitudes and to find the climatic factors in relation to the growth and development of seedlings under different light intensities.

The Species of Test Trees

Taiwan incense-cedar is a large tree and is one of the important conifers in Taiwan. These trees do not grow in pure stands in forests but are found scattered in broad-leaved forests of the northern and central parts of the island. They range from an elevation of 300 to 1,900 meters above sea level. The sapwood is light brown and the heartwood is yellow in color. The wood has a compact, fine and straight grain and is commonly used for building construction, furniture, coffins, railroad ties, and small articles.

Method of Study

Design of Light Shelter

Eight classes of light intensities were needed, namely, 9%, 16%, 25%, 36%, 49%, 64%, 81%, and 100% (full light). In order to control the light intensities, light shelters made of bamboo splints woven in cylindrical form, 60 cm. in height and diameter, were used.

Arrangement of Experimental Plot

The experimental plots were located at different altitudes of 250, 750, and 1,350 meters above sea level. The split plot experiment method with three repetitions in randomized blocks was used. Main plots were distributed at different altitudes, and sub-plots were established for different light intensities. Each plot was 1.44 square meters in area with ten seedlings transplanted. The study covered 72 plots in all.

Meteorological Equipment

1. Earth thermometer, dry and wet thermometer, and thermometer in every plot.
2. Sunshine recorder, maximum and minimum thermometer, earth thermometer, temperature recorder, rainfall gauge, anemograph, and other equipment at each elevation.

Results of Study

The results obtained are summarized as follows:

1. The growth of seedlings of Taiwan incense-cedar under different light intensities at various altitudes:
   a. *Low altitude (250 m.).* Based on the results of analysis, the light intensities of 16% to 64% are more adaptable for the height growth of seedlings, but those of 25% to 100% are the optimum for the growth of diameter and branch, and the leaf and root development of seedlings. It shows that both the weak and the strong lights are suitable for the growth of seedlings under annual total sunshine of 1,570 hours at low altitude of 250 meters.
   b. *Medium altitude (750 m.).* The light intensities of 36% to 100% are more adaptable for the height growth of seedlings; 81% to 100% for diameter growth; 49% to 100% for branch growth; 64% to 100% for leaf development; and 100% for root development of seedlings. In general, the growth of height, diameter and branch, and the leaf and root development of seedlings need strong light of 81% to 100% under annual total sunshine of 1,149 hours at medium altitude of 750 meters.
   c. *High altitude (1,350 m.).* The light intensities of 81% to 100% are more adaptable for the growth of height, diameter, and branch, and the leaf and root development of seedlings. It is found that under annual total sunshine of 1,139 hours the growth of seedlings needs strong light of 81% to 100% at high altitude of 1,350 meters.

According to the sunshine hours recorded at the three altitudes, it shows the higher the altitude, the less the sunshine, because of clouds. Sunshine hours are different at various altitudes. The sunshine affects the light intensity. It appears that strong light is required for the growth of seedlings at high altitude.

2. The growth of seedlings of Taiwan incense-cedar at various altitudes:
   The height growth and root development of seedlings at the altitude of 750 meters are much better than those at the altitudes of 250 and 1,350 meters. It shows that the optimum is the medium altitude of 750 meters. But the growth of trunk diameter and branch and the leaf development of seedlings are not significantly affected by the altitudes.
3. The growth of seedlings of Taiwan incense-cedar under general light intensities at three altitudes:
   The general light intensities of 81% to 100% are more favorable for the growth of height, diameter, and branch, and those of 64% to 100% are the optimum for leaf and root development of seedlings. It means that the growth of height, diameter and branch, and the leaf and root development of seedlings need strong light intensities of 81% to 100%.

Hence, the Taiwan incense-cedar may be classified as an intolerant-tree and near the class of intermediate-tree.

4. The interaction effect of altitude and light intensity on the growth of seedlings of Taiwan incense-cedar:
   The growth of height, diameter and branch, and the root development of seedlings respond to the interaction effect of altitude and light intensity with great significance. But the interaction effect has little influence on the leaf development of seedlings. It is found that the combined effects of altitude and light intensity are intimately connected as follows:
   a. Height growth:
      (1) *Effect of altitude.* With light intensity of 25%, the average height of seedlings reached 48.52 cm. at low altitude of 250 meters, and showed positive significance. But the average height decreased to 24.37 cm. at high altitude of 1,350 meters. This shows that the light intensity of 25% at low altitude is more favorable for height growth of seedlings than that at high altitude.
      (2) *Effect of light intensity.* At the altitude of 250 meters with different light intensities of 16% and 25%, the average heights of seedlings were 40.10 and 45.80 cm. respectively, and showed significantly positive effect. But the average height decreased to 35.00 and 34.77 cm. under light intensities of 81% and 100% respectively. It showed significantly negative effect. This

means that at low altitude the light intensities of 16% and 25% are more favorable for height growth of seedlings than those of 81% and 100%.

b. Diameter growth:

(1) *Effect of altitude.* At low altitude of 250 meters, the average diameters of seedlings were 7.39 and 8.87 mm. under light intensities of 25% and 64% respectively, and showed significantly positive effect. But it was decreased to 6.04 and 7.45 mm. at high altitude of 1,350 meters and showed significantly negative effect. The light intensity of 100% gave 7.80 mm. at low altitude with a significantly negative effect. Whereas at high altitude, the average diameter increased to 11.18 mm. with a significantly positive effect. It appears that the light intensities of 25% and 64% at low altitude are more favorable for diameter growth of seedlings than that at high altitude. But the strong light of 100% at high altitude gives better results than that at low altitude.

(2) *Effect of light intensity.* At low altitude of 250 meters, the average diameters were 8.75 and 8.87 mm. under light intensities of 49% and 64% respectively, and showed significantly positive effect. But with light intensity of 81% and 100%, the average diameter decreased to 8.12 and 7.80 mm. respectively, and showed significantly negative effect. At high altitude of 1,350 meters, the average diameters were 6.04 and 7.45 mm. with light intensities of 25% and 64% respectively, and showed significantly negative effect. But it reached 11.18 mm. under light intensity of 100%, which showed significantly positive effect. This shows that the light intensities of 16%, 25% and 64% are more suitable than those of 81% and 100% at low altitude. At high altitude, the light intensity of 100% is much better for diameter growth of seedlings than those of 25% and 64%.

c. Branch growth:

(1) *Effect of altitude.* At low altitude of 250 meters, the average weight of branch of seedling was 13.13 grams under light intensity of 100%, with a significantly negative effect. But it increased to 28.31 grams at high altitude of 1,350 meters, with a significantly positive effect. This means that the strong light of 100% at high altitude is more favorable for branch growth of seedlings than that at low altitude.

(2) *Effect of light intensity.* At low altitude of 250 meters, the average weight of branch of seedling was 14.91 grams under light intensity of 25%, showing significantly positive effect. But it decreased to 13.13 and 13.10 grams under light intensities of 81% and 100% respectively, which showed significantly negative effect. At high altitude of 1,350 meters, the light intensity of 64% gave 10.83 grams of branch growth. It indicates a negative effect. However, the branch growth increased to 28.31 grams under light intensity of 100%, with a significantly positive effect. It proves that at low altitude, the light intensity of 25% is more favorable for branch growth of seedlings than those of 81% and 100%. But at high altitude the strong light of 100% is much better than that of 64%.

d. Root development:

(1) *Effect of altitude at 100% light intensity.* At low altitude of 250 meters, the average weight of root was 10.47 grams under light intensity of 100%. At the altitudes of 750 and 1,350 meters the root growth increased to 22.39–26.89 grams. It means that with light intensity of 100% at low altitude the root development of seedlings is less than it is at medium and high altitudes.

(2) *Effect of light intensity.* At low altitude of 250 meters the average weight of root was 9.76 grams under light intensity of 25%. When light intensities increased to 81% and 100%, the average weight of root increased to 10.22 grams and 10.47 grams respectively. It shows that the weak light of 25% and strong lights of 81% and 100% are significant.

5. Effect of climatic factors on the growth of seedlings under different light intensities:

a. *Sunshine and growth.* The sunshine affected the growth of height, diameter and branch. But the development of leaf and root of seedlings does not have a significantly positive correlation at the altitude of 250 meters. However, it shows positive correlation at altitudes of 750 and 1,350 meters. It means that the sunshine influences the growth of seedlings significantly.

b. *Air temperature and growth.* Air temperature affected the growth of diameter and the development of root of seedlings with a significantly positive correlation at the altitude of of 250 meters. The growth of height and branch, and the development of leaf of seedlings show a significantly positive correlation at the altitude of 750 meters. But it shows significantly negative correlation to the growth at altitude of 1,350 meters. Then, it is found that the air temperature affected the growth of seedlings in proportion to the light intensities at low and medium altitudes.

c. *Soil temperature and growth.* Soil temperature affected the growth of seedlings with a significantly positive correlation at the altitudes of 750 and 1,350 meters but showed no significant correlation at the altitude of 250 meters. It is found that seedling growth is related to the soil temperature. It shows that the variation of the growth rates of height, diameter, and branch, and the development of leaf and root of seedlings under different soil temperatures is very apparent.

d. *Relative humidity and growth.* Relative humidity affected the growth of seedlings with a significant negative correlation at all altitudes (250, 750, and 1,350 meters). It is found that the light intensity decreases along with the increase of relative humidity, and that the relative humidity increases in line with the increase of altitude. This shows that the relative humidity intimately influences the growth of seedlings of Taiwan incense-cedar.

In general, among the four main factors of climate, sunshine is the most important factor in the growth of seedlings of Taiwan incense-cedar. It influences directly the air temperature, relative humidity, and soil temperature.

According to the results of this study, the growth and development of height, diameter, branches, leaves, and roots of *Libocedrus formosana* seedlings do not need strong light at low altitude, but they do need such light at medium and high altitudes. To apply these findings to silvicultural practice, it may be concluded that at low altitudes, Libocedrus seedlings in the nursery should be shaded immediately after transplanting. When the transplants are well established the shades may be removed. In the forest, at high and medium altitudes, light shade from residual trees is not required for the successful establishment of reproduction of Libocedrus, but at low altitudes such shade is desirable, and may even be essential.

RESUMES

Intensités lumineuses requises pour la croissance de plants de libocèdre de Taïwan (Libocedrus formosana, *Florin.*) *à diverses altitudes*

Cette étude a été effectuée dans trois régions se trouvant à des altitudes différentes, à savoir respectivement: 250, 750 et 1.350 mètres, à la Station d'Expérimentation de Lu-kuei, Institut de Recherche Forestière de Taïwan, Kaohsiung, Taïwan, Chine.

Les abris pour le contrôle de la lumière ont été conçus de façon à obtenir huit degrés différents d'intensité lumineuse, à savoir: 9%, 16%, 25%, 36%, 49%, 64%, 81% et 100%. Ils consistent en éclisses de bambou tressées en cylindres de 60 cm de haut et 60 cm de diamètre. On a appliqué la méthode d'expérimentation consistant en l'utilisation de parcelles divisées avec trois répétitions dans des îlots pris au hazard.

Croissance des jeunes plants sous des intensités lumineuses différentes aux diverses altitudes: Les résultats de l'analyse montrent que des intensités lumineuses de 25 à 100% sont plus favorables à la croissance et au développement des semis avec un ensoleillement annuel total de 1.570 heures à la basse altitude de 250 mètres, mais que des intensités lumineuses accrues variant entre 81 et 100% sont les plus favorables au développement des semis avec un ensoleillement annuel total de 1.149 et de 1.136 heures à l'altitude moyenne de 750 mètres et à l'altitude élevée de 1.350 mètres respectivement. Il résulte de ces constatations que le libocèdre de Taïwan peut être classé dans la catégorie d'essences tolérantes et près de la catégorie intermédiaire.

Croissance des jeunes plants aux diverses altitudes: La croissance en hauteur et le développement des racines sont beaucoup plus satisfaisants à l'altitude de 750 mètres qu'à celles de 250 et de 1.350 mètres. Les résultats acquis montrent que l'altitude optima est celle de 750 mètres. Mais l'altitude ne semble pas avoir un effet marqué surla croissance en diamètre et le développement du feuillage.

Effet des facteurs climatiques sur la croissance des jeunes plants sous les diverses intensités lumineuses: L'ensoleillement, la température de l'air, la température du sol et l'humidité relative ont une influence très marquée aux trois altitudes étudiées sur la croissance en hauteur, en diamètre et en branchage, ainsi que sur le développement du feuillage et des racines. La variation du taux de croissance avec les différents facteurs climatiques est très évidente.

Estudios de las Intensidades de Luz Requeridas para el Crecimiento de Semillones del Cedro de Incienso de Taiwan (Libocedrus formosana, *Florin.*) *en Distintas Alturas*

El estudio se efectuó en tres regiones a distintas alturas: 250, 750 y 1.350 metros en la Estación Experimental de Lu-kuei Cinchona, el Instituto de Investigaciones Forestales de Taiwan, de Kaohsiung.

Se diseñaron abrigos de luz para ocho clases de intensidad de luz: 9%, 16%, 25%, 36%, 49%, 64%, 81% y 100%, y se construyeron de listones de bambú dispuestos en forma cilíndrica, de 60 cm. de altura y de diámetro. Se empleó el método de parcela dividida con tres reproducciones en macizos escogidos al azar.

Crecimiento de los semillones en distintas intensidades de luz y a distintas alturas: a base de los resultados del análisis, las intensidades de luz de 25% a 100% son más favorables para el crecimiento y desarrollo de los semillones bajo luz solar anual de 1.570 horas, en altura baja de 250 metros, pero las intensidades aumentadas a 81% y 100% son las mejores para el crecimiento y desarrollo de semillones en luz solar anual de 1.149 y 1.136 horas en la altura media de 750 metros y la alta de 1.350 metros. Se observó que el cedro de incienso de Taiwan se puede clasificar como árbol intolerante y cerca de la clase de árbol intermedio.

Crecimiento de los semillones en distintas alturas: el crecimiento en altura y desarrollo de las raíces de los semillones en la altura de 750 metros son mucho mejores que en las alturas de 250 y 1.350 metros, pero el aumento de diámetro y desarrollo de ramas y de frondosidad de los no parece que se afectan notablemente en las distintas alturas.

Factores climáticos en el crecimiento de semillones bajo distintas intensidades de luz: la luz del sol, la temperatura del aire, la del suelo y la humedad relativa afectan a su crecimiento y desarrollo en altura, diámetro y ramas, así como a su frondosidad y raíces en modo muy notable en las tres alturas. La variante en proporción de crecimiento de los semillones en distintas condiciones de clima es evidente.

Forest Type—Base of Forest Management

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The purpose of forest management is the regulation of timber production as economically as possible, as well as to organize and maintain the forest for sustained yield purposes without impoverishing the soil.

With application of proper silvicultural treatment it is possible to raise the production of the forest to a certain limit, which would depend on the ecological condition of the location where a particular forest exists. Such locations, with the particular ecological conditions, according to V. Sukachev, are called "biogeocenose," which are commonly known as "forest types."

A rational forest management must be based on objective study of the forest types so as to better assess the productive capacity of the soil under the particular environment and decide about the method of working the forest to best advantage.

A good knowledge of forest types, their ecological requirements, and the process of optimum development will help in choosing the most economical treatment to ensure the best production from a particular forest. For a more or less natural forest, when assigned to proper forest types, such study will provide data on the constitution of the crop and its rate of growth. It will thus be possible to choose the right kind of silvicultural treatment, which will ensure proper upkeep of the form, mixture of the species, elimination of undesirable ones, and, where possible, introduction of more valuable species (economically more suitable), regulation of cuts, and will facilitate the natural regeneration of more desirable species without degrading the soil.

With a good knowledge of the forest type it will be easier to appreciate the site quality (Bonitat) for forest management and exploitation purposes and to fix the rotation for the principal species. If composition of the growing stock and the area are known, all other regulations to ensure the best yield can easily be decided.

For the degraded forests which must be improved or reforested, it will also be necessary to know the state of succession of the vegetation (progressive or regressive) in relation to the changes in the vegetation cover and the soil degradation. The determination of progressive succession of the vegetation and reinstallation of the forest with economically useful species will be of very great importance.

Proper knowledge of the forest type can be used as a basis for the introduction of a realistic silvicultural system which can, in turn, be the soundest basis for rational management. It would pay to delineate homogeneous areas of a forest, and this can be accomplished if division of the forest into different compartments is made according to forest type. In this way, each compartment or subcompartment would contain only one forest type. It would also be better to carry out the forest inventory by compartments delimited by this method, because this would represent more correctly the natural conditions. A map of the forest showing forest types prepared on a large scale would facilitate this work.

For a study of productivity of the forest and effects of silvicultural treatment employed it would be useful to lay out some research plots. Three principles will govern the choice of the research plots:

1. A plot must be chosen in a well-represented type of forest;
2. The form of the stand which is the object of study must also be representative; and
3. A plot must be homogeneous from the point of view of the type of forest and form of the stand.

Forest types were first talked about in America and Russia about 1898, but it is in Russia and Finland that the idea of forest typology was developed (Morosov, Cajander, Sukachev). Everybody agrees that the forest type is conditioned by the total of the ecological factors peculiar to the site where a particular type of forest has developed. But a forest is composed of a plant association which covers all its different stories. Above all, a plant community or phytocenose is particularly specific to a site.

The science which deals with the study of the plant community is named differently in different countries and varies from one country to another, such as: Phytosociologie, Phytocenologie, Plant sociology, Pflanzensociologie, etc. The system of defining the plant community differs slightly from one country to another or from one school to another. But what is important for forestry purposes is the basic unit which would correspond to the type of forest, and that would be "plant association" or, sometimes, "sub-association." The concept of association is considered in a larger sense by the Zuricho-Montpellièrenne school of J. Braun-Blanquet than by the Russian school of V. Sukachev. It is the same as the concept of "sociation" by the Nordic school of Du-Rietz and Nordhagen. These concepts differ in relation to the country where they were elaborated. In the Nordic flat countries, the flora is poor and the classification of the plant community is based on dominant plants, while in Mediterranean and mountainous countries where the flora is rich, the concept of characteristic species is of more practical importance.

As the science of study of the plant community is relatively young and developed in parallel lines in various countries, the systematic study of plant communities is not yet standardized. The case is the same with soil types.

The constitution of a plant community is the result of combined action of all the ecological factors. The floristic constitution is easy to describe, and that is what is practicable. When the ecological conditions of a certain type of forest are well known, then if one finds somewhere else a forest of a floristic constitution similar to the one already studied, he could be sure that the ecological conditions will also be similar. But in the floristic constitution another factor still intervenes—the flora development history. For example, in America and in Europe, under the same ecological conditions, there will be some coniferous forests consisting of species totally different. This is of very great importance for forestry purposes, because with the knowledge of the floristic constitutions of those two types of forest growing under similar ecological conditions, there exist possibilities to enrich those types of forest by mutual exchange of more economically valuable species, and thus it would help avoid a lot of useless gropings in the dark and errors. With the help of certain plants, ecological conditions can often be determined, because those plants have very strongly defined ecological requirements, for example: acidiphil, halophil, psammophil, calcarophil, hygrophil, xerophil, etc. Other ones exert by themselves an edaphic ecological action. Then there are pioneer plants coming up early in ecological succession which show the dynamic character of the plant community. With the help of those plants the evolution of a vegetation and its succession series can be followed. The study of the succession of the vegetation is well developed, mainly in the United States.

Proposals

The question of the study of forest types was previously raised in the last International Forestry Congress at Dehra Dun in 1954. Reports were also submitted. I should like to offer the following proposals:

As it is practically impossible to unify the methods of determination of the classification of forest types or forest plant communities or to adopt a uniform system of classification, it might be possible to entrust a commission with study of the various methods of classifying forest types and to find the comparative points of these different methods and, if possible, to find out the common rules. Those common rules should deal mainly with the presentation of the ecological data in a uniform way which will provide facilities to compare them, whereas the description of the vegetation could be left to be done according to the methods in use in the respective countries.

Ecological data may be condensed, recording information on climate, relief, soil type, site quality, etc., with the use of a uniform formula. To these can be added description of the vegetation, composition of the stand, data on rate of growth, representation of the principal species, and problems affecting their regeneration.

(i) Latin names should be used for denomination of forest types.

(ii) It should also be arranged to publish lists of forest types with all their data, to make a "Prodromus" (world-wide inventory of forest types).

(iii) Maps of forest types already prepared should be exchanged.

It would be advisable to constitute a permanent international organization to be entrusted with this work. Such an organization may be composed of national commissions who would carry out this work in their own countries and would be required to exchange information with other commissions.

RESUMES

L'aménagement forestier basé sur les types de forêts

Un aménagement forestier rationnel doit reposer sur une étude objective des divers types de forêts de façon à pouvoir évaluer la capacité de production du sol dans un milieu déterminé et décider quelle méthode d'aménagement forestier sera la plus satisfaisante.

Le choix du traitement le plus économique propre à assurer la meilleure production d'une forêt donnée est facilité par une connaissance approfondie des divers types de forêts, de leurs besoins écologiques et du processus de développement optimum.

Il est possible de condenser les données écologiques en groupant les renseignements obtenus par facteurs tels que climat, relief, type de sol, qualité du site, etc., même avec l'emploi d'une formule uniforme. On peut y ajouter une description de la végétation et de la composition du peuplement, des données sur le taux de croissance, les principales essences représentées et les problèmes relatifs à leur régénération.

La Administración Forestal a Base de Clase de Bosque

La administración racional de bosques se debe fundar en estudios de las clases de bosques a fin de apreciar mejor la capacidad productiva del suelo en ambiente particular y decidir la mejor manera de aprovechar más ventajosamente el bosque.

El buen conocimiento de las clases de bosques, sus necesidades ecológicas y del modo de lograr su desarrollo máximo, ayuda a escoger el tratamiento más económico para asegurar la mayor producción posible de un bosque dado.

Los datos ecológicos se pueden resumir registrando los informes de elementos demostrativos tales como el clima, relieve del terreno, clase de suelo, ventajas del sitio, etc., aún empleando una fórmula uniforme. A estos datos se pueden agregar descripciones de la vegetación, composición del arbolado, proporción de crecimiento, representación de las especies principales y problemas que afectan a su regeneración.

The Nature of the Taiga Forests and Cutover Areas

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The explorers of the forests situated in the zone of the taiga devoted and are devoting the greatest attention to the study of virgin forests. They are greatly interested in types of forests, the structure of sands, and their regeneration and formation. Great was the contribution of Russian, Scandinavian, American, and Canadian scientists in the exploration of the virgin forests in the taiga.

Well known is the enormous influence of forest fires upon the life of the forests in the taiga, upon their destruction and regeneration, and upon their formation. The results of forest fires in the taiga and in other forests are being intensively studied in a number of countries, among them Canada, the USA, Finland, Sweden, and the USSR.

In the USSR, based upon thoroughly elaborated schemes, the classification of forest burns, geographical belts showing the possible occurrence of forest fires, and scales of fire hazards in different forest types, a number of practical measures have been worked out for controlling forest fires and their harmful consequences, for the utilization of forests previously injured by fire and their reforestation with economically valuable species.

The forests of the taiga, and first of all the coniferous ones, are remarkable for their high-quality timber; their part in supplying mankind with lumber and other products is ever increasing. The amount of exploitation of the forests in the taiga is rising. The cuttings which are taking place in them also greatly alter them. That's why nowadays the forests in the taiga are not solely virgin forests.

The taiga forests have notably changed in character on account of selective cuttings. This refers, in the first place, to the regions where the forests were tapped long ago and where industrial-selective cuttings, performed for a long period of time—particularly during the XIXth and the beginning of the XXth centuries—resulted in an alteration of the stand composition, as well as in a change of the commercial size of trees, in the conditions under which new generations of forests were established, etc. The above-mentioned influence of selective cuttings must be taken into consideration, especially as they were applied not only to uneven-aged, but also to even-aged forests.

Even-aged stands in the forests of the taiga do not occur accidentally, but are rather characteristic and widespread; they were observed at the end of the last century by Scandinavian, Russian, and American foresters, primarily in pine forests with relatively rich soils, in which shade-tolerant species can get mixed with pines. This point was elucidated in the report of Professor M. E. Tkachenko at the International Congress of Experimental Forest Stations in Stockholm in 1929. Now it is possible to add that, as shown by investigations carried out in the North European forests of the USSR, as well as in the virgin forests of Bulgaria and some other countries, not only pine forests, but in some cases spruce forests, too, may be even-aged; spruce may play the part of pioneer on burned-out areas with well-drained soils in green-moss types of forests (*Pineta hylocomiosa*) and may, at the same time, form even-aged stands.

The results of selective cuttings are different in different forest types. In the USSR, the applicability of selective cuttings in some types of northern forests has been proved in reference to stands of different ages and age-structures. Apart from unfavourable ones, some favourable aspects of the application of selective cuttings in the forests of the northern taiga regions have been established; for instance, the possibility of increasing the rate of diameter growth of pines, even of old-aged ones (200–220 years of age), with a simultaneous increase of the amount of summerwood in the annual rings. Protective selection cuttings must play an important part in the preservation of subtundra forests, water-holding forests and mountain forests.

Great changes take place in the conditions of existence, regeneration and formation of forests in connection with clearcuttings, especially on big areas—so-called concentrated clearcuts. Such cuttings are practiced nowadays in the taiga forests in a number of countries.

That is why the problems, not only of natural characteristics of forests but also of the changes in forests due to man's management, and especially those caused by clearcuttings, are intensively attracting the attention of silviculturists, soil scientists, botanists, and specialists from other branches of science. The study of these problems is necessary for the most rational exploitation and reproduction of forests, and for increasing their yields. An extensive programme of forest reproduction in the USSR has necessitated the study of the nature of cutover areas in the taiga.

Studying the complex nature of the forest, silviculturists have learned to divide the forest into homogeneous categories. One of them, and the most important of all the categories, is the type of forest—a complex and synthetic category. The typological study of the virgin taiga forests has been greatly advanced by the scientific schools of V. N. Sukachev, A. K. Cajander, F. E. Clements, and others.

The profound study of the ecology of separate forest types, started in Sweden, Finland, the USSR and some other countries, is of great importance and should be further developed.

Valuable information has been obtained by the investigations of both quantitative and qualitative yields of stands in different forest types. Investigations have shown that the activity of the cambium is not the same in stands of different forest types, and as a result of this, the anatomical structure of wood and its quality also differ. In Northern European green-moss pine stands (*Pineta hylocomiosa*), the cambium awakes earlier and functions more intensively than in sphagnum pine stands (*Pineta sphagnosa*). As a result, the annual rings in *Pineta hylocomiosa* are notable for more thickwalled tracheids than those of *Pineta sphagnosa*. Only because of this, the quality of wood in *Pineta hylocomiosa* is much higher than that in *Pineta sphagnosa*. Many other aspects are also connected with forest types. At the present time, some regularities have been established in the natural regeneration of some forest species in different forest types.

Thus, the division of taiga forests into types, which is theoretically and practically very important, has fully justified itself.

When studying the characteristics of clearcut areas which are no less complicated, they should be divided into more or less similar categories, or types, of cutover areas and studied in detail. Nowadays the forest typology has to be supplemented with the typology of cutover areas connected with it. A cutover area, as well as a forest, must be regarded as a natural complex.

The disclosure of the natural characteristics of concentrated clearcut areas and their typification on this basis are necessary, first and foremost, for the determination of site conditions and the environmental conditions of the establishment and existence of a forest.

Natural unity, "biogeocenos," is distinguished by close reciprocal action and interrelationships among such factors as the whole vegetation, the fauna, the soil, and the atmosphere of a given site. The division of cutover areas into such sites is of theoretical as well as of practical importance.

To our mind, the most obvious index of a natural unity, its "reflector," when cuttings are under way, is the surface vegetation and, first of all, the ground cover (not excluding the nonliving soil cover). Different microclimates, diverse soil conditions and various other things are distinguishing characteristics of cutover areas with covers of *Deschampsia flexuosa* Trin., *Chamaenerion angustifolium, Calamagrostis* sp., *Calluna* sp., etc.

A type of cutover area in a natural historical meaning is determined first of all by the character of the surface vegetation—ground cover, in particular—by its changes in space and in time. Being a result of the changes of surroundings, it is notable at the same time for its own characteristic environment. It is of special importance to note such changes in the surface vegetation, taking place after a cutting, which, obviously reflecting a certain period, have the greatest importance for practice.

A type of cutover area, as well as a type of forest, is a geographical phenomenon. It is characterized by a definite geographical habitat (areal), soil quality, relief, and exposition and is connected with the type of forest.

The influence of fire upon the formation of a type of cutover area is great. The formation of pyrogenous or burnt types of cutover areas is connected with it. This should be taken into account when establishing the connections existing between the types of cutover areas and the types of forests. Based upon the study of forests and cutover areas in the European North of the USSR, such connections can be illustrated by schematic representation.

Confirming that the type of a cutover area depends on the type of forest, the scheme shows that:

1. Different (but strictly definite) types of cutover areas are formed on one and the same type of forest after cuttings, depending on whether these cutover areas were or were not subjected to burning.
2. The typological scale of cutover areas formed on the place of one and the same type of forest extends with the increasing of yields.

Since, after cuttings in the same type of forest, site conditions may not always be equal, the differences in them must reflect and show the types of cutover areas.

Characteristic plants growing on cutover areas are not only indicators of the environmental conditions which appear after cuttings, but are also "edificators," creators of definite conditions of the environment. The type of cutover area defines changes occurring in the soil and in the microclimate, in the composition of the over-and underground flora and fauna, in root secretion, and so on, i.e., it defines changes in the conditions of the environment on which the regeneration of the forest, both natural and artificial, depends.

It is necessary to distinguish burnt cutover areas from unburnt ones even with the same composition of grass cover, as the environment for the regeneration of forests may differ.

In spite of a formal resemblance, burnt cutover areas can greatly differ in nature even before surface vegetation appears on them. In some cases, owing to sufficient burning out of the ground cover, they can represent an ideal environment for the reproduction of a forest; in some others, a slightly burnt, thick layer of forest litter prevents the seeds from germinating; and at last, very intense burning, destroying the organic matter of the soil, decreasing bacterial activity in the soil, and sometimes leading to the glazing of the soil, makes the conditions of reproduction and forest growth worse. A timely diagnosis of the burnt, cutover areas and the study of their overground and soil peculiarities are of great importance for silvicultural practice.

Thus, the type of cutover area, being an elementary unit of forest growth conditions, is at the same time the focal point of all the main factors which, taken together, determine the environment necessary for forest regeneration, especially at its early and hardest stages; the type of cutover area and the forest type determine the conditions of further existence of the forest.

Among different types of cutover areas we may differentiate, according to their appearance, background types and fragments of other types interspersed with them, for instance, on places where slash piles were burnt, on skidways, and so on.

The basic (background) types of cutover areas may be divided into two groups: (1) with the preservation of the cover forming the forest floor, ecologically adapting itself to the conditions of clearcut areas; (2) with very big changes of the ground cover after cuttings.

The type of cutover area is of a dynamic nature. It represents a definite stage in the development of the vegetation; therefore, it should be considered also in reference to time. It is necessary to determine in due time the first phase of the stage, giving the opportunity to see its potential development and to determine the time of its culmination point, fall, and transition into a new vegetation stage.

Types of cutover areas differ in duration. Some of them are of short duration—from 3 to 5 years; the existence of others extends to somewhat longer periods—10 years and more. Thus, for instance, in the conditions of the European North of the USSR, the type with *Deschampsia flexuosa* and the type with *Polytrichum commune* usually differ from the type with *Chamaenerion angustifolium* by a longer period of existence.

The difference in the period of existence of one and the same type depend on a number of factors, among them, on the presence or the absence of trees on the cutover area, on their number and width, the direction of the cutover area, etc.

The origin of plants (by seed or vegetative) is of importance in the study of the ground cover of cutover areas and in the determination of their types, because many aspects of forestry are connected with the biology of "edificators." The study of the physiology of these plants on cutover areas (especially, in connection with the water regime and photosynthesis) is of importance.

The knowledge of the typology of cutover areas will permit the use of more effectively favourable conditions for the reproduction of forests and the prevention, in due time, of the birth of unfavourable ones. The types of cutover areas, reflecting the conditions of forest existence, not only point out the possibilities and ways of forest regeneration at a given moment but also permit judging the past and future changes in the conditions of forest existence, thus affording the possibility of foretelling in what manner the future regeneration and formation of forests will take place.

The processes of forest regeneration and ground changes, as well as changes in the soil, are interconnected.

The typology of cutover areas and the typology of forests are mutually connected not only because of the fact that a definite type of cutover area or a group of such areas take their origin from definite types of forest. There is another aspect, including the problems of a further succession of types on cutover areas "by forest series" and the formation of corresponding types of forests in place of definite types of cutover areas.

Speaking in this sense about the appearance, development, and establishment of forests on concentrated clearcuts, we can choose several ways, the following three of which are the most typical and sharply differ from one another:

1. By reforestation of cutover areas immediately after a cutting, at the expense of a preceding reproduction and a fast subsequent regeneration of the forest.
2. By having a definite type of cutover area directly replaced by a forest.
3. By the establishment of forests after a succession of several types of cutover areas.

If we take one of the schemes illustrating these subdivisions, we shall see that it reflects successive stages of the vegetation on cutover areas in the *P. myrtillosum* forest type (without the influence of fire) in the European North of the USSR. Such schemes may naturally be great in number, but these examples illustrate the possible method of approach for distinguishing the laws governing the changes in the vegetation on cutover areas. The differences in these vegetation stages and their mutual replacements also exert an influence upon the duration of forest regeneration.

There is no necessity to consider an afforested cutover area with a dense, young stand as a type of cutover area, but it should be considered as the beginning of a forest stage—the beginning of the formation of a forest type which acquires its most definite features of a fully formed type of forest when a stand begins to reach its age of maturity. Thus, the vegetation cover after a clearcutting passes through a number of stages. The first stages belonging to the formation of a typical surface vegetation on cutover areas, in the natural-historical and silvicultural sense, represent the types of cutover areas.

The working out of the typology of concentrated clearcuts in the taiga is not only of theoretical but also of practical importance, as the correct solving of the problems of forest regeneration, control of swamping, agricultural cultivation of cutover areas, etc., are connected with this problem.

The further stages are the stages of establishment and development of forest communities and the formation and establishment of definite forest types.

Here we are already dealing with the typology of forests. This problem is connected with the typology of cutover areas. Thus, we should like to emphasize the importance at the present time of developing the dynamic typology of the forest.

And so, the present-day forests of the taiga are represented by virgin forests and by forests that have been changed and are being changed by man. The area of the latter is always increasing. In connection with this, there arises a number of new forestry problems. Therefore, side by side with the study of virgin forests, it is necessary to thoroughly study the nature of forests that have been drawn into the orbit of man's activities.

This study of changes in forests in connection with cuttings is of great importance. In these investigations an important part must be played by the further elaboration of the problems of forest typology and the typology of clearcut areas closely connected with the former.

RESUMES

La nature des forêts de la taiga et des terrains exploités

Les forêts actuelles de la taiga sont représentées à la fois par des forêts vierges et par des forêts qui ont été et qui continuent d'être exploitées. La superficie de ces dernières augmente sans cesse, ce qui donne naissance à un certain nombre de nouveaux problèmes de sylviculture. En conséquence, parallèlement à l'étude de la forêt qui n'a jamais été exploitée, il est nécessaire de procéder à une étude approfondie de la nature des forêts qui se trouvent maintenant dans l'orbite des activités de l'homme. Les études qui ont été effectuées dans un certain nombre de pays sur les divers types de forêts vierges et sur les changements qui s'y produisent à la suite des coupes qui y sont pratiquées et des incendies se sont révélées une aide précieuse pour la théorie aussi bien que pour la pratique de la sylviculture. Certaines régularités ont été déterminées dans la structure des peuplements et dans leur rendement, tant quantitatif que qualitatif, pour les divers types de forêts. En se fondant sur l'étude de la nature des incendies et de leurs conséquences pour la forêt, on a pu mettre au point des méthodes pour la lutte contre les incendies de forêts et pour éliminer leur effet nuisible, et aussi pour faire du feu un moyen d'action précieux dans la pratique de la sylviculture.

Le type de la zone déboisée, dans le sens histoire naturelle, est caractérisé par l'unité naturelle, catégorie synthétique et complexe, et est déterminé en premier lieu par le caractère de la végétation —notamment de la couverture végétale—et par ses changements dans l'espace et dans le temps. Etant le résultat d'une modification de l'environnement, il est caractérisé à la fois par son propre milieu caractéristique, par son propre microclimat, les particularités des couches minérales inférieures et supérieures, par sa faune, insectes et organismes vivant dans le sol, etc.

Les types de zones déboisées aussi bien que les types forestiers sont des phénomènes géographiques. Ils se rattachent à la région géographique, au sol, au relief et à l'exposition.

Naturaleza de los Bosques de la Taiga, Vírgenes y de Corta

Actualmente, los bosques de la taiga se encuentran en zonas selváticas vírgenes y en otras que han sido o están siendo alteradas por la mano del hombre. La extensión de estas últimas va en constante aumento, y es en relación con ellas, que han surgido nuevos problemas forestales. Por eso, a la vez que se estudian los bosques vírgenes nunca explotados hasta ahora, también, es necesario investigar a fondo la naturaleza de los que han entrado ya en la órbita de las actividades del hombre. Las investigaciones realizadas en diferentes países sobre los tipos de bosques vírgenes y los cambios efectuados en ellos, por las diversas cortas y los incendios, han resultado muy valiosos para la teoría y la práctica de la silvicultura. Merced a ellos ha sido posible determinar ciertas irregularidades en la estructura de los bosques y el rendimiento cuantitativo y cualitativo de los diferentes tipos de zonas forestales. Tomando como base el estudio de la naturaleza de los incendios y de las quemas forestales, se han desarrollado métodos para contrarrestar las conflagraciones, eliminar los efectos nocivos y para aplicar el fuego como un recurso valioso para la silvicultura.

El tipo de área explotada es, en cuanto a la historia natural, una unidad común, de categoría sintética y compleja, determinada en primer lugar por el carácter de la vegetación superficial, y en especial por la capa que cubre el suelo y por sus cambios de espacio y de tiempo. Por ser resultado del cambio de ambiente, se caracteriza, al mismo tiempo, por su ambiente propio, su microclima, las peculiaridades de los estratos minerales superiores e inferiores, su suelo y la fauna de éste, etc.

Los tipos de áreas explotadas, así como también los tipos forestales, son fenómenos geográficos. Están relacionados con una región, un suelo, un relieve y una exposición geográfica definida.

Experiments on Survival of Natural and Artificial Conifer Reproduction in California—Design and Results

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Reproduction is an integral part of forestry practice and research. What the problems are depends on climate, soils, forest type, chance condition of the stands, and silvicultural systems employed. In California, of course, the discussion centers around summer drought and heat.

Some comments on how we see the problems of relevant forest research in the framework of modern research attitudes, trends, techniques, and activities may be helpful. There is a general drive towards smallness (microstudies). There are fields where further progress depends on such tools as electron microscopes, ultra-filters, isotope-labeling, chromotography, etc. We need an awareness of these tools as well as a steady realization of the levels of biological organization for which we are responsible. Only thus can we accomplish both (a) to remain informed about these tools, and (b) not to forget our actual forestry objectives.

To research, precision is essential. However, the quality of research is by no means so simply correlated with precision that the higher the latter the higher the research level. Comparatively low degrees can still be highly useful. Progress often depends on our ability and readiness to work with low degrees of precision and even with things we cannot imagine. The symbols which stand for infinity and the square root of minus one are examples.

To "understand" means different things on different levels. It means that one is able to deal with a problem successfully. The physicist works with Newton's Laws without really understanding them. In forestry, too, we have to live with such infinities and symbols. Low degrees of exactness are dangerous only if one is not aware of them.

Our objective is to understand our species and the accompanying vegetation better and better as entities responding in certain ways to the environment. Any helpful method is welcome. In the drive for smallness, for instance, in biochemistry, we are somehow after the mysteries of life as such. On this level we must try to get down to molecular reactions. Whether this is a way to better understand life is an open question. We hope it is and must try it. However, it is absolutely sure that the study of the integrated field-behavior of undissected plants will never be outdated.

There is no need whatsoever for us to question clearly observable facts; for instance, that certain species grow on certain sites, reproduce on certain spots, in certain years, here in overlap with others, there by themselves. In our endeavors to comprehend the significance of the vast number of observable facts, we keep shifting between studying plant behavior and environment, alternately using one to interpret the other. With this we are still in an early stage of exploring. We talk about "capacity of survival" and "limits of tolerance" without actually knowing the environment by which or in spite of which the plants survive.

Confronted in the field with a vast body of observable facts and with an irritating complexity, we must trust in our ability to cope with them, realizing that as far as environment is concerned plant life is governed by a limited number of fairly well-known factors. By relating our observations to each other we unify and thus reduce them to a manageable number. Whether and how the variables are interrelated does not strictly depend on the nature of the matter involved. If we ask: "On what does natural conifer reproduction depend?", we are confronted with an almost paralyzing complexity. Such heterogeneous things as amount of sexually mature trees, cone insects, conditions of seed dispersal, and rodent activities come in. However, if "summer drought" is the topic, we can eliminate all of those factors by just asking: "On what does first year survival depend?" Now we are dealing with actual seedlings and can focus our study on the impact of summer drought by further eliminating early losses by insects, animals, damping-off, etc.

An inexhaustible source for forestry research is the accumulation of field evidence. Fifty years of annual growth of entire tree populations provide access to facts which are the source of envy of any agriculturist who understands forestry. Bearing more directly on our studies are the presence or absence of reproduction, its exact location, abundance, age composition, species mixture, etc., all of them highly significant circumstances because of their relationship to our species' absolute and relative tolerance to light, heat, shade, litter, and other factors. The design of our experiments is aimed at exploring such accumulated evidence for comprehending the factors and responses involved.

Though summer drought is a dominating factor all over, California, due to its geography and size, embraces a wide variety of sites. Blodgett Forest in the Sierra Nevada (the Experimental Forest of the School of Forestry at Berkeley) has been the center of our studies, particularly as far as they concern experimental design.

The elevation is about 1,300 m.; the parent material, granitic rock; the precipitation is 850–1,500 mm. and more. The soils belong to the Holland Group and the Holland and Musick Series. They are brown, slightly acid (pH 6-6.5) sandy loams over brown, moderately acid (pH 5-5.9) loam, underlain by hard igneous bedrock. The depth is 90-150 cm. or "moderate to good." The site is occupied by the so-called "mixed conifer type" (see *Forest Cover Types of North America,* No. 243). The ground vegetation is dominated by evergreen shrubs.

Saturation of the soil in the spring and a long summer drought are the most consistent factors. The dry period may last from May through September or even longer. The favorable spring of 1957 coincided with a good seed crop of all species except *Libocedrus decurrens,* whereas the good crop of *Pseudotsuga menziesii, Abies concolor* and *L. decurrens* of the fall of 1958 encountered the unfavorable conditions prevalent in 1959 (see Fig. 1).

The imprint natural reproduction makes on the ground, including its failures to make any, may depend, among other things, on one or a combination of the following factors:

1. Absence or presence of *seed* of certain species in certain years.
   a. Seed crop: No seed at all, seed of one, or several, or all species.
   b. Dispersal of seed: Spot under study not hit at all, slightly, heavily.
   c. After landing on ground: Seed taken away by rodents heterogeneously depending on ground cover.

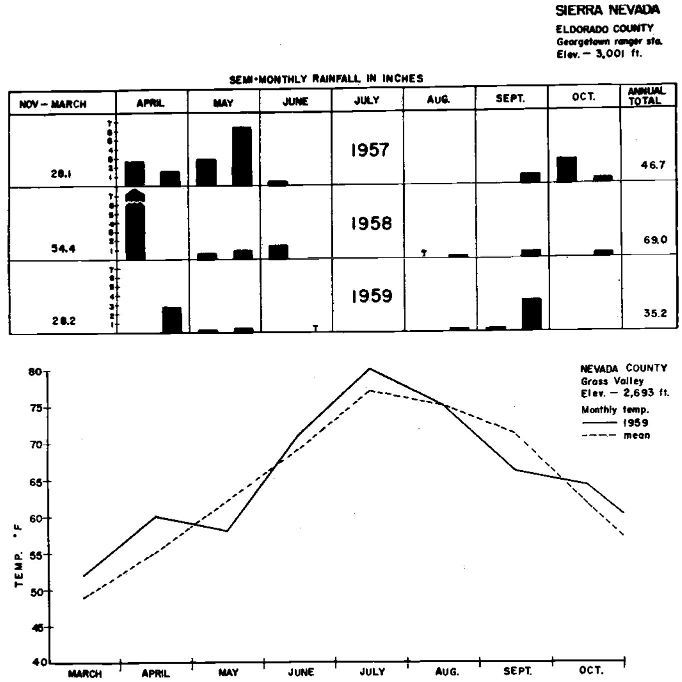

Figure 1. Semi-monthly rainfall distribution and monthly temperatures at two stations in the vicinity of study area.

2. Environment dependent differences in mortality *before summer drought becomes a problem* (insects, damping-off).

3. Coincidence of favorable and unfavorable *weather* with seed years.

4. *Suitability of spots* with particular reference to the impact of heat and drought on seedlings, (soil, aspect, shade, competition, litter, etc.).

The significance of each of these factors can be revealed with different degrees of certainty. For instance, consider 1a and b by using the model given in Fig. 2. If condition F appears repeatedly next to condition C and always carries significantly more seedlings than C, then the factors listed under 1a and b cannot be responsible for the differences, because there must have been ample seed on C. The factors 2, 3, 4 and others can be approached similarly. We thus arrive at definite proofs as to certain factors and high probabilities and promising leads as to others. Some factors may remain uncomprehended for the time being, thus requiring further work, as for instance, 1c.

To fully utilize such possibilities of interpreting the inherited evidence, access to more facts is needed. For this, two techniques have been employed so far. One is planting, which will be briefly discussed later on; the other is a close study of the first year's behavior of newly emerging seedling populations. The latter is explained in Fig. 2, where we confronted the presence or absence of older survival on 6 plots with first-year mortality curves of new populations. Insects and damping-off were the killing causes on A, heat on B. On C, some seedlings got close to survival. On D, E, and F, more and more seed-

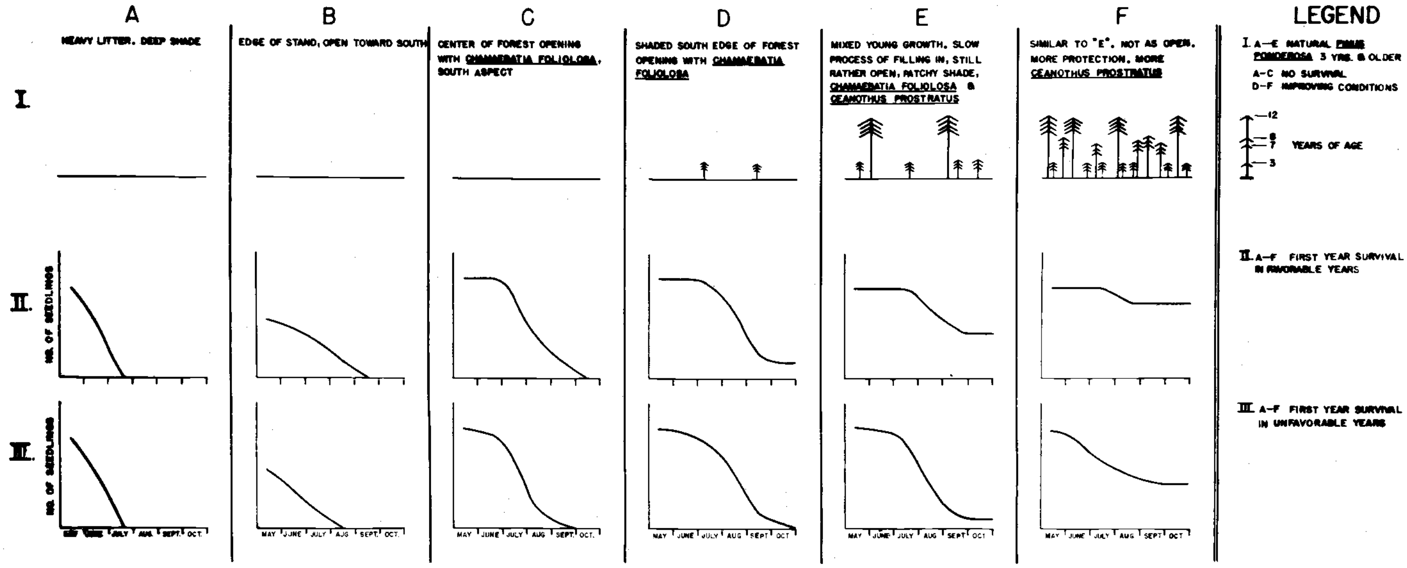

Figure 2. Model illustrating pattern of older survival (I) and of first year mortality (II and III) of natural seedling populations of *Pinus ponderosa* germinated on six ecologically different spots (A-F).

lings survived. This way, the assumed differences in suitability and the factors involved could be substantiated.

The plot shown in Fig. 3 embraces in a checkerboard pattern a wide variety of conditions from seemingly very favorable to very unfavorable. The main variables are light, radiation, heat, shade, ground vegetation, and litter. From the chart we can read answers to important questions of the following nature: How is past and 1957 survival related? To what extent and where exactly did survival in 1957 spread beyond the previous limits, or was second and third year mortality encountered?

Fig. 4 illustrating edge-effects is self-explanatory.

The measurement of the physical differences between the micro-sites studied will be the next step. So far, the ability of pine roots to keep up in growth with moisture depletion has been stressed as the decisive point. This concept may need revision. All that the bulk of our seedlings actually produce in their first season are tiny tops with primary needles and a root length of 6-8 inches. Even in 1957, growth of tops and roots ceased by early or mid-July. Thus, high probability exists that the micro-site conditions prevalent after early July are decisive to the survival of such seedlings for two or three more months of heat and drought. The other type of seedlings (the large ones which we may call fully self-supporting because they secure by their rapid root growth a steady moisture supply throughout a long growing season) was found almost exclusively on bulldozed areas, roadbanks, etc. Morphologically and physiologically speaking, we are dealing then with two different lines along which survival is possible. For the tiny seedlings a formula can be imagined stating that survival is dependent on whether the "environmental suitability" prevalent on spot 1, 2, 3 (es_1, es_2, es_3) after mid-July suffices to match the demands for protection of seedlings which have there achieved certain degrees of drought resistance (dr_1, dr_2, dr_3). Our mortality curves of seedling populations on ecologically very different plots may provide the first clues for such approaches.

Planting: Under a wide variety of micro-site conditions, many small samples of nursery and field-lifted seedlings (the latter bare-rooted and with root balls) were planted in the fall and in the spring without mechanical site preparation. The objectives are:

1. To get one more tool for interpreting ecological conditions by means of plant response.
2. To comprehend better behavior of planted seedlings by growing them under conditions for which behavior of natural seedlings is known.
3. To find out where one can plant successfully without site preparation and what kind of preparation suffices otherwise.
4. To show that for discussion on survival we must have available weather records as well as mortality curves of samples based on weekly checks.

We can, generalizing, state that the factors which help natural seedlings survive are beneficial to planted seedlings also, as is obvious along shaded edges (Fig. 4). Sometimes this is obscured by the fact that the help which suffices for the tiny natural seedlings whose shape and life rhythm had been molded steadily and without interruption by the environment does not quite do for planted seedlings.

Fig. 5 illustrates trials to alter the environment. The area is the most exposed part of the opening shown in Fig. 4. As almost always under our site-conditions, fall planting has advantages. The graph indicates what the planting time did and what the bear clover competition did. An interesting detail is revealed by comparing the unsprayed fall and spring plantings. Whereas the former remains intact until mid-July, the spring planting has lost 40% by then. However, after that the conditions reverse themselves. The promising fall planting drops down abruptly with only 16% final survivors, whereas the spring population never experiences such a sudden drop, ceases to lose seedlings much earlier, and finally comes through with 36% survival. Our explanation, to be substantiated by repetition, is that the conditions for the unsprayed

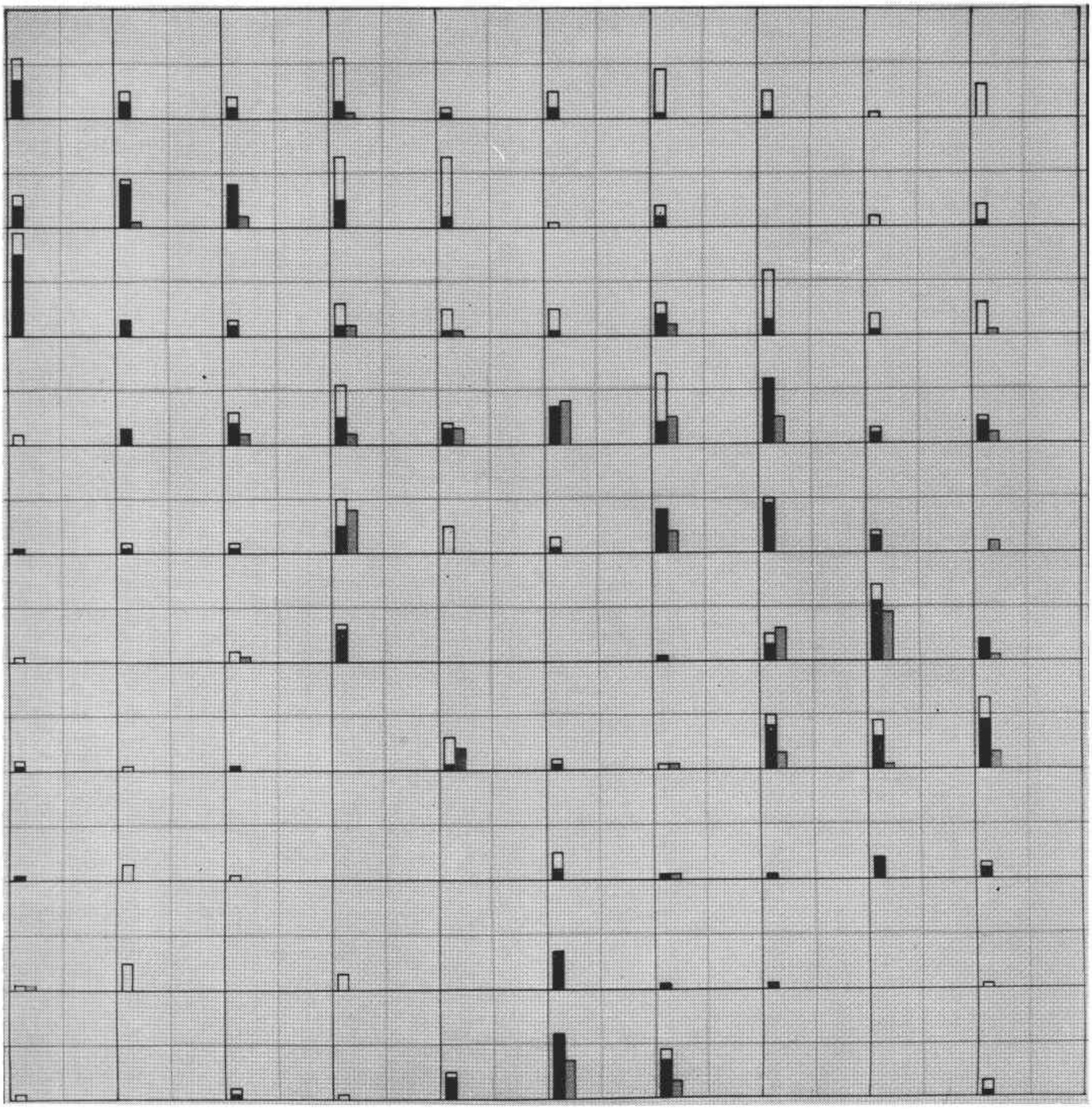

Figure 3. Heterogeneous pattern of survival of natural *Pinus ponderosa* seedlings according to heterogeneity of micro-site conditions.
Chart represents a plot of 400 square meters with 100 subplots, each 4 square meters in size.
Shaded bar represents seedlings established *prior to spring 1957,* about 4 to 8 years old (total, 93).
Black and white bar represents number of seedlings *of 1957 origin* found alive on July 5, 1957 (total, 444).
Black portion of bar represents number of seedlings found alive at end of season, October 26, 1957 (total, 248).

NOTE: A similar chart of the same plot, with identical data with respect to *Abies concolor, Pseudotsuga menziesii,* and *Libocedrus decurrens* has been omitted, owing to lack of space.

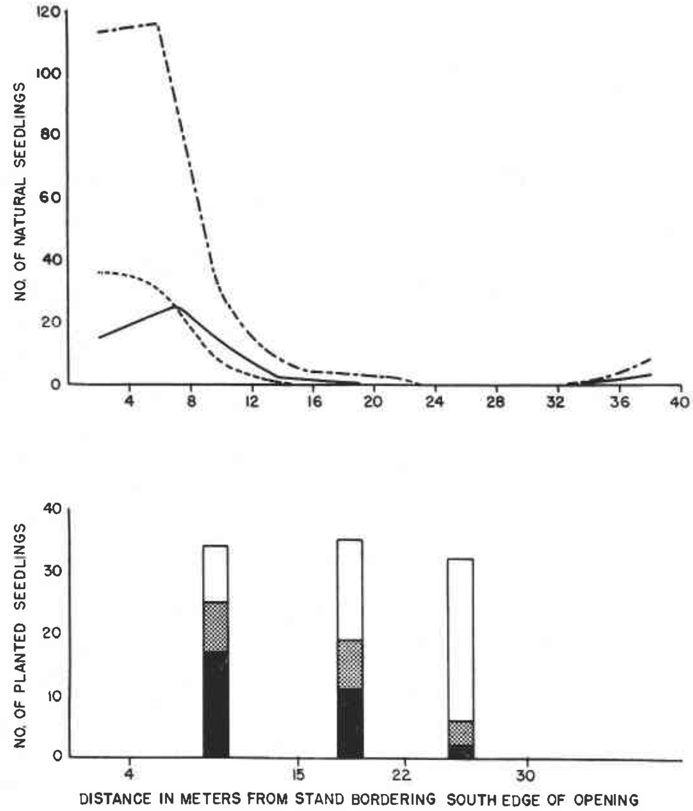

Figure 4. Effect of edge of stand bordering south edge of forest opening on survival of natural and planted conifer seedlings. Both graphs deal with the same forest opening, about 0.15 ha. in size.

UPPER GRAPH: Accumulation of natural seedlings prior to spring 1957
Long and short dashes: *Libocedrus decurrens* basis 281
Short dashes: *Abies concolor* basis 74
Solid line: *Pinus ponderosa* basis 55

LOWER GRAPH: *Pinus ponderosa* seedlings planted fall 1957 and spring 1958
Stock: natural seedlings of 1957 origin lifted fall 1957
Entire bar: total number of seedlings planted
Blank portion: mortality in 1958
Semi-shaded portion: mortality in 1959

fall planting were such that drought resistance was not induced in time. Thus, the seedlings were extremely poorly fitted to cope with conditions prevalent in bear clover covers in midsummer. The spring population, however, grew under heavy stress from the beginning.

RESUMES

Expériences visant à la préservation de la reproduction naturelle et artificielle des conifères en Californie; Programme des travaux et conclusions

En ce qui concerne l'organisation biologique dont la responsabilité incombe aux forestiers, les études relatives au comportement naturel des peuplements et des sujets n'ayant pas fait l'objet de dissection ne seront jamais périmées. Les méthodes modernes de recherche présentent pour nous une importance particulière du point de vue de leur utilité pour de telles études, plutôt que pour les études portant sur l'organisation biologique au niveau microscopique.

Pour les recherches sylvicoles, les constations faites sur le terrain constituent une source inépuisable d'information. L'absence complète de brins dans certains endroits, leur accumulation dans d'autres, le mélange d'espèces ou leur séparation, etc., contribuent à laisser sur le sol des empreintes qu'il nous faut apprendre à déchiffrer. L'on peut observer des faits innombrables, d'une complexité exaspérante; mais nous devons néanmoins y faire face.

Cette étude porte sur des problèmes de programmes expérimentaux et sur certaines conclusions obtenues à la suite des études pertinentes qui sont actuellement en cours à Blodgett Forest, forêt expérimentale de l'Ecole forestière de Berkeley dans la Sierra Nevada (voir *Forest Cover Types of North America,* No. 243).

Les connaissances que nous pouvons tirer de l'interprétation des constatations faites peuvent être considérablement accrues si l'on obtient des renseignements plus étendus. L'étude très minutieuse du comportement des peuplements de jeunes plants pendant la première année dans des conditions déterminées et la comparaison des conclusions avec les constatations faites sur le terrain ont constitué jusqu'à présent la méthode la plus fructueuse. La plantation s'est aussi révélée utile.

En étudiant le rapport entre la croissance des plants et le milieu dans lequel ils se développent, il a pu être déterminé par exemple qu'une gamme étendue de facteurs peut influer sur leur préservation pendant la première année. Dans les conditions étudiées, ce sont les différences dans les facultés d'adaptation au milieu, se produisant après la mi-juillet dans certains endroits, qui expliquent le cycle extrêmement hétérogène de survivance. De nouvelles études porteront sur le climat de certains emplacements qui ont présenté de grandes différences en ce qui concerne les facultés d'adaptation.

Experimentos de Supervivencia de la Reproducción Natural y Artificial de Coníferas en California; Diseño Experimental y Resultados

En el plano de la organización biológica, que incumbe a los silvicultores, los estudios de la forma en que medran en la espesura grupos de plantas sin desmembrar para análisis nunca serán anticuados. Los medios modernos de investigación son especialmente interesantes desde el punto de vista de su utilidad para tales estudios antes que para otros en el plano micrométrico de la constitución biológica.

Para la investigación forestal, los datos compilados en el campo constituyen una fuente inextinguible de conocimientos. La ausencia completa de semillones en ciertos sitios, su acumulación en otros, la superposición de especies y su separación, etc., se combinan para dejar huellas en el suelo que debemos aprender a interpretar. Sin embargo, el número de hechos discernibles es enorme y su complejidad irritante.

Esta exposición versa sobre problemas de diseño experimental y sobre algunos resultados de estudios pertinentes que se realizan en el Bosque Experimental Blodgett de la Escuela de Silvicultura de Berkeley, en la Sierra Nevada. (Véase la publicación *Forest Cover Types of North America,* número 243.)

El conocimiento que podemos derivar de la interpretación de los datos acumulados se puede aumentar inmensamente si se logra observar mayor número de hechos. El estudio cuidadoso de la forma en que medran los semillones durante el primer año bajo diferentes condiciones de sitios minúsculos y el cotejo de las observaciones con los conocimientos ya adquiridos, ha sido, hasta la fecha, la técnica más reveladora.

Valiéndose alternativamente del desarrollo de los semillones y del ambiente para interpretar a cada uno de ellos, se podría afirmar, por ejemplo, que la supervivencia durante el primer año, que es el más difícil, puede ser resultado de conjunciones muy diferentes de factores. Bajo las condiciones estudiadas, las diferencias de adecuación del ambiente que ocurren en el sitio y que prevalecen después de mediados de julio, son la causa de la forma sumamente heterogénea de supervivencia. Se emprenderán estudios más a fondo de las variaciones de micro-clima en los sitios donde se observó la mayor diferencia de adecuación.

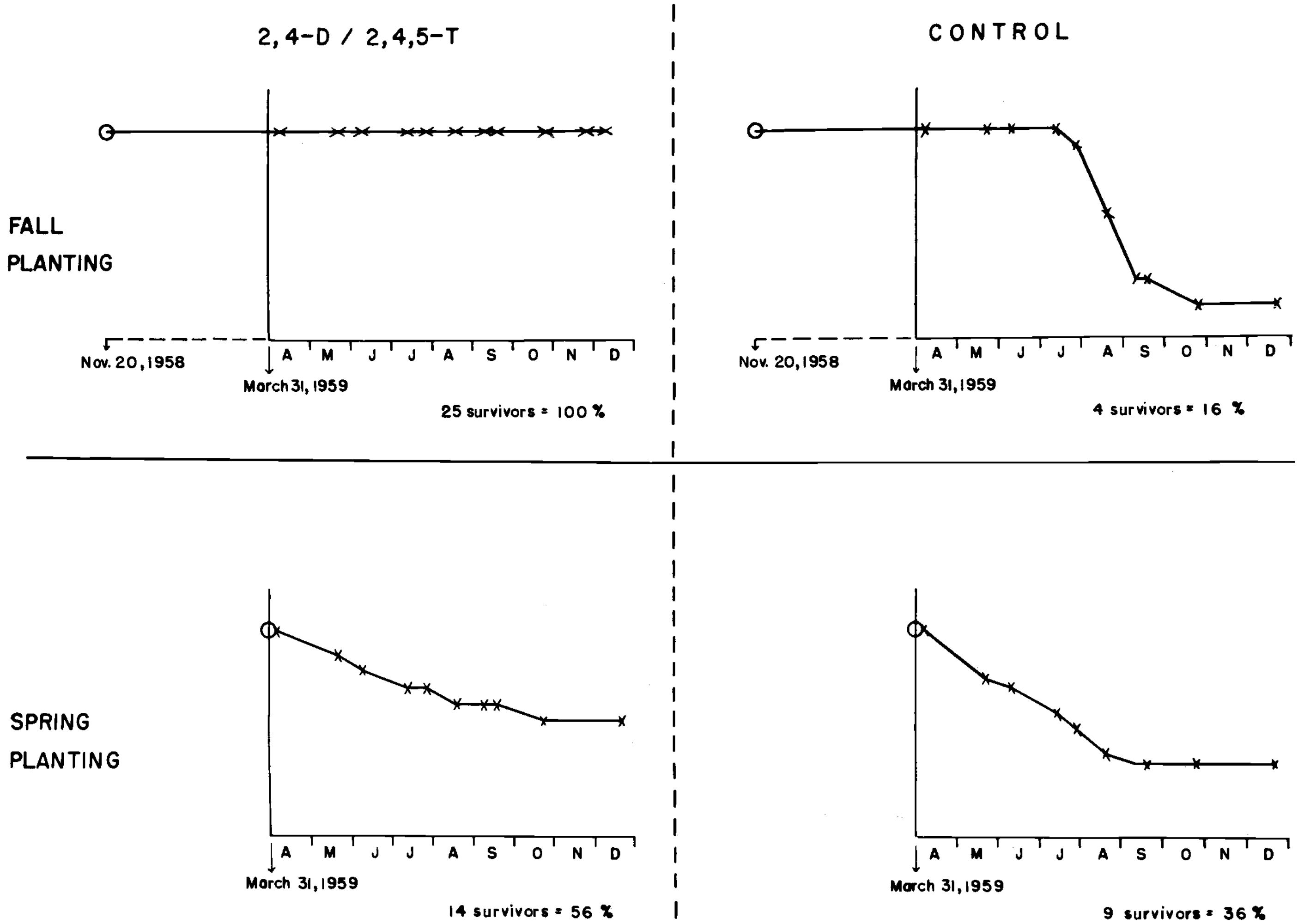

Figure 5. Survival of *Pinus ponderosa* seedlings planted in a heavy cover of *Chamaebatia foliolosa* under four conditions: planting in fall and spring, each treated and untreated.

Natural Historical Division of Forests (On the Example of the Urals)

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Half a century ago G. F. Morosov, formulating the deductions of silvics (doctrines of the forest), worked out by him, pointed out that silviculture rules, with the exception of most common theses, might be true only within the limits of special "silvicultural regions," homogeneous in natural and economic conditions. Besides, these theses should vary in conformity to different types of forest ranges.

He proposed the principle of dividing Russia into silvicultural zones and subzones, domains and subdomains.

The geographical principle of G. F. Morosov presents one of the main theoretical foundations of Soviet silvics and silviculture and has received subsequent development in the works of V. N. Sukachev, M. E. Tkachenko, P. S. Pogrebnyak, B. A. Ivashkevitch and many other silviculturists. It is used in the practical activities of Soviet forest management in cases when it is found necessary to change the methods of influence upon forests and their environments according to the natural and economic peculiarities of separate parts of the Union (such as the creation of field-protective forest belts, forest planting, and fire protection of forests). In all these cases the forest management is guided by different schemes of dividing the forest area into regions. Such schemes are usually specialized for solving separate, quite narrow production problems such as: division for forest planting purposes, for forest fire prevention purposes, for forest seed-control purposes, for ornamental and decorative purposes, etc. Such schemes were seldom compiled for the solution of a complex of forestry problems.

Most of the schemes refer to territories with intensive forest management. There are no "division into natural-forest regions" schemes for some important wooded areas of our country as, for instance, the Urals and the European North.

The increased needs of forest management have visibly heightened interest in the forest geography problem. Consequently, the study of natural-forest region division and forest management division now occupy a prominent position in the research plans of scientific forestry organizations of the USSR.

Under the term "division into natural-forest regions," we understand the generalization of all the acquired knowledge of forest geography, finally expressed in the form of a schematic map with an explanatory note, containing a forest-geographical characteristic of the chosen regions. The "division" consists of partitioning the territory into parts, uniform in the typological composition of forest types and in the character of the physico-geographical, biotical and "anthropogenic" factors (forest-formation factors), which define its peculiarities. When dividing, it is necessary to take into consideration and use the complex of indications and properties of the landscape of the studied area. But the main attention should be paid to its forest vegetation and to those peculiarities of geographical environment which determine the character of the forest and its economic value.

The purpose of natural-forest region division is to determine the special features of forests and their life conditions, the knowledge of which is necessary when planning and organizing a complex of utilizing, preserving, regenerating, and raising the productivity of forest resources of the territory to be divided.

It follows, from the above, that division into natural-forest regions quite often becomes a private case of physico-geographical (landscape-geographical) division, worked out from the position of a silviculturist and with due regard to the interest and prospects of forest management. It should give an idea of the potential possibilities of forest resources of the studied region which should be applied to its forests, so as to utilize in full their potential and guarantee their preservation and regeneration and the increase of the region's productivity. But the division into natural-forest regions cannot give instructions to the forester as to which of the forest management measures might be most advantageous and technically more expedient for the present time and the near future, insofar as it does not take into consideration the economic, production, and technological factors.

It can be said that division into natural-forest regions serves as the natural-historical basis of forest management division. By itself, the division into natural-forest regions in everyday practical activities of forest management might be used in the calculation and mensuration of forest resources, the surveying and mapping of forests, the working out of plans for the organization of forest management (general plans included), and in experimental forestry.

For revealing objectively the regularity of spatial distribution of the forest cover and its qualitative complication in the transition from part to a whole, and to show the connection of the established natural-forest regions with either adjacent or remote (but analogous to the type of landscape) ones, it is necessary to have a system of division units differing in size and class (superior and inferior, main and auxiliary). Such a system might be adopted from the physico-geographers, who in recent years paid much attention to the problems of the "division into regions" theory, making necessary corrections, which arise from the specific tasks of natural-forest region division.

As principal units of natural-forest region division we use the following: domain, zone, and district. The latter is equivalent in content and size to the term "natural-forest region" used by the majority of silviculturists of the USSR who studied the problem of natural-forest region division.

The *natural-forest domain* is a large azonal subdivision of territory, distinctive by having a common geological structure and relief which often coincides with a definite longtitudinal sector of the landscape-geographical belt and which is characterised by a certain similarity in the degree of continentality of climate. The following might serve as examples: The Eastern European plain, the Carpathians, the Middle Siberian plateau, the monsoon region of the Amur basin and Primorye territories, etc.

The division of the USSR territory into natural-forest domains makes it possible to separate mountain forest areas (with an undoubtedly protective trend of forest management) from the plain areas. This division permits the identification of the boundaries of application of mountain silviculture standards, which cause considerable limitations to the ways of using forest reserves and which complicate the methods of forest regeneration.

The *natural-forest zone* is characterised by the predominant distribution of definite zonal complexes of forest formations, uniform in: the affinity of their forest-forming arboreous species to similar "life forms" (light coniferous, dark coniferous, broad-leaved species, etc.); their requirements to geographical environment (thermal and aqueous regimes, fertility of soil, etc.); and the principal silvicultural properties (character and form of forest regeneration processes, susceptibility to fires, etc.).

The *district* is characterised by a definite combination of a series of forest types, regularly repeated on similar ecologo-topographical profiles; the boundaries of districts are generally determined by the geomorphology of the country.

In conformity to the task and minuteness of the division, it is advisable to use, only when necessary, the following terms of auxiliary units of natural-forest region division: subdomain, subzone, province (a group of districts), region (part of a district, uniform in the combination of forest types), subregion or forest range (part of a region, uniform in the history of forest management exploitation), and forest plot.

The principles mentioned are illustrated by the scheme of natural-forest region division of the Urals with the adjoining parts of the Eastern European plain (to the east of the Kolva-Kama-Ufa-Belaya valleys*) and of the Western Siberian plateau (to the west of the Ob-Irtish-Tobol valleys). Formerly they were used by us in composing the natural-forest region division of the Far East.

A considerable part of the forest resources of the USSR are concentrated on the examined territory, which is extremely dissimilar in its geographical conditions and the silvicultural properties of its forests. The dissimilarity is determined: by its extensive meridian stretch from the shores of the Arctic Ocean (the Pay-Hoy range) to the Caspian semideserts (the Mougodjary range) in the south; by the complex structure of its surface (the ancient Ural mountain system and plains, heterogeneous in origin, adjoining it on the east and west); by its position within the bounds of two climate belts (subarctic and temperate); and by being on the border of six climate provinces with different degrees of continentality. Besides this, the frontier between the Atlantic and the Western Siberian continental provinces passes along the Ural range. No less important are the differences between the separate parts of the examined territory in the paleo-graphical conditions of the post-tertiary forest history and the influence of man's activity in historical times.

In the mining and metallurgical districts of the Urals and on the adjoining plains the virgin forests have almost become extinct (from forest fires and intensive cutting from the middle of the XVIIIth century), and in the large tracts of forests changed by man's influence, industrial felling is carried out on a large scale. But to the north of the 60th parallel, at present, as in the past, the influence of man is of a very restricted and incidental character.

On the strength of the peculiarities of the geographical environment and the silvicultural properties of the forests, the examined territory is included in the composition of three natural forest domains:

1. The Ural highlands (enters completely).
2. The Western Siberian plateau (forming its 2 subdomains adjoining the Urals—the low-lying, marshy basin of the River Ob and the trans-Ural foothill plateau).
3. The Eastern European plain (its eastern foothills plateau subdomain adjoining the Urals).

Each of them is divided into natural-forest zones and subzones, the boundaries of which coincide with the corresponding latitudinal subdivisions of the earth's surface.

Within the limits of the *Western Siberian domain,* on the described territory, the following zones are defined consecutively from north to south: the tundra zone, with ribbonlike forests of willows and sparse, insular larch forests (*Larix sukaczewii*) in the river floodlands of its southern subzones; the forest-tundra zone with sparse larch forests; the subzone of preforest-tundra with forests and sparse larch forests; the subzone of the northern taiga with marshy forests of pine (*Pinus sylvestris*), larch, and dark coniferous trees (*Picea obovata* and *Pinus sibirica*); the subzone of the middle taiga with pine, birch (*Betula pubescens, B. verrucosa,* and *B. tortuosa*) and dark coniferous fir-spruce forests (*Picea obovata, Abies sibirica* and rarely *Pinus sibirica*); the subzone of the southern taiga with pine, birch (*Betula verrucosa* and *B. pubescens*), and aspen (*Populus tremula*) forests with linden (*Tilia cordata*); the subzone of preforest-steppe birch and pine forests with aspen; the forest-steppe zone of birch groves ("Koloks") and insular pine woods (with subzones of the northern, middle and southern forest-steppe); and the steppe zone.

A slightly different zonal spectrum is typical of the part of the subdomain of the Eastern European natural-forest domain which adjoins the Urals. In the watershed of the Pechora-Kama Rivers it starts with a subzone of middle taiga fir-spruce (with Siberian pine), birch and pine forests. Then, consecutively to the south follows: the southern taiga subzone of fir-spruce, birch and aspen forests with linden; the subzone of mixed broad-leaved fir-spruce forests with linden and *Ulmus laevis* (does not pass on to the eastern slopes of the Urals, wedges into the upper part of the River Ufa and, further to the east, is replaced by the subzone of birch and pine preforest-steppe forests); the subzone of broad-leaved forests—*Quercus robur,* linden, *Acer platanoides,* and birch-aspen (absent on the eastern slope of the Urals, wedges into the western foothills of the Urals in the basin of the River Belaya); the forest-steppe zone; and the steppe zone.

Peculiar to the Ural mountain natural-forest domains are the high-altitude vegetation belts. The formational composition of the forest of its separate belts is similar in composition to the corresponding latitudinal zones and subzones on the adjoining plains. This makes it possible to link the mountainous and the plain domains into a general scheme of high-altitude and zonal units of division, drawing the boundary lines of natural-forest zones and subzones over the boundaries of the analogous high-altitude belts. Due to this, the boundaries of all zones and subzones on the territory of the Ural domain appear to be stretched into narrow tongues in a southerly direction along the axis of the range.

Each zone and subzone in their mountainous and plain parts are characterised not only by a common composition of arboreal species forming the forest, but by the general trend of the forest formation process, which reflects the specific zonal peculiarities of the interrelationship between the forest and the geographical environment. It is possible to indicate the forest-formation factors peculiar to each zone and subzone, which determine the trend and the course of forest-formation process.

For instance, eternal congelation appears to be such a factor for the forest-tundra zone and the subzone of preforest-tundra forests and sparse forests; the excess of soil moisture in combination with prolonged seasonal congelation—for the subzone of the northern taiga forests; the grassing processes—for the subzones of the middle and southern taiga on felled areas and fire-sites; different degrees of deficiency of soil and atmospheric moisture and the processes of salt accumulation in soils—for the forest-steppe and steppe zones.

Deliberately applying to the forests a specific complex of silvicultural methods and forest management measures which aim to increase or weaken the influence on them and their environments of leading forest-formation factors, the foresters have a possibility of actively interfering with

* The northeastern part of the plain, adjoining the Urals by the valleys of the Pechora and Ussa Rivers, is not included.

the spontaneous forest-formation process; of altering its course and trend; of foreseeing with certainty the after-effects of economical activities; and of purposefully increasing the productivity of forest areas.

In this sense it is possible to speak of geographically-zonal systems of forest management, for instance, in regards to the forest management of the forest-tundra zone ("pretundra silviculture"), the taiga forest zone ("taiga silviculture"), the arid zones ("steppe silviculture"), and so on, the systems being specific by the complex of silvicultural methods used, and by the trend of forest management.

G. F. Morosov had in mind just such a geographical point of view in classifying the systems of forest management, when he mentioned the "dry," "damp," and "wet" silvicultures in his works. In the USSR at present his ideas have received further development in the form of the problem of "taiga silviculture" worked out by I. S. Melekhov and "mountainous silviculture" worked out by V. S. Goulisashvili. By the way, it is necessary to point out that the conception of mountainous silviculture is not equivalent to the conception of zonal geographical systems of forest management, so far as it, itself, can further differentiate by zone indications into silviculture of the mountains of the taiga, steppe, subtropical, and other zones.

The further detailing of natural-forest region division of the Urals is carried out by defining natural-forest provinces, the boundaries of which are determined by the intersection of longitudinal boundaries of domains and subdomains with the latitudinal ones of zones and subzones (for instance, the trans-Ural middle taiga province or the Middle Ural province of mountainous southern taiga forests). Still further, within the limits of the provinces, we distinguish natural-forest districts (for instance, the Middle Ural district of mountainous southern taiga dark coniferous forests, or the Pishminsko-Issetsky district of forest-steppe insular pine woods).

In the examined territory, division has already been carried out up to the level of province, or part of it, which is divided into 12 districts.

Using the scheme of natural-forest regions and according to all available data on the condition of forest management, economy, and the outlook for national economic development in administrative districts and regions, it is possible to divide the examined territory into 4 forest management zones.

1. *The pretundra forest management zone* (the territories of tundra, forest-tundra and preforest-tundra natural-forest zones and subzones), which has no industrial forest reserves, with local consumption of timber. The forests grow slowly, regenerate poorly, and have large climate-improving and protective importance. It acts as a zone of protective trend in forest management; this was preordained by the Government decree of establishing State forest shelter belts within the 30-100 km. belt of pretundra forests.

2. *The taiga forest management zone of plain forests* (the territories of the northern taiga subzone without their upland territories) with large forest ranges, but still slightly exploited by the timber industry. The forests grow slowly, but regeneration is carried out satisfactorily; only in some parts do they have water-conservation and protective values. This will be the zone of the forthcoming industrial-transport construction with the exploiting trend in the development of forest management.

3. *The industrial forest management zone* (the territories of the larger part of the middle taiga subzone, of all the remaining subzones up to the boundary of the forest-steppe on the plains and all the mountainous forest Urals, except the southern outskirts) with a powerful timber industry and other highly developed branches of national economy. The forests of the zone are intensively exploited, in many regions have been exhausted by industrial fellings, and have wide water-conservation, protective, sanitary-hygienic, and aesthetical values. This is the zone of intensive forest management with a protective trend and with a large forest-regeneration programme.

4. *The droughty forest management zone* (the territory of forest-steppe and steppe zones on the plains, the mountainous Urals to the south of the northern boundaries of the subzones of broad-leaved and preforest-steppe pine-birch forests) with low density of forests, unstable forest positions, and a high degree of industrial and agricultural development. The scanty forests have a large protective, climate-improving, sanitary-hygienic and aesthetical importance. This is the zone of intensive forest management of the protective trend with a considerable programme for the cultivation of forests of agro-forest-meliorating importance.

RESUMES

Division historique naturelle des forêts, d'après l'exemple de la région de l'Oural

La division en régions de forêts naturelles sert de base naturelle et historique aux divisions du régime forestier. Cette division consiste en une répartition du territoire en parties homogènes quant aux types forestiers et aux caractères des éléments physiques, géographiques, biotiques et anthropogéniques (facteurs de la formation des forêts) qui déterminent les particularités des forêts du point de vue de l'aménagement et de la géographie, ainsi que de celui des tendances et de la marche de leur évolution (processus de formation forestière). On a proposé une division en unités qui diffèrent par la taille et la catégorie. Ce système permet de faire apparaître les régularités de la répartition spatiale de la forêt sur de vastes étendues.

Ce système est illustré par l'exemple de la division régionale en forêts naturelles des monts Oural et des régions limitrophes des plaines de l'Europe orientale et de la partie occidentale du plateau sibérien. Ce territoire est subdivisé en domaines forestiers naturels, en sous-domaines, zones, sous-zones et provinces.

Le territoire à létude a été divisé en quatre zones d'aménagement forestier: trois zones de tendance protectrice (zone de la forêt prétoundra, zone de forêt industrielle et zone de la forêt aride) et une zone représentant la tendance à l'exploitation dans l'évolution de l'aménagement des forêts (zone de la forêt taiga).

L'ensemble des monts Oural appartient aux zones de tendance protectrice.

Division Histórica de Bosques Naturales (Los Urales como Ejemplo)

La división en regiones forestales naturales sirve de base natural histórica para la administración de divisiones forestales. Esta división consiste en separar el territorio en parte—homogéneas en la composición de las clases y naturaleza de los bosques en cuanto a factores físicos y geográficos, bióticos y antropogénicos (factores que influyen en la formación de los bosques)—que determinan la administración y las peculiaridades geográficas de los bosques, lo mismo que las tendencias y el proceso de su evolución (proceso de formación de los bosques). Se ha propuesto

el empleo de un sistema de división en unidades de diferente tamaño y clase, que permite determinar las regularidades en la distribución espacial de los bosques que cubren vastos territorios.

El estudio presenta como ejemplo la división natural de la región forestal de los Montes Urales, junto con las partes adyacentes de la planicie de la Europa oriental y de la meseta del oeste de Siberia. Este territorio está dividido en dominios, subdominios, zonas, subzonas y provincias forestales naturales, que se han agrupado en cuatro zonas de administración forestal: tres de tendencia protectora (la zona que precede a la de tundra, la industrial y la de sequía) y una de administración forestal de tendencia explotadora (la zona "taiga").

Los Montes Urales, en general, corresponden a zonas de tendencia protectora.

SPECIAL PAPERS IN THE FIELD OF AFFORESTATION AND REFORESTATION

Observations sur les rapports qui existent entre l'orientation des rangées de peuplier d'alignement et le comportement de quelques cultures herbacées

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Dans le but de contribuer à éclaircir l'ensemble des problèmes qui font l'objet de cette communication, à partir de 1958 on a recueilli une série d'observations dans/10 propriétés italiennes de la plaine du Pô.

Ici le peuplier tend depuis longtemps à perdre l'aspect d'arbre de forêt et à prendre la physionomie d'une véritable espèce agricole: étant donné la diffusion toujours croissante du peuplier, nous sommes d'avis que cette tendance peut aussi se manifester à l'avenir dans des pays où les diverses espèces de peuplier sont encore presque complètement considérées comme des arbres de forêt.

Dans les propriétés susmentionnées, le peuplier d'alignement était associé séparément au riz, au blé, à la prairie permanente, c.-à-d., à des cultures très fréquentes et importantes dans la région et pour lesquelles, en pratique, il est souvent nécessaire d'établir s'il se crée une action de concurrence avec le peuplier d'alignement, et dans quelle mesure.

A ce propos, des opinions ont été exprimées en divers lieux et à différentes époques par Piccarolo (9-10-11)*, Pavari (6-7-8), Hilf (4), Savi (12), Susmel (13), Fenaroli (3), De Philippis (2), Joachim (5) et Baumann (1). Sur la base des observations faites par lesdits auteurs en Europe, on peut conclure que si une action de concurrence est exercée par le peuplier par rapport aux cultures associées ou proches, cette concurrence se manifeste toujours dans des limites d'aire assez réduites, c'est-à-dire de quelques mètres à partir du pied du peuplier et que *l'éventuelle* dépression productive peut aisément être contenue moyennant les normales pratiques d'agriculture rationnelle (spécialement, fertilisations et labourages).

La culture du peuplier d'alignement offre, en définitive, un avantage considérable si on l'examine dans le cadre de la structure de la propriété agricole et de l'aménagement économique de l'agriculture, car sa réalisation produit des revenus qui, autrement, ne pourraient absolument pas être atteints.

La présente étude, relative à un aspect particulier d'une série de recherches de grande envergure actuellement en cours, a pour but principal d'établir si, dans les procédés agronomiques tendant à équilibrer la culture du peuplier d'alignement avec les cultures herbacées extensives usuelles, l'on pourrait inclure l'orientation des rangées de peuplier. En d'autres termes, on s'est proposé de déterminer, grâce à des expériences répétées, si l'on pouvait arriver à saisir des différences significatives entre les diverses orientations (N,S,E,O) dans dix propriétés qui, au point de vue des conditions générales de climat et des caractéristiques chimiques et physiques du sol, présentaient de grandes ressemblances.

Par conséquent, même dans cet exposé succinct nous sommes en mesure de prouver que parmi les dix propriétés agricoles les données analytiques n'indiquaient aucune différence ou variation importante, ce qui permet d'accepter en toute certitude les déductions élaborées.

Tous les résultats sont relatifs à l'année agricole 1959: les résultats pour le riz et le blé représentent le rendement en grains par le battage: les résultats pour la prairie permanente indiquent les rendements unitaires en produit vert de chacune des trois coupes annuelles, ainsi que le rendement total de l'année.

Les évaluations ont été faites suivant le schéma biostatique "split-plot" avec l'analyse de la variation, afin d'établir dans quelle mesure "F" est significatif: successivement, on a recherché la mesure probable d'incidence des différences parmi les moyennes suivant le "t" de Student.

Les résultats sont résumés très succinctement dans le tableau No. 1. En examinant celui-ci, on se rend compte

* Les chiffres entre parenthèses indiquent les références notées à la fin du présent article.

tout de suite que les productions les plus élevées sont obtenues dans les parcelles de terre où les rangées de peupliers sont situées au nord desdites parcelles. Dans les champs situés au nord, à l'est et à l'ouest de la ligne, les productions sont inférieures et, en général, on ne remarque aucune supériorité significative d'un champ sur l'autre. Des essais ultérieurs seront faits afin de déterminer si les résultats en question se répètent.

En conclusion, nos observations permettent d'admettre que, dans chaque cas, il est préférable de donner aux alignements de peupliers une orientation de l'est vers l'ouest, avec des champs cultivés situés au sud des rangées.

On se doit de mentionner ici que la validité de ces données est strictement liée aux conditions et aux situations constatées dans les propriétés dont il s'agit, et qu'il ne serait pas à conseiller de généraliser les considérations suggérées par ces données: à cet effet, il faudrait procéder à de plus vastes recherches, même si les éléments recueillis par nous peuvent être considérés comme valables pour une première orientation.

Enfin, pour ce qui a trait à une évaluation positive, exprimable en pourcentages, des avantages ou des désavantages qui peuvent dériver de l'association du peuplier aux plantes herbacées, il est clair que les données exposées ici ne peuvent avoir qu'une valeur relative. Toutefois, tel qu'il ressort également des observations que nous avons faites collatéralement, il est probable que l'état éventuel de concurrence entre le peuplier et les plantes herbacées puisse être limité, et jusqu'ici neutralisé, autrement que par les susdites mesures d'ordre agronomique (par exemple, labourage et engrais), par la détermination, pour les champs affectés aux cultures de plantes herbacées, d'intervalles convenables qui, en tout cas, doivent être fixés pour chaque culture. Le principe que l'état de concurrence, supposé comme existant, tend à diminuer en proportion de la superficie du champ, nous semble être clair et admissible, ce qui d'ailleurs est démontré par les autres données que nous avons recueillies et que, pour être concis, nous nous abstenons d'exposer et de soumettre ici.

Tableau 1. Productions moyennes pour les diverses orientations (quintaux par hectare)

Position de la ligne / Cultures	Sud	Ouest	Est	Nord	L.S.D. p= 0,05	L.S.D. p= 0,01
Blé	28,77	30,28	28,51	32,66	0,72	0,97
Riz	52,84	59,19	52,88	64,10	2,13	2,87
Prairie permanente Coupe I	172,32	171,72	149,12	182,02	6,27	8,45
Prairie permanente Coupe II	138,32	131,34	132,06	144,08	5,69	7,67
Prairie permanente Coupe III	122,76	127,52	127,44	133,10	4,43	5,96
Prairie permanente Quantité totale annuelle	431,80	430,58	408,62	459,20	10,31	13,88

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RESUMES

Observations on the Relationship Existing Between the Direction of the Rows of Poplars in Lineal Planting and the Behavior of Certain Herbaceous Crops

The author, a member of the staff of the "Istituto di Sperimentazione per la Pioppicoltura" (Experimental Institute for the Cultivation of the Poplar) at Casale Monferrato, Italy, has made a study in order to establish the relationship existing between the direction of the rows of poplar trees and the behavior of some important herbaceous crops.

The results, which he has compiled statistically, recommend the planting of the rows in an east-west direction. The highest production is achieved in fields facing south with respect to the rows. The differences are less marked if the fields face, respectively, north, east, or west in relation to the rows of poplars.

Observaciones sobre la Relación que Existe entre la Orientación de las Hileras de Alamos de Alineación y el Crecimiento de Varios Cultivos Herbáceos

El autor, miembro del Istituto di Sperimentazione per la Pioppicoltura di Casale Monferrato, de Italia, ha hecho un estudio para determinar las relaciones entre la orientación de las hileras de álamos de alineación y el crecimiento de varios cultivos herbáceos importantes.

Los resultados, expuestos estadísticamente, aconsejan la orientación de las hileras en la dirección de este a oeste. La más alta producción se obtiene con los campos orientados hacia el sur en relación con las hileras. Las diferencias son menos acentuadas si los campos se sitúan, respectivamente, al norte, al este y al oeste en relación con las líneas de álamos.

Scots Pine (Pinus sylvestris) in Britain

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Historical Background

Scots pine is the only coniferous forest tree indigenous to Britain. In this country, as elsewhere in north-west Europe, Scots pine was a more important species in Boreal times, prior to 5000 B.C., than later; it tended to retreat in competition with broadleaved species such as oak and alder in later times. It has persisted to the present day in Britain as a natural and native species only in the native pinewoods of Scotland north of the Firths of Forth and Clyde. The evidence in these woodlands confirms that Scots pine is successful in competition with broadleaved species, including birch, only on the less favourable sites, climatically and edaphically, such as north-facing slopes, and on soils of low nutrient status (Steven and Carlisle, 1959).

There are records of the planting of Scots pine in Scotland as early as 1613 (anon., 1885). Native seed was sent to James VI (James I of England) in 1613 from Mar Forest, Aberdeenshire, and a little later John Evelyn received some from the Marquis of Argyll (Evelyn, 1664). The extensive planting of Scots pine dates, however, only from the eighteenth century and was principally in Scotland, but also to some extent in England and Wales; the seed was almost certainly collected in the native pinewoods of Scotland or in plantations raised from seed from them, because there is evidence of an active trade in Scots pine seed from the Highlands of Scotland at that time (Haddington, 1765). There are a few records of the limited importation of Scots pine seed from the European mainland in the early decades of the last century, for example, from the Forest of Haguenau in France and from Riga (Louden, 1838). Such importation appeared to have greatly increased after about 1850, partly because of the failure of cone crops in Scotland over a period of several years (Grigor, 1868).

The importation of Scots pine seed ceased, except for experimental purposes, after the 1914-18 War. Since then, Forestry Commission collections have been mainly from the lower Spey Valley in the north-east of Scotland, and from Thetford Chase in East Anglia. The latter were initially from Scots pine hedges which had been planted for shelter at the end of the last century on the sandy Breckland soils. They had been kept pruned until the 1914-18 War made that impracticable. When the cone collections began from them after that war, the trees were phenotypic monstrosities. The thousands of acres of plantations raised from this seed, and provenance trials comparing this strain with others, show that they were, however, inherently good genotypes. It is not known with certainty what was the origin of the seed from which the plants used for these hedges were raised, but Mr. McBeath, who was head forester at Elveden in the Brecklands when the hedges there were planted, told the writer that he obtained the plants from Little and Ballentyne, a well-known firm of forest tree nurserymen in Carlisle, and the head of the firm at that time, James Watt, always claimed that he obtained Scots pine seed from Scotland. Many private estates have consistently collected local Scots pine seed, for example, the Strathspey Estate from the native pinewood, Abernethey Forest, and also the Darnaway Estate, near Forres, from its plantations.

The Present Status of Scots Pine in Britain

The Census of Woodlands, 1947-1949 (1952), showed that Scots pine was then the principal coniferous species in woodlands in Britain, 39 per cent of all conifers. The pattern of the use of this species varied, however, in different regions, and as between State and private woodlands. In Scotland, Scots pine constituted 46 per cent of the coniferous woodlands; the corresponding percentage for England was 38, and for Wales, 7. Scots pine is a much more important species in private than in State woodlands, accounting for 52 per cent of conifers in private against only 25 per cent in State woodlands, where Sitka spruce surpasses it at 27 per cent (anon., 1952).

There are no precise data on the trend in the use of different tree species since the date of the last Census of Woodlands, but information given in the Forestry Commission Annual Reports suggests that the percentage of Scots pine used in new State plantations is falling and is now under 20 per cent of all conifers. It is not known whether there has been a similar trend in private forestry, but if so, it has almost certainly been less marked. Even thus, however, Scots pine remains the principal coniferous species in British woodlands. This is not remarkable, because it has many good silvicultural qualities. When of good strain and reasonably well grown, its timber is superior for many purposes to that of most other conifers grown in Britain; its principal defect is the presence of "black knots," but this can be mitigated by the choice of a light branching strain, and largely eliminated by early artificial pruning.

Site Requirements of Scots Pine

As one would expect in the world's most widely distributed conifer, it is indigenous to regions with the most diverse climates and soils. It is found under an almost tundra climate at 70° 29′ N. in Finnmark, Norway; at relatively low altitudes in the Mediterranean region and Asia Minor; in an oceanic climate with high rainfalls in western Scotland and Norway; and in extreme continental climates in Siberia, with rainfalls as low as 8 inches (200 mm.), and a minimum temperature of −83°F. (−64°C.) (Steven and Carlisle, 1959). The geology and soils in its far-flung habitat are equally diverse. While it is often found on the poorer, dry, acid sands and gravels, because, as already stated, it competes successfully with other species on such soils, it is also found on wet, peaty soils, clay and even occasionally on calcareous soils, for example, in parts of Germany (Rubner, 1959).

Although Britain has a wide range of climates and soils for a small country (Macdonald, J. et al., 1957), nevertheless, these are much less diverse than in Scots pine's habitat as a whole. Experience in Britain has shown that it has a fairly well-defined place in plantation forestry in this country. It can play two roles: first, as the principal species in a stand where the site conditions favour its good development; and second, as a nurse or subsidiary species to another which is likely to be the dominant later, but not easily established initially. It was in the latter role that Scots pine was used in mixture with broadleaved species, particularly oak, on favourable lowland sites in Scotland in the eighteenth and nineteenth centuries. In the last century, and still more so in recent decades, Scots pine has been used as a nurse species to spruces, frequently, in recent times, in combination with single-furrow ploughing, on sites where spruces were likely to go into check, particularly on the moister heaths where *Calluna vulgaris* is dominant. It has also been used extensively in mixture with European larch, particularly in Scotland, when the health of that species was suspect, both in the last century and in recent years (Steven, 1927).

When used pure in Britain, Scots pine is usually the species of choice on the drier soils with moderately low nutrient levels and typically covered with dry heath communities. On such sites nutrient and/or moisture levels are not sufficiently high for larches, spruces and Douglas-fir. When such sites are single-furrow ploughed, and competition from the natural vegetation is thus eliminated for a time, some of these species, particularly Japanese larch, may grow reasonably well, but they have a greater risk of failure and fewer economic advantages under such conditions compared with Scots pine. It grows best where the climate is not markedly oceanic, that is, on the eastern side of the country, but even in the high rainfall districts in the west of Scotland, if not in western England and in Wales, there is a place for Scots pine on the drier knolls and ridges, provided one uses a strain from the native pinewoods in the west. Scots pine is rarely damaged by late frosts, and it is relatively resistant to exposure to wind, although it is, on occasion, deformed by wind and broken by snow; these qualities extend the range of its usefulness. On the poorest soils, for example, the peaty podsols and peat soils where *Tricophorum caespitosum* is an important component of the vegetation, Scots pine should give way to *Pinus contorta*—v. *latifolia* under the drier conditions when it is used pure, and the coastal form under wetter conditions when used in mixture with Sitka spruce. On sites otherwise suitable for Scots pine, but with higher summer temperatures than is general in Britain, for example, in the south of England, East Anglia and the coastal dunes, Corsican pine (*P.nigra* v. *calabrica* (Louden) Schneider) is generally preferred to Scots pine because of its higher volume production and greater resistance to pests and diseases (Steven, 1934). Scots pine has not grown well on basic soils in Britain. It may die out before reaching twenty-five feet when used as a nurse to beech on the South Downs, and it is also unsatisfactory on limestones, for example, in East Yorkshire. On sites in East Anglia, where the overlying glacial sand is shallow, chalk comes near the surface, and the pH of the soil may be at or over 7, *Fomes annosus* has caused serious mortality, particularly where the land was used previously for arable agriculture (Rishbeth, 1949, 1957).

Improvement of Strain

Perhaps in no other species is it more important to get the most desirable strain for given conditions. The Forestry Commission began provenance trials almost thirty years ago, two of the most interesting being at Thetford Chase in East Anglia and Findon Forest on the Black Isle in the north of Scotland (Edwards, 1952; Edwards and Pinchin, 1953; Lines and Aldhous, 1957). The seed origins under trial cover a wide range of both latitude and longitude, and oceanic and continental climates. The origins extreme from Britain, such as Finland, Spain and the Urals have done badly. Some of the origins from latitudes slightly farther south than Britain, for example, the Middle Rhine, show better height growth than home origins, and the slightly more northerly origins slightly slower growth, but on the whole finer branching. In general, however, the home origins are as good as any, taking habit as well as rate of growth into account. Schütt (1958) has recently brought together information about Scots pine provenance trials in different countries. The Scots pine in the native pinewoods of Scotland have persisted, often under adverse conditions of climate and soil, and have remained healthy for nine thousand years; their progeny and that of the best old Scots pine planted before 1850, and likely, therefore, to be descended from the native pine, should form the basic stock of this species for further improvement by selection and breeding in Britain.

During the past ten years, the Forestry Commission have done much work which should lead to the improvement of strain in this and other tree species. Scots pine stands in Scotland have been surveyed, and 970 acres of plus and almost plus stands have been registered for seed supply purposes, and the survey is proceeding in England and in Wales. In addition, several hundred individual plus trees of Scots pine, both in the native pinewoods of Scotland and in plantations, have been registered, and scion material taken for grafting in tree banks and seed orchards, in the first place for progeny testing and intra-specific crossing. This work has been described recently (Mathews and McLean, 1957). Private woodland owners and forest tree nurserymen are also taking steps to improve the genetic qualities of tree seed; the Scottish Forest Tree Seed Association was formed in 1956, and a similar association in England in 1959.

The native pinewoods of Scotland constitute a reservoir of valuable genetic material at the western extremity of the natural distribution of Scots pine which has current and potential value not only for Britain, but probably for other western European countries, for example, Denmark. The extent of these surviving pinewoods is now small, and the writer has recently made a plea that these woodlands should not only be perpetuated, but that the distinctive strains of Scots pine in them should not be contaminated by bringing in seed or plants of non-native and non-local origin (Steven and Carlisle, 1959). It is unlikely that the full potentialities of these native strains are yet fully known. The same plea is also made for other tree species in like circumstances and in other countries.

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RESUMES

Le pin sylvestre en Grande-Bretagne

Le pin sylvestre est le seul conifère indigène à la Grande-Bretagne. Il s'est maintenu dans les forêts de pins naturelles de l'Ecosse depuis neuf mille ans. Utilisé dans des plantations depuis 350 ans, c'est le conifère le plus important en Grande-Bretagne, surtout dans les forêts privées; dans les forêts domaniales, cependant, il est surpassé par l'épicéa de Sitka.

Le pin sylvestre non seulement est le conifère le plus répandu dans le monde entier, mais c'est aussi le plus adaptable. En Grande-Bretagne, il est utilisé comme essence principale et comme essence auxiliaire ou d'abri. Dans son premier rôle, il soutient favorablement la comparaison avec d'autres essences dans des sols plus secs, acides et plus légers—surtout dans les régions de landes, mais il joue aussi un rôle limité dans les régions à forte pluviosité de l'ouest anglais, à condition que l'on utilise des semences indigènes aux forêts de pins de l'ouest. Dans le second rôle, on le mélange avec les mélèzes européens et on l'utilise comme abri pour les épicéas. La sélection est particulièrement importante chez cette essence et, au cours des dix dernières années, de gros efforts ont été faits afin de sélectionner les meilleures origines de semences, aussi bien dans les forêts naturelles d'Ecosse que dans les meilleurs peuplements aménagés. Les premières devraient être conservées et perpétuées en tant que réservoir précieux de matériel génétique éprouvé, et ne devraient surtout pas être contaminées par l'implantation de pins sylvestres d'origine non indigène et non locale.

Pino Escocés (Pinus sylvestris) *en Gran Bretaña*

El pino escocés es la única conífera indígena de Gran Bretaña. Ha crecido en los pinares nativos de Escocia por más de nueve mil años. Ha sido usado en plantaciones por 350 años, y es la conífera más importante de la Gran Bretaña, especialmente en los bosques privados, aunque el abeto de Sitka le sobrepasa en los del Estado. No solamente es la conífera más extensamente distribuida del mundo, sino también la más adaptable. En la Gran Bretaña se le usa como especie a la vez principal y secundaria como árbol protector. Como *principal* se compara muy favorablemente a otras especies en suelos más secos, ácidos y más ligeros, en particular con los grupos de brezo seco, pero hace un papel limitado en las regiones de alto índice pluviométrico, siempre que se use semilla nativa de los pinares occidentales. Como especie *secundaria* suele mezclarse con el alerce europeo, y usarse para protección de los abetos. En esta especie, la estirpe es de especial importancia y durante los últimos diez años se han hecho grandes esfuerzos por seleccionar las mejores semillas de origen tanto en los pinares nativos de Escocia como en las mejores plantaciones. Las de los pinares nativos deberían preservarse y perpetuarse como una valiosa reserva de material genético probado, y sobre todo no deberían ser contaminados trayéndoles pino escocés de origen no nativo o no local.

Repoblación—Técnicas Españolas de Repoblación

SRES. SUSAETA, LUQUE, Y MONTERO

España

Variadas son las técnicas españolas de repoblación forestal como variada es la climatología y relieve de España.

Quizá el rasgo más sobresaliente de la climatología libérica lo constituye su dualidad de carácter; dos zonas marcadamente diferenciadas pueden distinguirse: la España húmeda o lluviosa sometida a la influencia de los templados vientos atlánticos con oscilaciones térmicas moderadas y con precipitaciones entre los 600 y los 2.000 mm. anuales bien distribuidos, salvo una ligera sequía estival, y la España seca con lluvias anuales inferiores a los 600 mm. y que en algunas regiones no alcanzan los 300 mm., con dos períodos de sequía, la estival especialmente acentuada, y la invernal; sus variaciones térmicas son extremadas.

Escasas son en España las grandes llanuras o depresiones. España es un país montañoso y amesetado en parte y a excepción de la meseta central, la fosa tectónica del Ebro y la depresión del Guadalquivir, en el resto domina la montaña. Agreguemos a ello que las dos terceras partes del país tiene pendientes superiores al 10%.

Esta somerísima descripción basta para hacer comprender las dificultades que presenta la mecanización, dentro de la técnica de repoblación forestal, ya que los terrenos llanos o semi-llanos están, en su casi totalidad, dedicados a la agricultura, los fenómenos erosivos, que especialmente en la España seca se presentan y la variedad de los sistemas de repoblación empleados.

Repobladas desde el año 1940 más de un millón de hectáreas, se ha dado especial preferencia por razones de tipo edáfico y ecológico y, en parte también, por un deseo de una más inmediata rentabilidad a diversas especies del género *Pinus* (*P. pinaster* Ait.; *P. sylvestris* L; *P. radiata* D. Don; *P. pinea* L.; *P. laricio* Poir.; *P. halepensis* Mill.; *P. uncinata* Ramond) y varios del género *Eucalyptus* (*E. globulus* Labill.; *E. rostrata* Schlecht.; *E. viminalis* Hook.;) por no citar más que aquellas especies con las que se han hecho repoblaciones masivas y a cuya experiencia nos atendremos en el presente estudio.

Para la síntesis más adecuada de este trabajo separaremos las técnicas de repoblación de las especies del género *Pinus* de las del *Eucalyptus* y dentro de ellas distinguiremos las técnicas empleadas en España húmeda y en la seca.

Repoblaciones con Especies del Género *Pinus*[1] En la España Húmeda

Si quebrado es el suelo español, especialmente acentuado es el relieve de la España húmeda. Suelos forestales de acusadas pendientes con estrechos valles cultivados, es la tónica dominante.

La preparación del suelo y la plantación con aperos mecanizados es prácticamente imposible, y por tanto, las técnicas de repoblación se basan en el empleo de mano de obra humana. Incluso la escasa profundidad del suelo, la excesiva pendiente en gran parte de los casos, y la abundante presencia de Ericaceae de mucho desarrollo impiden o dificultan el uso normal de aperos con tracción animal, aunque, por otra parte, su utilización no parece imprescindible.

Es tónica general de las repoblaciones de la España húmeda, la conveniencia, indicada por casi todos los ingenieros repobladores, de la quema previa del matorral.

Este incendio del matorral (realizado con las debidas precauciones mediante ejecución previa de una red de cortafuegos adecuada) se suele hacer de dos formas distintas.

Una de ellas, la más elemental, la quema continua aprovechando la sequía estival o incluso a veces la invernal. Otra, que se aplica en las zonas en que el matorral, por la especial climatología local, no llega a paralizar su savia totalmente en verano y por tanto arde difícilmente, consiste en rozar el matorral en los golpes, hoyos o casillas donde ha de plantarse y en una zona circular en su contorno extendiendo este matorral sobre el no rozado. Una vez seco el material rozado, se procede a la quema que puede conseguirse que sea total o al menos, por golpes suficientemente extensos.

Es importante que las cenizas queden incorporadas al suelo con lo que quiere decirse que la preparación del mismo debe ser lo suficientemente rápida para que al venir las primeras lluvias las cenizas queden retenidas en las casillas u hoyos, ya tapados, y convenientemente distribuidas y evitar el lavado superficial de un abono considerado importantísimo para el desarrollo de la planta en las primeras edades. No obstante, en muchas repoblaciones de la España húmeda se prescinde de esta quema previa del matorral obteniéndose, sin embargo, buenos éxitos.

La preparación, propiamente dicha, del terreno se hace en gran parte mediante hoyos de 0,40 x 0,40 x 0,30 m.; y a veces de 0,35 m. de profundidad ejecutados a mano, con azada y pico, sin que haya tenido éxito la aplicación de perforadoras helicoidales a motor.

Posteriormente, se procede al rellenado de los hoyos y, durante casi toda la época de otoño a primavera, se procede a la plantación de las especies reseñadas arriba, con ligeras interrupciones invernales debidas a las heladas.

La plantación se realiza mediante azada, plantadores cónicos, o planos de sección triangular o bien de sección sensiblemente romboidal.

Los fallos obtenidos por este sistema suelen oscilar del 20% al 35%.

En unas 4 ó 5 provincias de la España húmeda existe una tendencia muy marcada de abandonar el método de preparación del suelo mediante hoyos empleando en cambio una preparación más superficial mediante casillas niveladas de 0,30 x 0,40 m. con ligera contrapendiente, en las que, prácticamente, se realiza con exclusividad el sorrapeo del matorral a una profundidad en consonancia con el tipo del mismo y con el fin de retrasar en lo posible su rebrote. Es decir, el suelo apenas sufre remoción y en todo caso es superficial.

Una vez que el suelo adquiera el tempero adecuado se procede a la plantación en las casillas. Inmediatamente antes de plantar se procede a abrir una hendidura prismática en la casilla que permita la introducción de las plantas. Para realizar esta hendidura se abandonaron los plantadores de sección triangular por la facilidad que presentaban de dejar cámara de aire en estos suelos duros, y se emplean otros de nuevo tipo con sección sensiblemente romboidal de una anchura que oscila entre los 12 y los 18 cm. y un peso entre los 4,5 kg. y los 8 kg. Con estos plantadores la hendidura queda sensiblemente prismática, se dificulta extraordinariamente la aparición de cámaras de aire, no existe el peligro de que las raíces queden dobladas y su utilización no requiere demasiado esfuerzo, de modo que pueden ser manejados por obreros de complexión física inferior a la normal que se emplea en los trabajos de apertura de hoyos.

Los fallos obtenidos por este sistema no suelen rebasar el 15%, siendo en general inferiores al 10% y en cuanto a desarrollo, en los 5 primeros años no se observa diferencia desfavorable respecto a los hoyos; más bien lo contrario. No se tiene experiencia superior a los 5 años. Se han repoblado de esta forma unas 20.000 has.

En otras provincias se prepara el suelo mediante fajas niveladas realizadas con aperos con tracción animal, y a razón de 3.000 m. por ha.

Las fajas se construyen mediante cuatro pasadas de arado brabant y una de subsolador, posteriormente dos pasadas con gradas para alisar la superficie.

La plantación se realiza posteriormente mediante el empleo de máquina plantadora especialmente adaptada.

[1] *Pinus pinaster* Ait., *P. radiata* D. Don y *P. sylvestris.*

Es especialmente indicado este sistema en los montes más sujetos a fenómenos erosivos y donde resulte más importante la retención de aguas pluviales.

Se suele obtener por este sistema un porcentaje de fallos del 25%.

Las densidades empleadas para las especies indicadas en este epígrafe oscilan entre 1.650 y 3.000 golpes de plantación por ha., en cada uno de los cuales se suelen colocar dos plantas. Para el *Pinus pinaster* Ait. y el *P. radiata* D. Don, suelen emplearse densidades más bien bajas, frecuentemente 2.000 golpes por ha. y en rara ocasión 2.500.

Para el *Pinus sylvestris* L., de 2.000 a 2.500, obteniéndose muy buenos resultados con los realizados a 3.000.

Los costos por hectárea de las tres técnicas reseñadas dependen evidentemente de la densidad de plantación y del salario base de peón (que oscila entre 40 y 60 pesetas) y varían entre 2.700 ptas. y 6.190 ptas., la ha. lograda, incluido el precio de la planta y obras auxiliares (sendas y cerramientos).

Los más baratos corresponden a la preparación mediante casillas y los más caros a la preparación mediante fajas.

Ha de agregarse que en algunas zonas se requiere una o dos siegas de helechos en el verano inmediato posterior a la plantación e incluso una roza de matorral al año siguiente.

El tipo de planta empleada suele ser:

- Para el *Pinus pinaster* de 1 savia a raíz desnuda.
- Para el *P. radiata* de 1 savia a raíz desnuda.
- Para el *P. sylvestris* de 2 ó 3 savias, repicada al segundo año.

Repoblaciones con Especies del Género *Pinus*[2] En la España Seca

Las técnicas de repoblación empleadas en la España seca se distinguen en general de las empleadas en la España húmeda por la mayor atención y cuidado que se presta a la preparación del terreno.

La roza, descuaje y quema del matorral e incluso el labrado total del terreno, siempre que es posible, llegan a hacerse en forma muy frecuente.

En otros casos el labrado se hace por fajas niveladas empleando yuntas de bueyes o ganado mular. La roza de matorral puede hacerse asimismo en fajas.

Se siguen empleando los hoyos como preparación del terreno, pero en este caso es frecuente que la planta a emplear lleve preparaciones especiales.

Una vez preparado el suelo, en el momento oportuno se procede a su siembra o plantación.

Puede decirse que para el *Pinus pinea* L. se emplea exclusivamente el método de siembra, a razón de unos 40 kg./ha. en fajas e incluso unos 70 kg. en labrados totales. Suelen hacerse de 2.000 a 2.500 golpes de siembra en cada uno de los cuales se colocan varias semillas.

Es complemento necesario de la siembra el gradeo mecánico ó a mano.

En cuanto al *Pinus pinaster* se emplea en ocasiones el método de siembra, siempre sobre suelo labrado totalmente o en fajas y a razón de unos 7 u 8 kg. de semilla por ha.; pero es más frecuente que se siga el método de plantación.

En cuanto a las demás especies indicadas en este epígrafe se emplea invariablemente el método de plantación.

Tanto el *Pinus pinaster* Ait., como el *P. sylvestris* L., el *P. halepensis* Mill., y el *P. laricio* Poir., se suelen emplear a raíz desnuda pero en este caso se recomienda mucho realizar la plantación en épocas de máxima humedad del suelo y rara vez se hace uso de los hoyos, sino de suelos labrados totalmente o en fajas.

Se utiliza con frecuencia la máquina plantadora. Empleando como preparación previa los hoyos es más frecuente que se utilicen plantas con cepellón de macetas de barro o bien de madera laminada (C.M.L.), que tienen la ventaja de su baratura, y de que no es necesario desprender el cepellón de la pequeña maceta pues ésta se pudre en el terreno. Si se emplea raíz desnuda suele aprovecharse las umbrias de los montes.

Es tónica general de la España seca para conservar la humedad, la utilización de piedras de algún tamaño colocadas rodeando las plantitas con lo que suele obtenerse muy buenos resultados.

También en la España seca ha aparecido últimamente, la tendencia hacia preparaciones del suelo superficiales, es decir, en este caso, con labrados del suelo poco profundos obteniéndose, no sólo una economía en el costo de la obra sino incluso mejores desarrollos del repoblado plenamente comprobados, especialmente en la provincia de Córdoba.

Las densidades empleadas oscilan entre 2.000 y 2.500 golpes de plantación por ha. en cada uno de los cuales se suelen colocar dos o más plantas.

Con preparaciones del suelo mediante labrados totales o en fajas, utilizando el *Pinus pinaster* o el *P. pinea,* bien en siembra o en plantación y complementando la obra con binas primaverales, el porcentaje de fallos suele ser inferior al 15%.

Para el mismo *Pinus pinaster* empleando hoyos y sin binas primaverales, los porcentajes a reponer varían del 35% al 60%.

Para las demás especies los porcentajes de fallos, oscilan entre un 30% y un 60%, siendo los inferiores consecuencia aparente del empleo de macetas o C.M.L.

Si se emplea *Pinus halepensis* a raíz desnuda y en hoyos, el porcentaje a reponer, mediante sucesivas reposiciones, suele alcanzar incluso el 100% de lo repoblado.

En cuanto al costo de la ha. lograda no suelen aparecer en la España seca grandes diferencias. Con un salario base de 50 a 60 pesetas el costo oscila entre 5.125 ptas. por ha. y 5.900 ptas. por ha., sea cual fuere la técnica empleada. Hay que hacer excepción en el caso de emplearse el *P. halepensis* a raíz desnuda y en hoyos, pues a pesar de utilizarse un salario-base notablemente inferior (34 pesetas), el costo total de la ha. lograda asciende a 5.830 ptas., lo que es aparentemente debido al exceso de reposiciones.

El tipo de planta empleada suele ser:

- Para el *Pinus pinaster* Ait., una savia a raíz desnuda.
- Para el *P. sylvestris* L., dos o tres savias a raíz desnuda.

[2] *Pinus pinaster* Ait., *P. pinea* L., *P. sylvestris* L., *P. halepensis* Mill., *P. laricio* Poir.

Para el *P. halepensis* Mill., una savia en maceta, C. M.L. o raíz desnuda.

Para el *P. laricio* Poir., dos savias repicadas, en maceta o raíz desnuda.

Repoblaciones con *Eucalyptus globulus* Labill. En la España Húmeda

Limitada a la faja costera del norte y noroeste de España, con temperaturas suaves y mínimas que no bajan de 4° C., se han realizado extensas repoblaciones con *Eucalyptus globulus* Labill.

Se han empleado indistintamente sistemas que incluyen métodos de plantación o de siembra, si bien en repoblaciones extensivas se ha preferido la siembra por su menor costo.

A la preparación del suelo se le suele prestar mayor atención que a la repoblación con resinosas, si bien esta se reduce en general a una mera, si bien cuidadosa, preparación superficial.

Las repoblaciones por siembra comprenden las siguientes operaciones: (1) Roza del matorral; (2) Sorrapeo del terreno; (3) Apilado del césped y quema de los hormigueros; (4) Señalamiento de hoyos; (5) Apertura, recavado de la tierra y relleno de hoyos; (6) Distribución de cenizas; (7) Siembra de los hoyos; (8) Trasplante a los hoyos marrados; (9) Siega de helechos; y (10) Arranque de plantas sobrantes

Los trasplantes no suelen dar resultados completamente satisfactorios pues el crecimiento de la planta trasplantada se retrasa respecto del resto de la masa, por lo que se recomienda hacer la reposición con planta criada en semilleros con cepellón de tierra, si bien ello encarece la obra.

El costo de la ha. lograda, con una densidad de 2.000 a 2.500 hoyos por ha. y un jornal de 60 pesetas es de unas 10.250 pesetas. Se suelen emplear 250 gramos de semilla por ha.

En las repoblaciones por plantación puede prescindirse del sorrapeo del terreno o bien puede hacerse por fajas, que es lo más recomendable.

Se roza desde luego el matorral que se quema juntamente con los tepes, distribuyendo las cenizas en los hoyos. Se utiliza planta con cepellón de tierra y se hacen las siegas estivales oportunas.

Las densidades empleadas suelen ser de 2.000 hoyos por ha. o inferiores. Para una densidad de 1.785 hoyos por ha. y con un salario base de 60 ptas. el costo de la ha. lograda es de 9.823 pesetas.

Existe la tendencia de prestar cada vez mayor atención a la preparación del suelo, pues se consideran altamente productivas las inversiones en este sentido.

Repoblaciones con Especies del Género *Eucalyptus*[3] En la España Seca

Como es lógico, en la España seca se presta una atención primordial a la preparación del suelo.

La roza y quema del matorral, el labrado del suelo, incluso, si es posible, previamente, con subsoladores, se considera imprescindible, hasta conseguir dejar el terreno completamente limpio y mullido.

Se planta con cepellón de tierra en momento de buen tempero del suelo, previa apertura de 625 ó 1.000 hoyos por ha.

Es fundamental, si se quieren evitar elevados porcentajes de marras, dar una labor de arado inmediata a la plantación o incluso mejor antes del marquilleo y apertura de los hoyos, y en primavera una labor de grada cruzada con la primera.

En caso de no ser factible las labores de grada y arado a causa de la accidentación y pendiente, se hace una cava con azada alrededor de cada pie en un círculo de un metro de radio.

Es frecuente también una labor de aporcado en caso necesario.

Se considera económico realizar una labor anual de cultivo hasta el fin del turno.

El costo de la ha. lograda con un salario de 37 pesetas oscila de 5.000 a 5.450 pesetas.

[3] *Eucalyptus globulus* Labill., *E. rostrata* Schlecht., *E. viminalis* Hook.

RESUMES

Reforestation: Spanish Reforestation Techniques

As a result of the climatological diversity of Spain, the techniques used in reforestation are unusually varied.

In most cases it is almost impossible to mechanize this kind of work because of the steep slopes that have to be reforested.

Since 1940 over one million hectares have been reforested with different species of the *Pinus* and *Eucalyptus* genera, just to mention the two species that have been used for the reforestation of extensive areas.

In so-called humid Spain, pine reforestation is carried out by first burning the underbrush and by planting in holes or in small openings on which the underbrush has been eradicated. Trees are planted with their roots bare and come directly from the nursery. If they are planted in furrows, small prismatic crevices are made by using especially designed, rhombus-shaped sectional planters.

In dry Spain greater care is given to the preparation of the soil for pine reforestation.

The clearing, eradication, and burning of the underbrush and the tilling of the soil, at least in strips, are considered to be necessary.

The *Pinus pinea* L., and in some cases the *P. pinaster* Ait., are sown together with other species that are also used. The planting method is employed. If the land has not been prepared as carefully as is necessary, frequently plants are used which have been grown in pots made of clay or laminated wood.

Eucalyptus reforestation in humid Spain is carried out by sowing or planting trees with earth around their roots in holes after the underbrush has been cleared, eradicated, and burnt.

In dry Spain, planting is exclusively on lands that have been cleared, burnt, and tilled, using trees with roots covered with earth, and the land is tilled every year.

Régénération—Méthodes espagnoles de régénération

Les conditions climatiques de l'Espagne étant très variées, il en résulte que les méthodes de régénération forestière le sont aussi.

Dans l'immense majorité des cas, la forte pente des terrains en voie de reboisement rend presque impossible la mécanisation des travaux.

Depuis 1940, on s'est servi, pour reboiser plus d'un million d'hectares, de diverses variétés des genres *Pinus* et *Eucalyptus*, pour ne citer que les essences ayant servi aux repeuplements extensifs.

A l'intérieur de l'Espagne dite humide, on commence, avant de procéder au reboisement en pins, par mettre le feu aux broussailles; après quoi on prépare le sol en y creusant des fosses ou simplement des poquets là où l'on s'est borné à sarcler le terrain. Pour la plantation, on se sert généralement de plantes à racine dénudée, cultivées en pépinière; et quant aux plantations en poquets, on y pratique au préalable des fentes prismatiques en se servant de plantoirs spécialement conçus pour donner aux trous creusés la forme de rhombes assez réguliers.

A l'intérieur de l'Espagne sèche, la préparation du sol pour le reboisement en pins fait l'objet des plus grands soins. On estime qu'il est nécessaire de sarcler, déraciner et brûler les broussailles, et même de labourer la terre, ne serait-ce que par bandes.

On a coutume de semer le *Pinus pinea* L. et dans certains cas le *P. pinaster* Ait., alors qu'on applique la méthode de la plantation aux autres essences utilisées. Il arrive souvent, notamment lorsqu'il n'a pas été possible de donner tous les soins nécessaires à la préparation du sol, que les plantes soient utilisèes avec la motte de terre cultivée dans des pots de terre ou de bois laminé.

Dans la région humide de l'Espagne, les reboisements par l'eucalyptus, que l'on fait précéder du sarclage, et du brûlage des broussailles, s'effectue en semant, ou en plantant dans des fosses, des plantes avec leur motte de terre.

En Espagne sèche on plante uniquement dans des terrains sarclés, brûlés et travaillés, en se servant de plantes avec leur motte de terre et en effectuant des travaux de culture une fois par an.

La Repoblación del Cedro Rojo (Cedrela mexicana M. J. Roem.) por Diseminación Artificial—Ventajas sobre el Método De Plantaciones

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Se ejecutaron así durante varios años plantaciones en diversos sitios sin ningún resultado práctico a pesar del empeño y del alto costo que el procedimiento reclamaba, ya que implica principalmente trabajos de recolección de semilla, siembra, cultivos, trasplante, empaque, transporte, y plantaciones en el Iugar definitivo.

La reacción de los sujetos así obtenidos al ser colocados en el medio natural, fué totalmente negativa pues el resultado final era la pérdida en la mayoría de los casos del 100%.

Se hizo un análisis de la situación determinada, primero la acción de la espesura en el temperamento de la especie y se ejecutaron trabajos de aclareo gradual hasta llegar a la supresión de la vegetación de las masas dejando a cielo abierto y sólamente el cedro rojo y se pudo apreciar que a pesar de desenvolverse en un medio de gran espesura resiste perfectamente los rigores a que están sujetas las especies de temperamento robusto, obteniéndose la enseñanza de que en un medio aclarado convenientemente el cedro rojo se desarrolla perfectamente, no obstante, las plantitas colocadas en distintas condiciones naturales se morían, entonces se hicieron investigaciones sobre factores externos encontrándose que las plantitas provenientes de vivero eran atacadas por un Bupréstido que depositando sus huevecillos en la porción inferior de la planta y exactamente en una zona dañada por la acción de los rayos solares desarrolla su estado larvario en el interior degollando totalmente al sujeto, ataque que a simple vista no es perceptible.

Se carece casi en todo el mundo de experiencia e investigaciones sobre la repoblación artificial de las especies preciosas de clima tropical. Las normas contenidas en la legislación forestal mexicana y el interés de los industriales de enriquecer los suelos del trópico con especies valiosas para contar con centros de producción y abastecimiento cada vez mayores y de mejor calidad para subvenir a las necesidades mundiales del consumo, se han traducido en México en motivos de experimentación que han dado ya sus frutos permitiendo desde luego apreciar como primicias de un intento inicial las ventajas en el empleo de un método sobre otro, en el orden técnico y económico: me refiero al método de diseminación artificial sobre el de plantaciones empleado en la repoblación del cedro rojo (*Cedrela mexicana* M. J. Roem.).

La propagación artificial del cedro rojo, con fines de repoblación se inició en México por el método de plantaciones en el Territorio de Quintana Roo y los Estados de Yucatán y Campeche, sirviéndose de viveros especiales.

Este fenómeno se producía un año después de que la planta era llevada al monte, coincidiendo el ataque con el período anterior al principio de la época de lluvias, la muerte de la planta se operaba en un período sumamente corto comprendido entre 5 y 6 días.

Fué hasta el año de 1951 en que se atribuyó fundadamente la causa de las pérdidas al insecto de que se trata.

Conforme al hecho citado se hicieron plantaciones en zonas cubiertas por pastizales donde la acción de la competencia resta crecimiento al cedro rojo. Posteriormente completando el ciclo de experimentación se hicieron plantaciones en pastizales previamente quemados y las plantitas reaccionaron respondiendo con un rápido crecimiento hasta obtener 1.50 m. en un año.

Se hicieron ensayos con éxito para el ataque de la plaga tomando en consideración la acción de los rayos solares y aplicando lechados a base de D.D.T. lográndose el control de la plaga.

A semejanza de la caoba, las plantas de cedro rojo durante los primeros cuatro años de su vida son también víctimas del ataque de la *Hipsiphilla gandensis* que destruye la yema terminal.

El efecto de la Hipsiphilla se traduce en una acción retardataria del crecimiento de la planta y en la deformación del fuste pues la destrucción de la yema terminal trae como consecuencia el desarrollo de las ramas principales dando una conformación defectuosa a los árboles así crecidos.

Del examen del repoblado obtenido por diseminación natural de la caoba que no es atacada ni con la frecuencia, ni con los resultados señalados para el cedro, se pensó en ejecutar la repoblación por diseminación artificial.

La clase de brinzales obtenida directamente en el monte tiene una mayor resistencia a los agentes de destrucción y evitan asímismo todos los gastos que reclama la repoblación por plantaciones pues de los datos obtenidos por la práctica por lo menos en lo que se refire a la Península de Yucatán se requiere una inversión de $100,000.00 m/n aproximadamente para obtener una producción de 200,000 plantas anuales. En esta cantidad no están incluídos los gastos propiamente de producción, cultivo, transporte y plantaciones, sino simplemente los gastos iniciales tales como valor del terreno, trabajo de adaptación, construcción de eras, techados, sistema de riego, bodegas, casetas, herramienta, etc.; en los trabajos de repoblación es siempre condición obligada pensar en que la función económica principal la determinan dos factores: los costos de producción y los de transporte, factores que por el sistema de diseminación artificial quedan reducidos a su mínima expresión haciendo de esta manera factible los trabajos de repoblación en un área inmensamente mayor a la que pueden abarcar los trabajos por plantaciones, además de la más valiosa de las circunstancias que es la de obtener una mayor resistencia a los agentes de destrucción y una mayor efectividad en el logro de la repoblación.

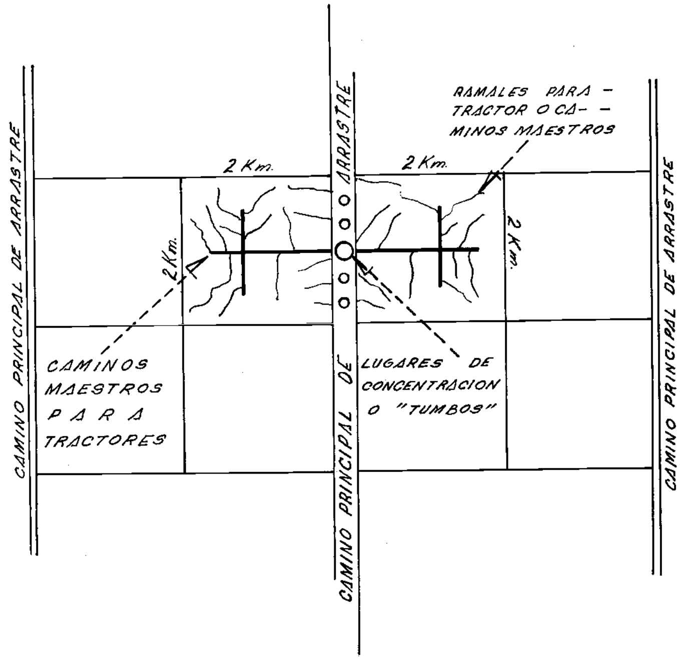
A las circunstancias citadas debe agregarse la no menos importante de que la repoblación por diseminación artificial puede combinarse perfectamente con los trabajos de aprovechamiento ya que la destrucción de los productos en bruto en el área de corta reemplazan una preparación del suelo para que semilla se deposite en un medio que le proporcione condiciones fáciles de germinación; no debiendo perderse de vista además de que aunque las labores de limpia, de liberación y aclareo deben también ser ejecutadas durante los primeros años para promover el más rápido desarrollo de las plantitas; ésto se hace necesario en menor número que el que requieren las plantaciones ya que el arbolado que ha nacido directamente en propio terreno se desarrolla con mayor rapidez y domina fácilmente la vegetación que lo rodea, liberándose así definitivamente en su vida posterior.

Una circunstancia especial que debe tenerse siempre presente es que uno de los enemigos más importantes en las plantaciones de cedro es el ataque del Hipsiphilla que, como se ha podido comprobar, ocurre por lo menos dos veces al año siendo el primero de ellos al poco tiempo de iniciada la temporada de lluvias y esta circunstancia le da una preponderancia extraordinaria al procedimiento de diseminación artificial ya que cuando se inicia la temporada de lluvias la plantita proveniente de la siembra apenas ha germinado.

Si además de los hechos citados se toman en cuenta los resultados obtenidos hasta hoy en la práctica y se aúnan las ventajas de tipo económico sobre cualquier otro procedimiento de repoblación y la posibilidad de combinar los trabajos de repoblación con los de aprovechamiento, es fácil comprender que este sistema alcanza el mayor éxito.

Con el objeto de dar una idea más completa de la forma en que se ha combinado el sistema de repoblación por diseminación artificial con los trabajos de aprovechamiento se hará una breve descripción de ésta:

Las explotaciones de especies preciosas (caoba y cedro) son efectuadas por las empresas mediante el empleo de cuadrículas. Estas cuadrículas son generalmente de un km.^{2}, máximo de 4 km.^{2}.



El arrastre de la trocería de las áreas de corta a los sitios de concentración se hacen generalmente usando tractores de oruga. Este movimiento ocasiona una escarificación del suelo que sirve como labor preparatoria a la siembra de la semilla, además de que segrega la vegetación herbácea en el medio en que esta va a desarrollarse, evitando así la competencia y, dando a la vez las condiciones de aclareo que favorecerán al desarrollo de la planta, contribuyéndose asímismo tal vez a la disminución del ataque de la Hipsiphilla.

El cedro rojo es una especie que se caracteriza por la forma en que vegeta, formando manchones irregularmente distribuidos. No sería aventurado afirmar que utilizando los mismos lugares o superficies donde el cedro ha vegetado, la semilla al ser regada, encuentre las condiciones ecológicas óptimas para reproducirse. Es también un hecho comprobado, que el cedro rojo es una especie sociable, que prepara mejor en los lugares en donde el hombre ha habitado, ayudando con la limpieza a que el cedro encuentre condiciones más favorables para su crecimiento.

Tal hecho se comprueba, porque es precisamente en los lugares donde se encuentran vestigios o ruinas de que el hombre vivió, donde se localizan los manchones más abundantes de cedro rojo. En consecuencia, al pasar la explotación maderera precisamente en las superficies en donde se localizaron los manchones de cedro, es lógico suponer que en esas superficies, la especie encontrará un medio ecológico apropiado para desarrollarse. La misma explotación en sí trae aparejado un aclareo en esas superficies, tan necesario para completar las condiciones favorables a la siembra.

Incluimos a continuación un croquis que comprende una superficie cuadriculada, con las anotaciones correspondientes para una mejor comprensión de lo expuesto.

Al reforestarse las zonas explotadas con el método de siembras al voleo, la semilla cubre la totalidad de las superficies donde la especie vegetó y se utilizan además los caminos maestros y los ramales, lo que trae como consecuencia una distribución uniforme de la reforestación en toda el área explotada.

Este sistema trae aparejada otra ventaja más. Existiendo el trazo previo de la cuadrícula por necesidades de explotación, en un plano adicional, con datos exclusivos para reforestación, puede tenerse la cuadrícula, con la localización exacta de todos los "caminos maestros y ramales" en donde ha pasado la reforestación, lográndose por lo tanto tener un control absoluto de la misma, incluyendo datos adicionales como cantidades empleadas de semilla en cada cuadro e inclusive en cada camino y ramal.

La recolección de la semilla no presenta problemas aun cuando hay años poco productores de semilla; recolectar la cantidad relativamente pequeña, que se necesita para la siembra al voleo, dado el poco peso de la misma y la gran superficie que se puede cubrir con ella, siempre se contará con las cantidades necesarias para los trabajos de siembra.

Cuando los trabajos de reforestación en general se iniciaron utilizando esta especie, allá por el año de 1950, la conservación de la semilla presentó problemas, pues al cabo de tres meses como máximo, ya no estaba en condiciones de usarse. Tanto para la producción en vivero como para la siembra al voleo, se necesitaba contar con porcientos de germinación aceptables, ya que en el primer caso convenía producirla lo más retardado posible para no tenerla un tiempo demasiado prolongado en vivero, y en el caso de las plantaciones, éstas tenían que retardarse también en los años en que la temporada de lluvias no llegaba oportunamente. Se comenzó a ensayar su conservación con muy buenos resultados.

La recolección de la semilla se hace durante los meses de febrero y marzo y la utilización de la misma tiene que detenerse hasta el mes de junio en los años en que la temporada de lluvias no llegaba oportunamente (generalmente se inicia desde abril) se comprendió que la conservación de la semilla, con porcentajes de germinación tolerables, era de vital importancia para el éxito de los trabajos, tanto en plantaciones como en las siembras al voleo.

Se procedió a ensayar con lotes pequeños de semilla, perfectamente seleccionada y limpia; ésta se colocó en bolsas de nylon perfectamente cerradas y se depositaron en refrigeradores domésticos. Se hicieron pruebas de germinación con lotes de 100 semillas en el vivero. El resultado de estas pruebas fué alentador, pues pudo comprobarse que el porciento de germinación de la semilla después de un año de recolectada, en ningún caso fué inferior al 60%. De esta manera se pudo emplear semilla en trabajos de reproducción después de lapsos mayores de tres meses, cosa que no ocurría hasta antes de estas pruebas.

El rendimiento de semilla limpia, en relación con el peso total del fruto recolectado, varía entre el 8 y el 10%. Se ha calculado que un kilogramo de semilla limpia, contiene un mínimo de 20,000 semillas. El costo de la misma, es un tanto elevado, porque la recolección del fruto se tiene que hacer mediante el desrame, haciendo una limpieza previa de la superficie circundante, etc., etc., trayendo como consecuencia que el costo de la mano de obra, por concepto de recolección sea elevado. De cualquier manera, aún así, el número de semillas por unidad de peso es tan grande que el costo de la planta sale bajísimo. Como dato ilustrativo únicamente consignaremos que el costo por kilogramo obtenido en el Sureste de semilla limpia es de $50.00 m/n.

Las labores propias de la siembra al voleo no necesitan la intervención de personal especializado. Sí debe tenerse especial atención en lo que se refiere a graduar adecuadamente la distribución de la semilla, con el objeto de evitar el tener superficies con repoblado excesivo. Durante la primera prueba hecha en Yucatán, se reforestaron zonas, que una vez germinada la semilla, tenían la apariencia de verdaderos almácigos, llegándose inclusive a hacerse transplantes con parte de estas plantas, en zonas que se prepararon en las inmediaciones de esas prequeñas superficies.

La cantidad de semilla que debe diseminarse por unidad de superficie es variable, de acuerdo con el número de ramales por recorrer, pero en términos generales se puede tomar como un dato aceptable, utilizar ½ kg. para cada cuadro de 4 hectáreas de superficie.

Desgraciadamente, como ya se dijo, no se han realizado trabajos sistemáticos, sujetos a un plan determinado, ni se han calculado costos de una manera precisa, pero por los resultados ya comprobados, en el Sureste de México, se puede concluir que bajo todos los aspectos, tratándose de reforestación con la especie cedro rojo, con el sistema de siembras por diseminación se obtienen resultados técnica y económicamente superiores al método de plantaciones.

Las labores de limpieza en años posteriores a la siembra, también deben hacerse, como en el caso de las plantaciones; sin embargo se ahorra el gasto de lo que debe darse hacia el final de la temporada de lluvias en la plantación. Por otra parte, el costo de la mano de obra en las limpiezas posteriores en la siembra al voleo, es menor debido al hecho de que los caminos maestros y ramales que se reforestan, se encuentran limpios de árboles de grandes dimensiones atravesados, lo que no sucede en las plantaciones.

Es posible asimismo que el número de limpias pueda reducirse. En determinadas zonas del Estado de Yucatán se obtuvieron altura de más de dos metros durante el primer año. Lo anterior hace pensar que con semilla seleccionada y bajo condiciones óptimas, la planta obtenida pueda liberarse al cabo de tres años como máximo, cosa que nunca sucede con la plantación.

RESUMES

Regeneration of Mexican Cedar (Cedrela mexicana *M. J. Roem.) by Artificial Seeding—Advantages Over the Seedling Transplanting System*

For replanting Mexican cedar (*Cedrela mexicana* M. J. Roem.) tracts, artificial seeding is recommended in those zones where it can be combined with forest exploitation.

As compared with seedling transplanting with the same species, a zone can be replanted by artificial seeding at a considerably lower cost.

Replanting the Mexican cedar by artificial seeding produces trees that are a great deal less susceptible to the attacks of a borer known in Mexico as "gusano degollador" (a Buprestid) and those of the tip moth, a borer that feeds on the tender shoots of the plant and has a great influence over the development of the tree. Trees grown by artificial seeding are resistant to the attacks of this pest.

Repleuplement du cèdre rouge (Cedrela mexicana *M. J. Roem.) par dissémination artificielle—Avantages de cette méthode sur celle de la plantation*

Dans les zones où cette pratique peut être combinée avec l'exploitation forestière, il est recommandé de se servir de semences pour la dissémination artificielle de l'essence dénommée cèdre rouge (*Cedrela*).

Ce système permet d'obtenir des zones reboisées à un prix considérablement inférieur à celui qu'exige la plantation de cette même essence.

Le repeuplement par le cèdre rouge, selon le système de la dissémination artificielle, produit des sujets infiniment moins vulnérables aux attaques de la chenille destructrice (Buprestidae), et à celles du papillon du bourgeon terminal, ce dernier surtout, dont l'influence joue un rôle tout à fait déterminant dans la conformation des sujet, ce qui ne se produit pas dans le cas de la dissémination artificielle.

Peat Afforestation

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Accumulations of organic matter over twelve inches deep (thirty centimetres), are defined as organic soils, and the term "peat" is best restricted to such organic soils, thinner layers of organic matter being considered as peaty horizons of mineral soils. These organic soils are formed anaerobically on account of waterlogging which inhibits normal decomposition processes. Peats bearing *Molinietum* are no longer a problem in afforestation, and in this paper only the highly acid oligotrophic peats principally occupied by the three vegetation communities, *Sphagnetum, Trichophoretum (Scirpetum)* and *Eriophoretum*, are considered.

Foresters have, until recently, believed that it was impossible to grow trees on acid peat. Thus James Brown (1861) remarked that "Moss (i.e., peat) land, even after draining, is found of a dull and inert character and not apt to give life and energy to the growth of useful plants"; and Boyd, as late as 1918, after experience both at Corrour and at Inverliever in the west of Scotland, stated that no areas bearing *Scirpus, Sphagnum, Eriophorum* or *Narthecium* should be planted.

The Forestry Commission first attempted to notch Norway spruce (*Picea abies*) or Scots pine (*Pinus sylvestris*) directly into the peat, sometimes with some system of drains, but it soon became clear that although the trees often survived for a long time, they did not grow. New methods were obviously necessary, and a large programme of experimental work was undertaken. The results, which were published (1954) in "Experiments in Tree Planting on Peat" (Forestry Commission Bulletin No. 22), may be briefly summarised as follows:

It is first necessary to remove excessive water by making drains and, as peat is colloidal and loses water slowly if at all, aerated turf must be provided by inverting some of the peat to provide a suitable medium on which trees can grow. Hand methods had been elaborated by the Prussians and Belgians and were introduced into Scotland by Sir John Stirling-Maxwell (1907) at Corrour, and a successful method of combining draining and turfing was soon elaborated for the *Molinietum* and eventually intensified for the poorest types of peat.

The successful experimental plots described below were based on this laborious method of hand working, but such operations could only be extended when they came to be mechanised, and this was not possible until 1945. Special ploughs (the Cuthbertson models) pulled by standard tractors with specially wide tracks have been developed. These are unable to deal with the *Sphagnetum* peats, which are too soft to be traversed by this machinery and are therefore not afforestable, but, in general, any peat which can be ploughed with such an outfit can be planted successfully with trees.

Plough furrows and ridges spaced at intervals of about 6 feet, which is as close as is possible on soft peat, are necessary for quick, early tree growth. The plants are put in on the ridges, with their roots not far above the "sandwich" between the inverted ridge and the original peat, and a delay of less than a year between ploughing and planting is desirable to avoid excessive competition between the trees and regrowing vegetation.

Many of the experiments were carried out with various species of spruce, because spruces are traditionally suited to wet sites, but the spruces went repeatedly into check, and no suitable technique for raising any species was found. Pines, on the other hand, are oligotrophic and can grow on the poorest sites. The native Scots pine is not the most suitable species under the most extreme conditions, where mountain pine (*Pinus mugo*) is the best, but the latter is not a timber tree, and lodgepole pine (*Pinus contorta*) from the northwestern parts of the continent of America has been found to be the most suitable.

Fertilization with phosphate is an important necessity in Britain as had earlier been found to be the case in

Belgium, but experiments with other fertilizers, including trace elements, did not yield advantageous results.

The work summarised above has produced plots of lodgepole pine 40 feet (13 metres) tall at 30 years of age, with a timber volume of 1,500 hoppus feet per acre (1,900 cu. ft. true measure per acre, or 134 cu. m. per ha.) excluding that below 3 in. (7½ cm.) in diameter. This is equivalent to the third quality class of Scots pine in the standard yield tables.

Scots pine raised similarly has grown less fast and has only attained the fourth (lowest) quality class. But the rate of increase in volume in plantations of both these species has already passed its maximum and has begun to slow down. Thirty years of age is unusually early for this to happen, and the future of these plantations is therefore still in doubt.

Recent investigations of tree nutrition by means of foliage analysis have indicated that it is possible to diagnose nutrient deficiencies. The results so far suggest that more fertilization will be required. Not only will the increasing size of the trees necessitate more phosphate to maintain growth, but also potash supplies, which were adequate in the early stages, apparently now need increasing. Probably the additions of these fertilizers will bring others into short supply, and further deficiency symptoms may be encountered, though they cannot yet be detected.

It is desirable to try to draw up some kind of balance sheet to determine our assets on peat, and whether it is likely to be able to grow mature crops of trees. The evaluation of a piece of land for forestry in terms of its plant nutrients is a difficult method of approach, and though attempts have been made on mineral soils, little is known about peat. Previous analyses have been mainly with a view to using the peat as fuel, and not from the biological angle. Analyses of the peat are therefore being made in collaboration with the Department of Agriculture for Scotland and the Scottish Peat Committee, Moss Survey Group, both where the trees are growing and on other peat mosses. So far, the data available suggest that the nutrient status of most mosses bearing similar types of vegetation is approximately similar and, therefore, there is every reason to suppose that the experimental plantations so far raised can be repeated on other mosses where the climatic factors are equivalent. Nevertheless, timber production on all these mosses is still uncertain, and even if it proves possible to bring forests on peat to maturity and to regenerate them successfully, it seems probable that considerable expenditure on fertilizers will be required.

It is often stated that windblow is severe on peat, and as a general statement this may be true. But windblow is common in Scotland on many soils, and investigations, especially since the great windblow of 1953 in the east of Scotland and the less dramatic ones of 1954 and 1956 in the west, have shown that it is mainly shallow-rooted trees over a certain height that are blown down. Restriction of roots to shallow depths is common on peaty gley soils where the trees root in the peat but are unable to penetrate the clay beneath, and the junction between the peat and the mineral soil presents a plane of low resistance which permits the mass of peat and tree roots to be over-turned by high winds. A high water table may similarly restrict the roots, but modern ploughing on peat is deep, and the water-table can be kept low down. In order to do this the plough furrows have been placed close together, with the result that growth of roots in the horizontal plane is restricted to a very narrow strip. The experimental plantations on peat are only now attaining the critical tree height at which windblow may be expected, and it remains to be seen whether their root systems are adequate in horizontal spread as well as in depth to resist it.

Evidence has been brought to show that growth on ploughed peat can be limited by water shortage, and it seems that in times of drought, plantations on what was formerly very wet peat can suffer from moisture deficiencies, to which may be related a nitrogen deficiency (Binns, 1959). It may be relevant to note that on the peaty podsols of the upland heaths, the first problem in afforestation was to remove the excessive superficial moisture due to the peat skin and the iron pan. Ploughing can change this problem into one of water shortage, at least in certain seasons, in areas of low rainfall, but a similar problem on peat in wetter climates is unexpected and possibly more serious. Moisture deficiency on a porous, non-retentive sand which, without the addition of organic matter, may not be able to hold moisture, may be contrasted with peat which is either waterlogged and devoid of oxygen or else when drained retains the moisture so tightly that it is equally unavailable to trees. Further experimental work on the method of ploughing to be adopted in future is clearly desirable.

In Scotland, the peat mosses are typical of the Highlands, a terrain of acid rock and ample rainfall, or in the Lowlands, of basin bogs raised above the mineral soil. Originally bearing considerable forests of oak, pine, hazel, birch and alder, deforestation has resulted in large areas of land covered by grasses, sedges or heather, usually on peat and often grazed by cattle or, more frequently by sheep or deer. The reafforestation of such peat areas may not prove to be an economic proposition, but it is hoped to rehabilitate them by a deliberate change of policy from the production of protein to the production of cellulose, to be integrated with agricultural and sporting interests and some form of industry, in order to ensure the viability of rural society.

In conclusion, the problem of establishing pine plantations on deep acid peat has been solved. Only certain experimental plantations have reached the pole stage, and these present problems of nutrition and moisture supply which are under examination. Other problems of older crops such as windblow, have not yet arisen. Current research is investigating both the constitution of the peat and also the growth of the trees, but it is not yet possible to be sure that productive forests can be maintained on deep acid peat.

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RESUMES

Boisement des tourbières

L'auteur décrit le boisement de sols organiques, d'une profondeur supérieure à 12 pouces (trente centimètres), porteurs de groupements végétaux *Trichophoretum* (*Scirpetum*) et *Eriophoretum*. Les plantations expérimentales fondées sur des opérations intensives de drainage et d'enlèvement manuel de la tourbe ont atteint le stade de perches, et l'on procède à de nouvelles plantations en utilisant des charrues spécialement conçues et tirées par des tracteurs ordinaires à grands tracs. Le *Pinus contorta* et le *Pinus sylvestris* se sont révélés comme étant les essences qui réussissaient le mieux. L'amendement aux phosphates au moment du plantage est essentiel. Un amendement répété aux phosphates peut être souhaitable, ainsi que l'adjonction de potasse. Jusqu'à présent, aucune déficience d'autres éléments n'a été constatée.

L'examen d'autres sols tourbeux indique que le boisement peut être étendu partout où existent des conditions climatiques semblables. On prévoit des problèmes de chablis par le vent au fur et à mesure de la croissance des arbres, du fait que leurs racines sont limitées par le labour profond et peu espacé, mais ceci ne s'est pas encore produit et ne sera peut-être pas plus grave que dans le cas des sols minéraux impénétrables où l'on pratique un labour semblable.

Encore que tous les problèmes ne soient pas résolus, il est possible d'avoir des plantations allant jusqu'au stade de perches et on espère que ce type de boisement combiné avec des travaux agricoles et autres permettra de remettre en valeur les tourbières.

Forestación de Turberas

En este estudio se describe la forestación de suelos orgánicos (de más de 12 pulgadas de profundidad) donde hay espesa vegetación de *Trichophoretum* (*Scirpetum*) y de *Eriophoretum*. Las plantaciones experimentales, a base de intenso trabajo manual de desagüe y escarificación, han alcanzado la altura de pértiga, y las nuevas plantaciones se hacen con la ayuda de arados de diseño especial tirados por tractores corrientes provisto de llantas anchas. Las especies de *Pinus contorta* y *Pinus sylvestris* han resultado las más apropiadas. Es esencial abonarlas con fosfato en el momento de plantarlas. Los abonos repetidos con fosfato pueden ser convenientes, lo mismo que agregar potasa. Hasta el momento no se ha encontrado que el suelo carezca de otros elementos.

El examen de las demás turberas de musgo indica que la forestación puede efectuarse en cualquier lugar donde las condiciones climáticas sean similares. Puede preverse el problema de que el viento descuaje los árboles cuando lleguen a la madurez, debido a que sus raíces se ven restringidas por la aradura profunda en surcos muy próximos pero no se ha presentado todavía y quizás no sea más grave que en suelos minerales impenetrables donde se practica una aradura similar.

Aunque no todos los problemas están ya resueltos, se han logrado plantaciones que han alcanzado la altura de pértiga y se espera que esa forestación, con la agricultura y otras actividades, contribuya a rehabilitar las turberas.

Peatland Afforestation Techniques in Northern Ireland

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The purpose of this paper is to present an overall picture of the afforestation techniques applied to deep peat in Northern Ireland, where most of the land available for afforestation is medium elevation peatland. This is ombrogenous or climatically formed peat which is relatively infertile. The terms "blanket bog" and "terrain covering bog" are particularly apt descriptions, for they convey the impression of whole mountain slopes and plateaux covered with a peat layer varying in depth from one to twenty feet and reflecting to a great degree the topography of the mineral substrata. The uniformity of this scene is broken only by rock outcrops, streams and lakes.

Afforestation techniques can best be described with reference to ideal conditions, and in this paper these physical irregularities are ignored. It falls to the skill of the efficient forester to modify the ideal prescription to suit his own particular problem.

A common characteristic of blanket bog is its extreme fluidity once the surface vegetation has been broken. In some areas it is possible to push a ten-foot pole out of sight with one hand, and workers frequently strap boards to their feet for support while draining.

With this description of typical blanket bog in mind, the sequence of operations used to convert raw peatland into productive forest are described, together with the reasons for carrying them out.

In Northern Ireland only a few areas of forest on deep peat are past the pole stage, and it is therefore difficult to forecast the reaction of extensive and exposed areas to wind. However, from experience on mineral soil and shallow peat it is possible that windblow will present a major problem, principally because of the shallow rooting habit of the species used and the poor root-holding characteristics of the peat. In the past, little attention was paid to road location during plantation establishment, and large areas were planted without a proper road system. Subsequent cutting of roads prior to thinning has led to windblow resulting from the exposure of unstable stand edges.

It is now standard practice, however, to prepare at the outset a combined drainage, road and extraction plan, the roads and extraction routes being left unplanted. In this way not only is the forest made more windfirm, but the drainage system is designed to minimise road construction costs as a result of savings on bridges and culverts. Another important factor in drain planning is the possibility of scouring or drainage erosion occurring. It is common practice in Northern Ireland to cut main drains through the peat to the underlying soil. Some soil types, particularly boulder till, scour easily and collapse of the drain sides can result. Drains must therefore be planned to control the rate of runoff and thereby minimise the chance of erosion.

For management purposes the newly established forests are divided into blocks or "compartments" averaging 25 acres. Uniformity of shape or size is not an objective, but limits of 15 and 40 acres are laid down and the divisions made as follows.

According to the layout plan, roadlines are laid out first, then follows a system of rides, which with the roads, form the compartment boundaries and are left unplanted. Most rides form a network of secondary extraction routes and therefore must be negotiable. Some, however, are planned along natural firebreaks, but here again, they are aligned where possible to make them accessible to traffic.

Within each compartment additional unplanted strips called racks are left. These are 15 feet wide and normally situated at 600 feet intervals, thus leaving a maximum extraction distance of 300 feet from stump to rack. This layout system takes some ground out of tree production but serves as an insurance against wind damage.

When all roads and rides have been indicated on the ground by survey pegs, their outlines are marked permanently with deep plough furrows and the compartments are thus defined. These furrows, together with cut-off drains, form the basis of the main drainage system of the area. The cut-off drains are constructed along the upper boundary of the planting area to trap all inflowing water.

Additional widely spaced drains are then constructed across the slope and these usually coincide with the position of the racks, running parallel to them and emptying into the main drainage system.

The initial drainage carried out on an area prior to afforestation is termed "predraining." This operation gradually lowers the water table of the area and makes it more favourable for tree growth. The period elapsing between predraining and planting varies with the wetness of the area. In relatively dry areas it may precede it by only a few weeks, and in wet areas by as much as 5 years.

The effectiveness of this early drainage in lowering the water table and producing aeration of the surface peat is indicated by a general consolidation of the surface and an improvement in the vegetation types.

Predrainage ploughing is carried out by caterpillar tractors specially developed from standard agricultural models. Both wheeled and standard tracked tractors have in the past proved inefficient on peat, and more time was spent extricating them than ploughing. The standard machine currently in use is a modified Fordson County tractor with 30-inch tracks, having a draw-bar pull of 5,000 pounds and a ground pressure of 2.5 pounds per square inch. A semi-amphibious Cuthbertson Water Buffalo, also having a ground pressure of 2.5 pounds per square inch, has been used successfully, but its draw-bar pull of 15,000 lb. is in excess of the amount needed for ploughing. It is gradually being superseded by the smaller machine.

The drainage ploughs, which are large, modified versions of former agricultural ploughs, are fitted with wide wheels to bring their peat-crossing abilities to the standard of the tractors. Cuthbertson hill drainage ploughs are now in general use, and their main feature is a mechanism which ensures an even bottom to the drain, irrespective of surface undulations. This makes it possible to plough effective, free running drains up to a depth of 30 inches, through soft peat. Single-furrow 30-inch ploughs are standard for predraining, but subsequent draining, which will be described later, is done by a double-furrow version of the same plough. The double- and single-furrow attachments are interchangeable on the same carriage, which makes the unit extremely versatile.

After a short drying-out period, the 30-inch predrains may be further deepened by hand and in very wet areas considerably widened to prevent closing due to peat flow.

When it is considered that the predraining has had time to take effect, the planting area is ploughed at 10-foot intervals using a double-furrow implement which turns out peat ridges or ribbons from 4 to 12 inches thick at 5-foot spacing, on top of which the trees are planted. These planting ridges are ploughed, as far as possible, at right angles to the extraction racks, thereby enabling eventual extraction to take place along the rows onto the racks, thus eliminating the necessity of crossing the irregular surface caused by the ploughing. All the shallow drains so produced are connected into the main drainage network.

The time lag between this final ploughing and planting is dependent on the drying effect of the predraining. In areas with a relatively high water table ploughing should precede planting by as much as a year, but in drier areas if it precedes it by a season or even a few weeks it is sufficient.

Before discussing planting techniques the problem of road construction is worthy of mention. Many of the peatland areas now being afforested are remote from existing roads, and a road system into and through the planting area is necessary to make it accessible to men, machines and planting material. However, only the minimum road length required for these purposes and also for forest maintenance and fire fighting is constructed at the time of planting. The remainder of the system is constructed just prior to first thinning.

During the predraining period the road sites will dry out considerably and the peat will compact. Due, however, to the instability of the peat, special construction methods have to be used. In very soft areas roads are sometimes rafted over the peat on a raft of poles. These poles will last indefinitely so long as they are covered, especially at their ends, with peat or other spoil.

Low-cost, durable roads have been constructed over the past number of years using a 10- to 15-inch layer of compacted gravel laid directly on the peat. Irrespective of the construction method or material used, one basic principle must always be observed: that the surface layer of vegetation must not be removed unless absolutely necessary. When it has been removed or disturbed, some form of vegetational matting must be laid on the soft peat surface; otherwise, parts of the road will gradually disappear.

Sitka spruce (*Picea sitchensis*) and lodgepole pine (*Pinus contorta*) have proved the most promising species on peatland, both being planted in pure stands. The lodgepole pine is usually confined to the least fertile areas.

Late March is the normal time for planting on exposed areas. Planting can be done earlier where conditions are less severe, but losses due to exposure are minimised by postponing planting time to just before the commencement of growth. Two- or three-year-old nursery stock with good roots is recommended, and a survival rate of 90% is common. The normal planting distance is 5 feet x 5 feet, although closer spacing of 4½ feet x 4½ feet may be desirable on areas having a heavy vegetation. Planting espacement is partly controlled by the distances between the peat ridges which is, in turn, dependent upon the width of the plough and the tracks of the tractor.

A special semi-circular spade is used for planting, and with this tool a peat plug 4 inches in diameter and 9 inches long is removed from the peat ribbon and the plant inserted in the resulting hole so that the root tips reach the double layer of vegetation produced by the inverting of the ridge. The plug is then broken up and replaced around the plant. When planting on the thick ridges thrown up from the main drains, a triangular step is cut from the ridge which allows the roots to reach the vegetation layer. When this step is cut on the leeward side of the ridge the newly planted trees are provided with valuable shelter during the first season.

As a further precaution against windblow damage, no planting is done within 5 feet of main drains so that the trees may develop a windfirm root system unrestricted by the drain.

On the poorer type peat a phosphatic fertilizer is applied at the time of planting, and experiments have shown that 2 ounces of basic slag per tree give better results than other forms of phosphate. This gives the trees an initial boost, but the effect is sometimes not long lasting.

As the surface peat dries out following this intensive draining, the heather (*Calluna vulgaris*), which is invariably present as a constituent of peat vegetation, becomes increasingly vigorous. Two to three years after planting a critical period in the establishment of the young trees occurs, when frequently, the vigorous heather successfully competes with the young trees for the limited available nutrients, causing the latter to turn an unhealthy yellow colour and to appreciably slow down in growth rate (a condition described locally as being "in check"). The exact cause of this "checking" is not known, but experiments suggest that the young trees are suffering from nitrogen starvation probably due to the more efficient take-up of this element by the heather. A number of remedies for the trouble have been discovered, and these include removing the heather, spreading peat from drain deepenings around the base of the young trees, mulching with cut vegetation and applying various types of nitrogen-containing fertilizers; of the latter, organic nitrogenous manures are particularly effective. Many of these treatments are expensive, however, and experiments are continuing to discover the most effective and economic method of preventing this "check" period of the trees. Once the young trees have been given the extra boost to take them through the critical "check" period, the shade cast by the side branches is sufficient to reduce the vigour of the light-demanding heather and to eventually kill it out, and the tree plantations develop without further check.

It will be seen that some aspects of peatland afforestation are beyond the experimental stage. The Northern Ireland Forestry Division is confident that the system of forest layout, draining and planting described will prove successful and that windblow, which is the principal hazard of healthy, developing plantations, can be controlled, at least over a short rotation. The problems of plant check and fertilization are being tackled, and present evidence suggests that successful establishment and subsequent growth of valuable forest stands may be expected on these semi-derelict, peat-covered moorland areas in Northern Ireland.

RESUMES

Les techniques de boisement utilisées en Irlande du Nord dans les sols tourbeaux

La présente communication donne une brève description des "marécages couvertures" (blanket bog) qui couvrent la majeure partie des plus hautes terres en Irlande du Nord et fournissent une proportion élevée du terrain propre au boisement. En prévision de la plantation de ces zones, la disposition des canalisations de drainage et des futures routes et plates-formes d'extraction est prévue d'après un plan bien étudié. Les techniques de drainage comportant un "pré-drainage" suivi d'un drainage intensif de surface grâce au labourage sont également décrites. Des charrues et des tracteurs chenillés spécialement adaptés permettent la mécanisation de ces travaux de drainage. La construction de routes sur la tourbe est importante et présente des difficultés. Pour établir des forêts en tourbe profonde, le problème essentiel est d'éviter un retard de croissance chez les jeunes arbres, dû à l'absorption concurrentielle par les bruyères de la quantité limitée d'azote assimilable; mais les travaux expérimentaux semblent indiquer que l'on peut remédier à ce problème. Il peut arriver que les peuplements plus anciens établis en tourbe profonde résistent mal aux vents, et différentes méthodes d'aménagement sont employées afin de réduire ce risque.

Técnicas de Forestación de Turberas en el Norte de Irlanda

En este estudio se describen brevemente los pantanos típicos que cubren gran parte de las tierras altas del norte de Irlanda y que ocupan una elevada proporción de terrenos disponibles para forestación. Para la preparación de la siembra en estas regiones debe seguirse un plan cuidadosamente preparado que disponga los principales canales de desagüe y fajas y caminos para las extracciones futuras. También se describe la técnica de desagüe que comprende un "predesagüe" preliminar seguido de intenso avenamiento de la superficie por medio del arado. Este trabajo de desagüe se ha mecanizado gracias a tractores y arados especiales. La construcción de caminos en las turberas es importante y presenta problemas difíciles. El problema principal es el que plantea la siembra de árboles en las turberas profundas y que consiste en restringir el desarrollo prematuro causado aparentemente por los arbustos de brezo en su afán de absorber el limitado nitrógeno disponible, pero los trabajos experimentales indican que este problema se puede vencer. La inclinación y descuaje de árboles por la fuerza del viento es otro problema que bien pueden experimentar las plantaciones más viejas en turberas profundas. Se emplean varias técnicas para disminuir este riesgo.

Reclamation of Lands Stripped By the Opencut Method of Coal Production

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The early pioneers, scratching under the ledges and out-croppings for fuel, were the first surface coal miners. Around 1910 a crude and laborious process of strip mining was instigated by use of teams and road scrapers. Since that time the urgent demands for coal due to economic development and national crises have resulted in the evolvement of highly mechanized machinery for the production of coal by the open-cut method. The largest mobile machines on earth are now used to strip off the overburden to get to the seams of coal underneath.

There are several multi-million-dollar shovels in use today, with dippers that will scoop out sixty-five cubic yards of earth and rubble. Now being built for the Peabody Coal Company in western Kentucky is a stripping shovel that stands 20 stories high and has a dipper capacity of 115 cubic yards. Surface mining is still an expanding industry and now accounts for one quarter of the national coal production.

Strip mining is in practice in 23 States of the United States of America but is more prevalent in the coal fields of the Ohio River Valley. With its rapid growth, and the unsightly scars left by some of the early operators, it is not surprising that public concern was given material form in State legislation, starting in the 1930's. Laws in Ohio, Indiana, Kentucky, Pennsylvania, and West Virginia provide for a bond of a specified amount per acre to be forfeited by the operator upon failure to reclaim the abandoned site within a given period of time after stripping.

Many coal operators in the various States voluntarily formed associations with the rehabilitation of strip banks as one of their chief aims. Their close cooperation with the Central States Forest Experiment Station of the United States Forest Service and with other governmental agencies has resulted in the knowledge being used at this time for the most effective restoration of stripped lands. Despite the very real contribution made towards reclamation by the majority of the coal operators, there is agitation for more and more stringent laws, and for Federal investigation. Since less than 1% of the total land area in each State where strip mining is practiced is affected, or ever will be affected, the consensus is that there is no real need for Federal legislation, and the matter should be left to local option (Schoewe, Walter H., American Mining Congress).

Strip-mined land, like other areas of land, varies greatly in the characteristics which determine its greatest potential. The overburden is composed of two or more rock strata differing in hardness, texture, thickness, and chemical content. As accessory minerals in some coal mining operations marcasite and pyrite are widespread, and they probably represent the principal ultimate source of coal mine acid. When exposed to the air, sulfuric acid (H_2SO_4) and ferrous sulfate ($Fe\ SO_4$), sulfates of aluminum, manganese, and others, are formed, thereby causing highly acidic or toxic conditions. Acid banks (so designated if more than 50% of the surface consists of acid-producing sulfides) are one of the most vexing problems confronting reclamation of the stripped areas. It is not always possible to ascertain the occurrence of acid-forming materials in the overburden. At one time it may be found finely dispersed and invisible to the naked eye, and at other times in a large size range of single crystal and crystal aggregate. In time these highly acid or toxic compounds leach out, and the overburden may become suitable for plant growth. It is desirable that coal operators do their utmost to minimize or prevent acid formation by covering or otherwise disposing of waste coal products (2)*.

Calcareous banks are so designated if more than 50% of the surface area has a pH of 7.0 or more. Some of these areas can be restored to farming, but extremely few acres will be suitable for cultivated crops. There are a few farms established on stripped lands in Illinois and, to a lesser extent, in Indiana, Ohio, Pennsylvania, and West Virginia. Many of the banks are rich in mineral elements essential to plant growth, with the exception of nitrogen. Cattle, if given a choice, will invariably graze on reclaimed banks in preference to old fields(6).

Mixed banks generally predominate and consist of patches of toxic, acid, and calcareous areas. Variations in the hardness, texture, and thickness is generally to be found. Some strata are sandy, some loamy, and some clayey. Some contain hard, massive rocks, others are soft and poorly cemented, and disintegration is rapid. All the materials are frequently so mixed that the surfaces may vary from spot to spot in any given area.

It is most important in planning reclamation in any area to study and test the overburden, the topography, and the climate. In States where grading the banks to a gently rolling topography is mandatory, special emphasis must be given to a careful selection of humus and nitrogen-producing legumes. In other areas, grading the strip banks is not always feasible or wise. If left ungraded where the overburden is more or less acid and consists of rubble, mantle-rock, and regolith, the stone on the bank

* Numbers in parentheses denote the references listed at the end of this paper.

Table 1. Principal grasses and legumes used for seeding for forage crops in strip mine reclamation

Botanical Name	Common Name	Acidity Range (pH)	Remarks
Agrostis alba	Redtop	5.0–6.0	Successful in ravines in mixtures
Bromus inermis	Smooth brome	6.0–8.0	Wildlife food—cover and forage
Coronilla varia	Crownvetch	5.5–7.5	Steep banks. Erosion control
Dactylis glomerata	Orchardgrass	6.0–8.0	Use in mixture. Hardy
Festuca elatior	Ky. 31 fescue	5.5–7.5	Cool season grass, acid tolerant
Lespedeza cuneata	Chinese lespedeza	4.5–6.5	Profuse cover for wildlife
Lespedeza stipulacea	Korean lespedeza	4.5–6.5	Good forage, seed good quail food
Lolium perenne	Perennial ryegrass	6.0–7.0	Quick cover. Cool season grass
Lotus corniculatus	Birdsfoot trefoil	6.0–7.2	Long lived. Cannot withstand severe competition
Medicago sativa	Alfalfa	6.5–7.5	Very good pasture. In mixture with other grasses and legumes
Melilotus alba	Sweetclover	6.5–7.5	Good wildlife food-cover, forage
Poa pratensis	Bluegrass	6.5–7.5	In mixtures with legumes. Good pasture fall and spring
Pueraria thunbergiana	Kudzu (a vine)	5.5–7.5	Erosion control. Not to be planted near trees

surfaces reduces erosion from raindrop splash. Tests have shown that the infiltration and percolation rates on ungraded banks are sometimes four times greater than those on graded banks. Compaction of the surface materials caused by use of heavy machinery in levelling the banks reduces aeration and leaves a hardpan surface where rainfall is not absorbed and erosion begins (4).

Aside from the aesthetic value, the need for grading is influenced by climate and the intended land use. In some areas, such as Kansas, where droughts are common during the growing season, precipitation is lost through evaporation and runoff, and tree survival and growth are adversely affected by grading. Conversely, in areas where the materials have a heavy clay content, precipitation gathers in valleys and in depressions caused by unequal settling, and plantations are frequently "drowned out." As the surviving plantations grow older, the adverse effects of grading on growth become even more pronounced (4). Some operators are getting good results by striking off the ridges of the banks to provide access roads and grading only those banks that are adjacent to highways. For practical purposes of establishing a forest, or for grazing, it is not necessary to grade the banks.

The first formal experimental research plantings of various species of forest trees were made by the Central States Forest Experiment Station under the supervision of Dr. A. G. Chapman in the Nelsonville-New Straitsville strip mine areas of southeastern Ohio in 1937. Ten years later the reclamation associations in several States became actively cooperative with research projects as strip bank rehabilitation was begun on a large scale. From these plantations, as well as from study of the thousands of acres that have been restored, the science of reclamation of stripped land is becoming established.

The most widely used tree for reclamation purposes has been the black locust. This tree is valuable as a nurse crop for shade-tolerant species; as a rapid-growing humus- and nitrogen-producing legume; and as quick cover for highly erosive banks. However, as the early plantations mature, the beneficial aspects of planting black locust heavily are proving questionable. The locust borer (*Megacyllene robiniae*) is severely damaging many plantations, especially in southern Indiana, Ohio, and Illinois. Often stands that escape this damage grow so rapidly on strip banks that they overtop the associated species and develop such a closed canopy that the competition for light and moisture becomes critical, and interplanted trees die. Therefore, if it is determined that black locust is needed for quick cover to reduce erosion, or for rapid soil improvement for growth of other trees, not more than 25% black locust should be used in mixed plantings with other hardwood species (1, 3, 4).

At the present time, intensive experiments are being made with the European type alders (*Alnus incana* and *A. glutinosa*) to see if they can be used to take the place of black locust in hardwood mixtures. This tree has a wide pH range (4.5-7.5) and, although it is not a legume, it has excellent nitrogen-fixative qualities.

In addition to those listed in Table 2, several other species, such as the European and Japanese larches (*Larix decidua* and *L. koempferi* Sarg.) (4), white spruce (*Picea glauca* (Moench) Voss), black cherry (*Prunus serotina* Ehrh.) and river birch (*Betula nigra* L.) are showing promise. Direct seeding in comprehensive tests has proved generally disappointing, due mainly to drying out, erosion, and siltation, and rodent pilfering (4). Exceptions are stratified nuts of the hardy northern pecan (*Carya pecan* (Marsh.) Engl.), shagbark hickory (*Carya ovata* (Mill) K. Koch), and Chinese chestnut (*Castanea mollissima* Blume), which have met with fair success.

In selecting the species of trees to plant on stripped surfaces, the most important consideration is given to the pH range of the desired plants. Table 2 gives recommendations for species to consider for plantations. All species recommended have been planted on many areas, and studies have been made. Selection is also directly affected by the ultimate use desired by the landowner. Topography and climate must be evaluated, as well as the predominance of insects and diseases in the locality (4, p. 45). In most States, planning must be submitted to State reclamation officers and cleared before planting can begin. Last, but not least, quality stock must be acquired. Because the quality as well as the development of the stock varies greatly among nurseries, it must be judged

Table 2. Principal tree species planted on strip mined land

Botanical Name	Common Name	Acidity Range (pH)	Remarks
Acer saccharinum L.	Silver maple	4.0–8.0	Mixture of 25% black locust
Acer saccharum Marsh.	Sugar maple	4.5–8.0	Mixture with other hardwoods
Fraxinus americana L.	White ash	4.0–8.0	Mixture with other hardwoods
F. pennsylvanica Marsh.	Green ash	4.0–8.0	Mixture with other hardwoods
Juglans nigra L.	Black walnut	5.0–8.0	Stratified nuts or seedlings. All areas
Juniperus virginiana L.	Redcedar	5.0–7.0	Grow under open black locust stands
Liquidambar styraciflua L.	Sweetgum	4.5–7.5	Mixed plantings in all materials
Liriodendron tulipifera L.	Tulip-poplar	4.5–7.5	Mixed or underplanting black locust
Maclura pomifera (Raf.) Schneid.	Osage orange	4.5–8.0	Early harvest as fence posts
Picea abies (L.) Karst.	Norway spruce	5.0–6.0	Christmas trees
Pinus banksiana Lamb.	Jack pine	4.0–7.5	North of Ohio River—loose or sandy media
P. echinata Mill.	Shortleaf pine	4.0–7.5	Survival often affected by drought
P. nigra Arnold	Austrian pine	4.0–7.5	Christmas trees, wildlife cover
P. resinosa Ait.	Red pine	4.0–7.5	Northern conifer. Subject to tipmoth
P. rigida Mill.	Pitch pine	4.0–7.5	Resists tipmoth but often has poor form
P. strobus L.	White pine	4.0–7.5	Recommended for compact loams and clays
P. sylvestris L.	Scotch pine	4.0–7.5	Early harvest for Christmas trees
P. taeda L.	Loblolly pine	4.0–7.5	Southern conifer. Fast growing. Good form
P. virginiana Mill.	Virginia pine	4.0–7.5	Subject to tipmoth (*Rhyacionia* spp.)
Platanus occidentalis L.	Sycamore	4.0–8.0	Large-scale plantings in pure stands
Populus deltoides Bartr.	Cottonwood	5.0–8.0	Fast-growing, all areas. Pure stands
Quercus alba L.	White oak	5.0–6.5	Plant in mixture 25-50% black locust
Q. prinus L.	Chestnut oak	4.0–7.5	In silty clay; mix with other hardwoods
Q. rubra L.	Northern red oak	4.0–7.5	In well drained areas, hardwood mixtures
Robinia pseudoacacia L.	Black locust	4.0–8.0	All areas. Valuable legume
Taxodium distichum (L.) Rich.	Baldcypress	5.5–6.5	Subject to bagworms. Has straight stems

mainly on the basis of size, balance, and condition. Stock-grading standards should be simple and easily applied. If it is found that 80% of the stock meets the grading requirements, further grading is generally unnecessary (4).

It is doubtful if any method of planting will ever completely replace hand planting. Planting machines are used to a limited extent on graded banks, but in general stripped land cannot be planted by machine. Slit planting with a planting bar is the fastest and most common method. In places where the ground is extremely stony or compact, it may be necessary to use a mattock. Planting crews of 8 to 10 men, with a trained foreman, are recommended. Spacing is controversial among reclamationists, and varies from site to site. In general, spacing should be wide enough to postpone thinning until mer-

Table 3. Reclamation of strip mined areas in the principal coal producing states

			Number of Acres			
State	Acres Affected	Number of Trees	Planted 1960	Trees	Grasses	Total
Kentucky	17,878 (1)	8,561,380	2,695	10,520	6,600	17,120
Illinois	90,815 (2)	15,675,555	800	14,190	14,190	50,162
Indiana	68,446	49,465,700	1,945	53,392	6,563	58,010
Ohio	109,975	29,989,125	4,900	52,023	35,891	94,208 (3)
Pennsylvania	(4)	75,724,442	(4)	62,963	12,635	75,600
West Virginia	(4)	(4)	(4)	23,729	35,594	59,323

(1) To December 31, 1959
(2) To December 31, 1958
(3) 81.2% of acres affected by strip mining has been reclaimed.
(4) Figures not available

Information is from: Kentucky Reclamation Association, John M. Crowl, Executive Director, Mid-West Coal Producers Institute, Inc.
Indiana—L. E. Sawyer, Director of Conservation
Illinois—L. S. Weber, Assistant Director of Conservation
Ohio Reclamation Association, Larry Cook, Executive Vice-President
Commonwealth of Pennsylvania, Department of Mines and Minerals Industries, Wilson H. Wheeler, Forester
State of West Virginia, Department of Mines, John G. Hall, State Agronomist

Table 4. Some additional plants recommended for wildlife food and cover.

Botanical Name	Common Name	Optimum pH Range	Remarks
Cytisis scoparius	Scotch broom	4.0–7.5	Valuable wildlife food and cover plant
Elaeagnus umbellata	Autumn olive	6.0–7.5	Bird food fall and winter
Lespedeza bicolor	Shrub lespedeza (bicolor)	4.5–7.5	Good food and cover plant
L. japonica	Shrub lespedeza (japonica)	4.5–7.5	Good food and cover plant
Lonicera tatarica	Bush honeysuckle	4.5–7.0	Game food and cover. Takes acid well
Rhus glabra	Smooth sumac	5.0–6.5	Late winter bird food, deer browse
Rosa multiflora	Multiflora rose	4.5–6.5	Sometimes spreads where not wanted
Symphoricarpos orbiculatus	Coralberry	5.0–6.5	Cover crop under black locust plantations and borders

chantable products can be obtained, and close enough to insure good form and development. Stock should be planted as soon as possible after receipt, and roots must be kept moist at all times. If it is not possible to plant immediately, then the stock should be heeled in or held in cold storage at 34° to 38° F. (4).

Restoration of strip mine lands directly affects the watershed units of the area. The Ohio River Valley Water Sanitation Commission and the Coal Industry Advisory Committee to ORSANCO are dedicated to the study of and abatement of acid mine water pollution. The greatest strides toward reducing stream pollution in the coal industry have been made by the strip mining companies (5). It has been estimated that 95% of the stripped land will eventually be restored to productive use, with propitious effect upon the streams, lakes, and rivers.

Trees, interplanted with game food and cover plants, attract and protect various small animals and birds. Pheasant (*Phasianus colchicus*) and quail (*Colinus* v. *virgineanus*) are frequently released on planted banks by the coal companies and the State Fish and Wildlife Services. Survival rates, as shown by count and by bands mailed in by sportsmen during hunting seasons, are generally good (7). Lakes and ponds created by the final cut in many of the coal operations are stocked with bluegill (*Lepomis macrochirus*), bass (*Micropterus salmoides*), and surface minnows (*Cyprinidae*), in balanced proportion, wherever the impounded waters are neutral enough to support them.

Christmas trees, posts, and mine props can be produced in 5 to 15 years; small poles and pulpwood in 20 to 30 years. Sawtimber will take much longer. Growth rates will, of course, vary with conditions (4). Reclamation by forestation is creation of desirable multiple land use. From habitat for wildlife, to post and mine props, to pulp and sawtimber; with the land in simultaneous use for recreation by the fisherman, the hunter, and the naturalist: This is nature's cycle that is re-created by the reclamationist who plants the raw and denuded barren land of the strip mine operation.

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RESUMES

Remise en état des terres appauvries par l'exploitation de mines de charbon à ciel ouvert

La remise en valeur de terres dévastées, quelles qu'elles soient, est un problème universel. L'exploitation des mines de charbon en bandes à ciel ouvert laisse derrière elle des terres dénudées d'un caractère particulier qui, même lorsqu'elles ressemblent à d'autres terres soumises à des programmes de mise en valeur, exigent des connaissances spéciales et une compétence technique si l'on veut les remettre en état dans les meilleures conditions possibles. L'extraction du charbon à ciel ouvert se pratique aux Etats-Unis dans 23 états, mais ce système est surtout répandu dans la Vallée de l'Ohio. C'est par cette méthode qu'est extrait un quart de la production américaine de charbon.

Au-dessus de la veine, les morts-terrains se composent de deux ou trois gisements rocheux superposés. On enlève cette couche au moyen de pelles mécaniques géantes, de câbles de traînée et de bulldozers. La pierraille ainsi produite varie quant à son contenu et à sa texture chimique. La superficie de terres ainsi appauvries, susceptible d'être remise en culture est extrêmement limitée.

Dans les travaux de remise en état des mines en bandes on cherche avant tout à rétablir la productivité de la terre tant pour les propriétaires que pour la collectivité, et à la maintenir telle. La plupart des spécialistes estiment que le boisement est certainement l'exploitation la meilleure et la plus souhaitable de ces régions dénudées.

Le principal obstacle à une bonne remise en état de ces régions est une forte teneur en acide des morts-terrains. Il est dans tous les cas nécessaire de procéder à un examen approfondi des éléments suivants:

- Utilisation des terres avoisinantes
- Etude topographique et hydrographique de l'emplacement
- Analyse chimique des morts-terrains
- Quantité relative de terre
- Texture et stabilité des morts-terrains
- Couvert végétal existant
- Conditions climatiques propices aux essences choisies
- Arbres et plantes adaptés aux caractéristiques de l'emplacement
- Quantités suffisantes de jeunes plants disponibles
- Eaux de mine captées
- Utilisation ultérieure des terrains envisagée.

Au fur et à mesure que les travaux de recherche se poursuivront et que les méthodes de plantation s'amélioreront, on prévoit que 95% des terres appauvries par l'extraction minière pourront être rendues à la production. Les travaux de remise en état ont pour but d'établir des forêts à usages multiples qui pourront être utiles en même temps qu'agréables pour les générations à venir.

Restauración de Tierras Desnudas a Causa de la Explotación del Carbón a Cielo Abierto

La restauración de todo terreno devastado constituye un problema mundial. El método de extracción a cielo abierto de mantos de carbón deja una clase particular de terrenos estériles que, aunque tengan cualidades similares a las de otras tierras, que son objeto de restauración, requieren conocimientos, pericia y práctica especiales para su rehabilitación.

La explotación a cielo abierto de mantos de carbón se practica en 23 estados de los Estados Unidos de América, pero es más común en el Valle del Río Ohio. Con este método de explotación se extrae ahora una cuarta parte de la producción de carbón de los Estados Unidos.

Los terrenos de recubrimiento que están sobre el estrato de carbón consisten en una o más capas de roca, que se quitan con gigantescas palas mecánicas, excavadoras de cuchara arrastradora y con tractores de cuchilla frontal. El ripio resultante varía en composición química y en textura. Muy pocas de las hectáreas desnudas pueden rehabilitarse para la agricultura.

El aspecto más importante de la restauración de esta clase de terrenos desnudos es el de rehabilitarlos lo más pronto posible para uso productivo de sus dueños y del público y el de mantenerlos en producción. La mayoría de los restauradores de tierras opina que la forestación es, sin duda, el uso más práctico y conveniente que se puede hacer de los terrenos devastados.

El mayor obstáculo a la restauración eficaz se presenta cuando las zonas devastadas tienen un alto contenido de ácido en las capas de recubrimiento. En todo caso, es necesario estudiar a fondo lo siguiente:

Uso de las tierras adyacentes
Análisis del sitio, incluso topografía y vertientes
Análisis químico de la capa de recubrimiento
Proporción de partículas del suelo
Textura y estabilidad de la capa de recubrimiento
Recubrimiento de tierra existente
Límites climáticos de las especies deseadas
Arboles y plantas que toleran la naturaleza del sitio
Disponibilidad de almácigas adecuadas
Aguas embalsadas del manto
Uso a que se desea dedicar la tierra.

Con la continuación de las investigaciones y el mejoramiento de los métodos de siembra, se espera restaurar al uso productivo el 95% de las tierras desnudas. El sistema o método de rehabilitación consiste en formar bosques de uso múltiple que se puedan aprovechar en forma lucrativa y que sirvan de solaz para generaciones venideras.

Registro de Ensayos y Observaciones en Plantaciones Forestales

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Durante los últimos años, se ha introducido en la República Argentina una cantidad considerable de especies exóticas de rápido crecimiento, especialmente eucaliptos, álamos y pinos, con el fin de diversificar la producción forestal en distintas zonas del país.

Los rendimientos que se obtenían con estas especies impulsaron a muchos plantadores a utilizarlas, aun sin conocer detalles sobre sus comportamientos ecológicos y modalidades propias de cada una de ellas.

Asimismo, las observaciones que se realizaban con esas especies y otras, ya sean exóticas o indígenas, muchas veces no podían compararse, por no realizarse en forma uniforme.

Era necesario entonces, por un lado, realizar nuevos ensayos para establecer el comportamiento de esas especies exóticas y su relación con el medio, a fin de determinar las zonas más adecuadas del país para cada una de ellas y cuales eran las de mayor rendimiento económico, y por otra parte, también era necesario, que los datos obtenidos de estos ensayos y de aquellos que se llevaban a cabo desde hacía algún tiempo, fuesen compilados de una manera uniforme, es decir mediante un sistema anticipadamente determinado, para que pudieran servir de comparación y poder extraer de ellos conclusiones valederas.

Es por ello que la Administración Nacional de Bosques, por intermedio de la Dirección de Investigaciones Forestales, ha confeccionado un formulario de Registro de Plantaciones Forestales, con sus instrucciones respectivas, que tiene vigencia en todo el país, y cuya utilización en la práctica ha dado buenos resultados.

El Registro comprende 8 grandes puntos, agrupándose en ellos los datos que más interesan, reseñándose a continuación los mismos, con fines informativos:

A. *Generalidades de la plantación:* se inscribe el nombre científico y vulgar de la especie registrada; la superficie de la plantación; la posición geográfica, relieve y exposición del lugar.

B. *Descripción del suelo:* se indican los factores más importantes (composición, espesor de la capa humífera, profundidad, cohesión, humedad, características externas), según escalas prefijadas. A base de estos datos, los factores climatológicos y los del lugar, se hace una clasificación provisoria de la clase de calidad del sitio, que luego se rectificará o ratificará según los resultados que se obtengan en los futuros cálculos volumétricos. Asimismo, en este capítulo se especifican los tratamientos culturales y de mejoramiento del suelo realizados, ya sea anteriores o posteriores a la plantación, anotándose la fecha y los costos.

C. *Características forestales de la plantación:* se consigna el mes y año en que fue ejecutada, el número de plantas utilizadas y edad de las mismas, método y forma de cultivo, número de fallas, fecha y cantidad de plantas repuestas, procedencia de las semillas y/o plantas, y calidad según porciento de germinación o arraigo. También se indica el método de beneficio y la composición de la masa arbórea.

D. *Costo de implantación:* dado por adquisición de semillas y/o plantas, recolección de semillas, producción de plantas y ejecución de la plantación.

E. *Tratamientos silviculturales realizados:* se anotan cronológicamente, con sus costos.

F. *Datos volumétricos:* cuando se trate de especies de rápido crecimiento, aprovechadas en turnos cortos, podrán compilarse desde el nacimiento de la plantación hasta su corta final. Si dichos datos se determinan y registran cada 5 años se estará en condiciones de confeccionar la tabla alsométrica local. Para especies de turnos largos, ese lapso es de 10 años. De esta manera, uniformando la obtención de los datos volumétricos a la misma edad, podrán éstos luego servir para realizar estudios dasocráticos comparativos.

Estos datos se discriminan, según correspondan a:

1. Masa arbórea principal e incrementos;
2. Masa arbórea intermedia (raleos); y
3. Masa arbórea total y sus incrementos.

G. *Factores climáticos:* se insertan los datos de la Estación Meteorológica más próxima a la plantación, y expresados como término medio de un período bastante amplio.

H. *Crónica de la plantación y observaciones:* se detallan todos los factores que incidan sobre la plantación, como ser: plagas, incendios, heladas extraordinarias, sequías, granizos perjudiciales, etc., con sus consecuencias (resistencia), y forma de contrarrestarlos. Se inscriben también observaciones de carácter económico y cultural, por ejemplo, estado sanitario, necesidad de realizar raleos y podas, recopilación de datos fenológicos y toda otra observación que resulte de interés a juicio de quien realiza el registro.

Las poblaciones forestales sobre las cuales se obtienen estos datos se encuentran ubicadas en los Establecimientos que la Administración Nacional de Bosques posée en distintos lugares del país y en cualquier otro bosque o plantación, ya sea fiscal o particular, de importancia económica o científica, cuyo desarrollo y estado forestal satisfaga las finalidades del Registro.

De esta manera se espera llegar a conocer los rendimientos anuales de distintas especies en formaciones naturales o artificiales, como asimismo determinar los valores y renta del suelo y vuelo y en base a ellos establecer los turnos financieros de mayor renta. Se podrá determinar también los métodos de beneficio, de cortas y de reforestación más apropiados para cada especie según finalidades de la economía forestal.

Sería muy conveniente que todos los países miembros de la FAO, utilizasen un formulario uniforme, para registrar los datos obtenidos en sus investigaciones forestales, pudiendo servir de base orientadora el que aquí se comenta.

De esta manera, el intercambio internacional de datos será eficaz, ya que podrán ser fácilmente comparados, lo que no sucede en la actualidad al emplear cada país distinto método o sistema de compilación.

Los datos y experiencias recogidos en un país sobre cultivo y plantación de bosques artificiales, pueden ayudar mucho a otros países, máxime teniendo en cuenta que la producción rápida de madera es de importancia mundial, y por lo tanto, la colaboración internacional y la ayuda mutua en la actividad forestal resulta de interés general.

RESUMES

Register of Experiments and Observations in Forest Plantations

In recent years many rapidly growing exotic species have been introduced into the Argentine Republic, which, on account of their satisfactory yield, prompted many planters to utilize them without knowing much about their ecological behavior.

That caused the National Forestry Administration to schedule a series of experiments in order to determine which of those species yielded the best return from an economic standpoint, and what areas of the country were most suitable for them. In order to be able to compare the data obtained from these experiments with results from others that were carried out some time ago with native and exotic species, it was necessary to have a single form in order to standardize the compilation of such data.

With this in view, the National Forestry Administration, through the Office of the Director of Forest Research, set up a Register of Forest Plantations [Form], with its pertinent instructions, which is in use throughout the country, utilization of which has given good results in practice.

This Register brings together under eight headings the essential information, in the following form:

A. General data concerning the plantation;
B. Description of the soil and treatments to improve it;
C. Characteristics of the plantation from a forestry standpoint;
D. Planting costs;
E. Silvicultural treatments applied;
F. Volumetric data
   1. Principal stand of trees and increments,
   2. Intermediate stand of trees (thin-outs),
   3. Total stand of trees and its increments;
G. Climatic factors;
H. Chronological record of the plantation and observations.

It would be most advantageous for all countries that are members of the FAO to utilize a standard form for recording data obtained in their forest research, and the form discussed here can serve as a basis for guidance so that the exchange of data on an international level may be more effective, in view of their being comparable.

Registre des essais et des observations de plantations forestières

Au cours de ces dernières années, on a introduit dans la République argentine de nombreuses espèces à croissance rapide. Les bons rendements de ces espèces ont encouragé de nombreux planteurs à les utiliser, sans en bien connaître le comportement écologique.

C'est ce qui a motivé l'institution, par l'Administration nationale des Forêts, d'une série d'essais à l'effet de déterminer quelles étaient, parmi ces espèces, celles dont le rendement était le meilleur du point de vue économique, et quelles étaient les régions du pays qui leur convenaient le mieux. Pour pouvoir comparer les données résultant de ces expériences, aussi bien que de celles auxquelles on se livrait depuis longtemps sur des espèces tant indigènes qu'exotiques, il est nécessaire que nous ayons à notre disposition un formulaire unique, afin d'uniformiser la compilation de ces données.

Dans ce but, l'Administration nationale des Forêts a fait préparer par la Direction des Recherches forestières un Registre des Plantations forestières, accompagné d'instructions y afférentes, qui est utilisé dans le pays tout entier, et dont l'emploi a donné de bons résultats dans la pratique.

Ce Registre réunit les renseignements indispensables dans huit chapitres, présentés de la façon suivante:

A. Généralités concernant la plantation;
B. Description du sol et traitements destinés à l'améliorer;
C. Caractéristiques de la plantation du point de vue forestier;
D. Coûts relatifs à l'implantation;
E. Traitements sylvicoles réalisés;
F. Renseignements volumétriques
   1. Peuplement principal et accroissements,
   2. Peuplement intermédiaire (éclaircies),
   3. Volume total et son accroissement;
G. Facteurs climatiques;
H. Historique de la plantation et observations.

Il serait bon que tous les pays membres de la FAO se servent d'une formule unique pour enregistrer les données obtenues grâce à la recherche forestière, contenant les renseignements ci-dessus, pour que les informations ainsi fournies sur des bases comparables puissent permettre des échanges internationaux de données plus efficaces.

Le reboisement des terrains dénudés en Grèce

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La Grèce, pays montagneux, était couverte autrefois par de vastes forêts. Les invasions multiples, l'occupation de la Grèce pendant de longues périodes, ainsi que le parcours nomade du bétail—imposé par les guerres, par l'ambiance climatique défavorable et surtout par la sécheresse estivale—ont provoqué la destruction systématique des ses forêts. Pendant la dernière guerre mondiale 25% des forêts grecques ont été dévastées.

C'est ainsi qu'aujourd'hui les forêts ne couvrent plus qu'une surface bien réduite, comme on le voit dans le tableau suivant (3):*

Répartition actuelle des modes d'utilisation des terres

	Hectares	%
1. Superficie des terres arables	2.762.000	20.9
2. Superficie des terres arboricoles	753.000	5.7
3. Forêts	1.958.000	14.8
4. Pâturages montagneux et semi-montagneux	5.209.400	39.4
5. Superficie non productive	2.312.800	17.4
6. Superficie en agglomérations, routes, etc.	261.000	2.0
Total	13.256.200	100.0

Une grande partie des montagnes et des collines, à vocation nettement forestière, se montant à 24,5% de la superficie totale du pays, doit être reboisée pour: 1) subvenir aux besoins en bois de la population, étant donné qu'on importe chaque année 700.000 m.c. de bois d'oeuvre, de pâte à papier, etc.; 2) mettre en valeur ces terres en friche par la forêt; et 3) corriger environ 500 torrents destructifs ainsi que pour conserver le sol et les ressources d'eau. J'estime (3) d'autre part qu'on devrait planter aussi au moins 20.000.000 de plants de peupliers euraméricains.

On n'a pu reboiser jusqu'à présent que 0,38% de la superficie du pays, soit 50.000 ha. dont la plupart se trouve dans le bassin de réception des torrents, et on n'a planté que 2.000.000 environ de plants de peuplier—pourcentage minime de la surface à reboiser. Cela provient du fait qu'on doit employer des méthodes de reboisement, surtout de plantation, très coûteuses pour surmonter les nombreux obstacles au reboisement, tels que le parcours du bétail (qui impose d'entourer de clôtures les surfaces à reboiser), la sécheresse excessive, les hautes températures de la surface du sol, les basses températures des régions de haute montagne, le manque de compréhension de la population pour l'importance des forêts, le manque de moyens financiers, etc.

* Les chiffres entre parenthèses indiquent les références notées à la fin du présent article.

Je me bornerai ci-après à mettre l'accent sur les obstacles essentiels (intéressant probablement aussi d'autres pays) pour maintenir l'exposé dans les limites fixées par le Congrès.

Le plus grand obstacle est la sécheresse excessive pendant l'été; elle se présente dans plusieurs stations à partir des forêts xérothermophiles méditerranéennes, à feuilles persistantes (Oleeto-ceratonion), jusqu'à celle des forêts mésophiles (Fagion). Nous avons pu constater que l'humidité du sol a baissé en dessous du point de flétrissement permanent à une profondeur de plus de 0,55 m.: 1) dans la station de la chênaie kermès, à pistacier térébinthe aux environs de Thessalonique, pendant 45 jours en été (2); et 2) dans les vides des sapinières à sanicule d'Europe sur la montagne Pindos (à Pertouli), pendant 20 jours en été. Le résultat fut que presque tous les plants de *Pinus brutia* et *Pinus halepensis* dans le premier cas et 50% des plants du *Pinus nigra* var. *pallasiana* dans le second cas ont été desséchés parce que leurs racines ne s'enfonçaient pas plus profondément que le niveau du point de flétrissement permanent.

Planter ou semer des essences ligneuses dans les régions où la racine des plants ne pénètre pas plus profondément que le niveau du point de flétrissement permanent du sol paraît être un travail inutile et dispendieux, provoquant une perte du temps, et des déceptions, bien que quelques plants puissent survivre un certain temps en tombant dans un état de vie latente (2).

Pour assurer autant que possible la réussite du reboisement de ces terrains dénudés, on fait alors une étude détaillée pendant la préparation du plan du reboisement d'un périmètre étendu. On exécute, à titre d'essai, dans tous les points caractéristiques du périmètre à reboiser, des labours du sol selon différentes méthodes et on plante et on sème les essences choisies pour le reboisement. On mesure, d'une part, la profondeur du sol où son humidité baisse au point de flétrissement permanent, et d'autre part, la profondeur du sol à laquelle pénètrent les racines des plants des espèces choisies dans la région donnée pendant l'époque critique de l'été. Tout cela peut se faire d'après des procédés exposés par ailleurs (2).

En comparant les résultats de cette étude, on peut rationaliser autant que possible le reboisement et préparer des plans adaptés aux microambiances d'un territoire, souvent très variées.

On est alors en mesure de:

1. Choisir le semis, la plantation et le mode de labour garantissant une pénétration progressive des racines au moins jusqu'à la profondeur du point de flétrissement permanent.
2. Adapter aux différents endroits la longueur de la

racine et la profondeur des trous de plantation, de telle sorte que les racines des plants atteignent le niveau du point de flétrissement permanent avant l'époque critique de l'été.

3. Préciser la méthode de plantation, plantation basse ou plantation au niveau du sol, de manière à assurer la pénétration de la racine des plants au moins jusqu'au niveau du point de flétrissement.

4. Distribuer sur le terrain à reboiser les essences choisies suivant la longueur de leurs racines en été et la profondeur du point de flétrissement.

5. Indiquer enfin les mesures spéciales propres à sauver les plants, telles que l'extraction de la flore antagoniste, binages ou encore arrosage, si possible. Dans ce dernier cas, on pourra aussi déterminer la quantité d'eau.

Il serait également utile de déterminer sil n'existe pas de moyens pour faire pénétrer les racines des plants à une profondeur plus grande que d'ordinaire et pour ne pas laisser baisser le point de flétrissement permanent aussi profondément dans le sol.

Pour satisfaire autant que possible à ces deux exigences on prend les mesures suivantes: 1) On utilise des semences (des espèces choisies) qui ont des dimensions plus grandes que la moyenne, et le plus grand pourcentage de germination. On utilise aussi des plants de conifères, dont la racine est en général plus grande que la cime (p.ex. racine 25-30 cm. et cime 15 cm.); 2) On sème, ou on plante le plus tôt possible, soit en automne, soit au printemps selon les ambiances concrètes, afin que les racines des plants disposent d'un plus long temps pour croître jusqu'à l'époque critique; et 3) Quant aux plantations, plus spécialement, on plante à l'époque pendant laquelle les racines des plants peuvent s'accroître immédiatement après leur mise en place.

Si les racines des plants de conifères à planter acquièrent à la pépinière, jusqu'à l'époque de leur extraction, une longueur beaucoup plus grande que la profondeur du trou (soit 40-70 cm. longueur de racines et soit 20-30 cm. profondeur du trou) on sectionne ces racines des plants (surtout de *Pinus brutia* et *Pinus halepensis*) en pépinière, in situ, quelques semaines avant leur plantation, à la longueur qu'elles doivent avoir pendant la plantation (soit 25 cm.). On extrait et on met en place ces plants sectionnés lorsque les racines commencent à émettre des racines secondaires (extrémités blanches) au bout sectionné. L'enracinement de ces plants, qu'on appelle "plants préparés" a lieu immédiatement après leur plantation, et en tout cas à peu près 25-90 jours avant l'enracinement des plants non traités (4). Ainsi, les plants "préparés" produisent jusqu'à l'époque critique une racine d'environ 20 cm. plus longue que celle des plants non traités.

D'autres méthodes pour renforcer l'accroissement des racines consistent à utiliser des phytohormones, mais les résultats obtenus ne sont pas satisfaisants.

On utilise, en général, surtout dans les stations sèches, la plantation en trous ayant une profondeur de 30-35 cm. et un diamètre de 20-25 cm. Aussi, on plante des plants en pots de plastic.

Les moyens qu'on emploie pour que le point de flétrissement ne baisse pas à une grande profondeur du sol, sont d'une part; ceux qui consistent à emmagasiner l'eau dans le sol et d'autre part, ceux qui empêchent son évaporation intensive ainsi que la transpiration par les végétaux avoisinant les plants.

Pour l'emmagasinage de l'eau: 1) Les surfaces des potets et des banquettes sur lesquelles on sème, ainsi que les surfaces des potets après la plantation, sont formées en pente vers l'amont; 2) En amont de chaque bande (d'une largeur 1-2 m.) qui suit le long des courbes du niveau et sur laquelle on sème, on ouvre un fossé pareillement orienté. Ces fossés de conservation de l'eau ont été préconisés déjà par notre philosophe Platon; et 3) En amont des potets de plantation on ouvre deux petits sillons, qui recueillent l'eau et la conduisent dans le trou de conservation. Ce dernier se forme après la plantation de chaque plant (profondeur 10 cm., diamètre 30-40 cm.).

Pour empêcher l'évaporation de l'eau du sol ainsi que la forte transpiration des végétaux avoisinants les plants: on laboure le sol superficiellement (10-12 cm.); on extrait les végétaux sur toute la surface à semer ou sur de larges bandes de 1-2 m.; on plante minutieusement sur les endroits ombragés par des souches d'arbres abattus ou par des arbrisseaux ayant des racines profondes (p.ex. par *Quercus coccifera* et non par *Cistus*); on dépose des pierres ou des copeaux sur la surface du potet et on fait des binages superficiels, des sarclages, etc. Enfin, si tous ces moyens ne suffisent pas, on arrose avec de l'eau, qui doit imbiber le sol au moins jusqu'au fond du trou, ou encore, on utilise des espèces pionniers, qui s'installent facilement. Il est bien compréhensible qu'un choix rationnel parmis tous ces moyens ne peut pas être fait sans une étude détaillée, comme décrit ci-dessus.

En dehors de la sécheresse, les hautes températures estivales de la surface du sol et de l'air proche du sol, s'élevant jusqu'à 74° C. aux environs d'Athènes pour une température de l'air 41,9° C., et 69° C. dans les sapinières à sanicule d'Europe de la montagne Pindos, à une altitude de 1.300 m., peuvent tuer nos plants, qui se trouvent pendant l'été dans cette ambiance extrême. L'ordre de grandeur de ces températures indique la méthode de reboisement la plus propice à éviter les dangers. Si la température n'est pas trop excessive, on emploie des semis plus ou moins dense. Mais si les températures sont très élevées, on plante à l'ombrage d'arbrisseaux vivaces (ou pérennes) ou de broussailles. S'il n'en existe pas assez, on plante des plants de conifères de qualité spéciale, c.à.d. des plants ayant une hauteur de 20-25 cm., une cime conique d'un diamètre d'au moins 10 cm., une tige de diamètre supérieur de 5 millimètres et âgés au moins d'un an, pour que le plant soit assez xéromorphe (1).

Le reboisement des étendues mentionnées est une oeuvre salutaire pour la Grèce. Il exige cependant d'énormes dépenses. Le Dr. Strehlke (5) qui visita la Grèce en 1958, considère qu'il est un devoir international d'aider la Grèce à reconstituer ses forêts, étant donné que la destruction de ses forêts a été faite aussi pour sauvegarder la civilisation ancienne.

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RESUMES

Reforestation of Denuded Terrain in Greece

Greece is a montainous country. What once were vast forests have been devastated as a result of numerous invasions, occupation during long periods of warfare to defend Western civilization, etc. Therefore, its forests now cover only 14.8% of its total area.

An area of 24.5% of the country's total area, that is, more than three million hectares, must be reforested. Only .38% of that area, that is, 50,000 hectares, have been reforested! That is chiefly because reforestation is very costly, because of drought, high temperatures of the soil surface, and other adverse conditions.

It has been noted, with respect to excessive summer drought, that soil moisture drops to the permanent wilting point at a great depth for long summer periods. All reforestation plants whose roots do not penetrate beyond the wilting point level dry out. High summer temperatures at the soil surface, which reach 74° C., can also kill reforestation plants.

To rationalize reforestation in such regions, one determines in advance on characteristic sites, according to methods described elsewhere: (1) Depth of soil where soil moisture drops to permanent wilting point and surface-soil temperatures; and (2) depth of soil penetration by roots of plants of the species selected for reforestation. In comparing the results, it is necessary to select the most appropriate reforestation method: ground preparation methods (total or spot clearing, clearing in strips of terracing), seeding or planting, plants with shallow or deep root systems, deep or ground-level planting, etc.

We then discuss the methods employed to produce exceptional depth penetration of root systems and to prevent deeper wilting points.

Reforestación de Terrenos Desmontados en Grecia

Grecia es un país montañoso. Sus grandes bosques de antaño han sido devastados como resultado de múltiples invasiones y por la ocupación durante largos períodos en las guerras para salvar la civilización occidental, etc. Es por esto que los bosques no abarcan más que el 14,8% de su superficie total.

Una extensión del 24,5% de su superficie, o sea 3.000.000 de hectáreas, debe ser repoblada; y se ha repoblado tan sólo el 0,38% o sea 50.000 hectáreas. Esto se debe principalmente a que la repoblación forestal es muy costosa por la excesiva sequedad, a las temperaturas elevadas en la superficie terrestre y a otros factores adversos.

En cuanto a la excesiva sequedad estival se ha comprobado que la humedad del suelo baja a un punto de sequía permanente hasta a grandes profundidades durante una larga temporada veraniega. Todos aquellos árboles de reforestación y cuyas raíces no penetran más allá de donde llega la sequía permanente, se secan. Las altas temperaturas en la superficie del suelo que llegan a alcanzar los 74° centígrados secan también a los árboles repoblados.

Para repoblar como es debido estas zonas, hay que determinar por adelantado los lugares apropiados y, de acuerdo con métodos mencionados en el contexto, tener en cuenta los siguientes factores: (1) la profundidad del suelo, el lugar donde su humedad baja al nivel de sequía permanente y las temperaturas en la superficie del suelo; y (2) la profundidad del suelo a que llegan las raíces de las plantas de las especies que se quieran repoblar. Al comparar los resultados obtenidos, se puede escoger el método de repoblación más conveniente: la manera de preparar el suelo (en su totalidad, por partes, en fajas o terrazas), las semillas o sistema de plantación, si las plantas deben tener raíces cortas o largas, si la plantación ha de ser a profundidad o a ras de tierra, etc.

Nos referimos después a los medios que se usan para que las raíces de las plantas penetren a una profundidad mayor de lo ordinario y para que el punto de sequía no baje a gran profundidad.

Méthodes de boisement des terrains sablonneux des régions semi-arides sur des bases écologiques

EUGEN COSTIN

Roumanie

Le boisement des sables dans les régions arides et semi-arides est un problème difficile, pour la solution duquel des recherches assidues ont été faites et se font dans maints pays.

Il semblerait ne pas exister jusqu'alors de méthode d'évaluation précise des facteurs écologiques, en vue d'établir par leur connaissance exacte une technique de boisement et un type de culture des plus propice.

Ci-dessous se trouvent exposées brièvement les méthodes de recherche et les résultats obtenus en R.P.R. dans le problème de la fixation et la mise en valeur des dunes sablonneuses sur la rive roumaine de la Mer Noire, c.a.d. du "Delta du Danube," ainsi que pour le relèvement de la production du bois sur les dépressions entre les dunes et la même région.

Données naturalistes informatives sur les régions considérées

Les sables littoraux du Delta du Danube se trouvent dans une région semi-aride, avec des précipitations moyennes annuelles de 350 mm., dans certaines années de sécheresse de seulement 134 mm. (1942), avec des vents puissants et des températures élevées dans les mois d'été. La température moyenne annuelle est 11°C. et, dans les mois les plus froids, de —1,6°C. Les sables sont de nature cochilifère et ont une texture grossière. Les eaux fréatiques dans un mois d'été descendent sur les dunes au-dessous d'une profondeur de 200 cm. La végétation herbeuse est formée d'espèces de type semi-désertique avec un développement réduit à la surface du sol, mais avec un enracinement puissant sous forme de feutre dans les premiers 15 cm. du sol.

Dans ces conditions tous les essais de boisement des dunes sablonneuses faits jusqu'à présent ont échoué.

Pour établir les causes de cet échec et élaborer des méthodes de boisement, des recherches systématiques ont été faites à partir de 1956 concernant les niveaux des eaux fréatiques, l'humidité du sol, la condensation, l'évapora-

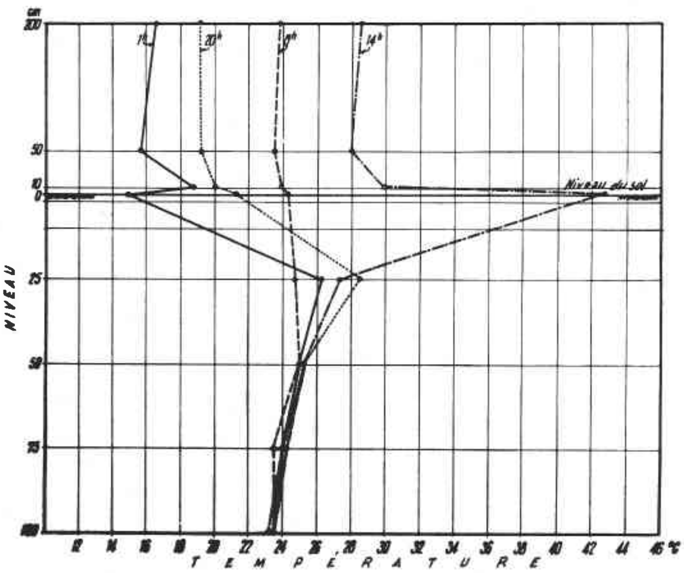

Figure 1. Distribution de la température moyenne mensuelle dans l'atmosphère et le sol, le mois d'Août 1957, a 1, 8, 14 et 20 heures, sur une dune plane. Température à 14 heures.

tion, la température du sol et de l'air, le développement des cultures dans les premières années, l'enracinement et la transpiration.

De l'évaluation des données, il ressort que les principaux facteurs limitatifs pour l'installation des cultures forestières sur les dunes du Delta du Danube sont les températures à la surface du sol (du sable) et le régime de l'humidité du sol.

Par exemple, les températures maximales au niveau du sol dans les mois d'été dépassent 55°C. et l'amplitude moyenne journalière dans le mois d'août, toujours au niveau du sol, dépasse 27°C. Dans le sol, la variation journalière se manifeste plus évidente jusqu'à 25 cm., mais plus atténuée entre 25 et 50 cm. Au-dessous de 50 cm. les températures deviennent uniformes à toutes les heures (Fig. 1).

En ce qui concerne l'humidité du sol, on prend en considération les seules soi-disant réserves d'eau physiologiques-actives, exprimées en mm. précipitations. Ces analyses ont amené à la constatation que dans les premiers 50 cm. du sol, la réserve d'eau active est très réduite, c.a.d., sous 5 cm., mais augmente seulement en profondeur. Par exemple, l'izohiète de 150 cm. qui indique la limite inférieure de l'existence de la végétation forestière des régions sèches descend dans le cours des mois d'été même jusqu'à une profondeur de 170 cm. (Fig. 2).

On constate donc dans les mois d'été que les températures à la surface du sable sont plus élevées et l'humidité extrêmement réduite; des conditions favorables de température sont réalisées au-dessous de 25 cm. profondeur; et celles d'humidité au-dessous de 150 cm.

Plantations expérimentales sur les sables du "Delta du Danube" et leurs résultats

Pour éviter les conditions défavorables de la surface du sable et bénéficier de celles favorables de la profondeur, on a essayé des plantations avec des marcottes longues de 155 cm. de *Populus nigra* var. *thevestina* (Dode) Bean et *Salix triandra* L. Les marcottes ont été introduites dans le sol jusqu'à 150 cm. profondeur en arrivant avec leurs extrémités dans la zone qui dépasse 100 mm., jusqu'au niveau de l'eau utile et pour éviter la brûlure des rejetons, l'écorce à la surface du sol, le sable autour des marcottes a été couvert de paille.

Fig. 2 RÉSERVE D'EAU DANS LE SOL, PHYSIOLOGIQUEMENT ACTIVE, EXPRIMÉE EN mm DE PRÉCIPITATIONS, SUR UNE DUNE PLANE; LE LITORAL ROUMAIN DE LA MER NOIRE, À LETEA.

Les résultats de ce marcottage ont été très satisfaisants. La preuve: dans la troisième année de végétation 85% des marcottes installées étaient viables (le reste de 15% avait été détruit par la larve des hannetons). Toutes les autres expériences par lesquelles on a essayé des plantations ou des marcottages normaux, inclusivement les variantes dans lesquelles on a employé des engrais organiques, ont échoué. Par ce procédé donc, on a employé d'une manière rationnelle les conditions écologiques respectives, obtenant une culture viable de peupliers et de saules.

Pour la mise en valeur continue de ces sables, on a entrepris des expériences, qui ont pour but l'introduction du pin noir comme principale espèce d'avenir. Par les expériences effectuées jusqu'à présent, dans des conditions semblables, il résulte que le pin noir réussit si le sable est préparé d'avance par le labourage (en extirpant la flore herbue qui consomme une grande quantité d'eau du sol) et si on emploie des rejetons bien développés de 2-3 ans aux racines profondes, plantés un peu plus profondément au-dessous du niveau du collet. Mais le labourage du sol expose le sable à la pulvérisation.

Pour éviter cette situation, on a prévu que, dans la première phase, on créera des rideaux d'une seule rangée de *Populus nigra* var. *thevestina* ou une autre espèce de peupliers.

La plantation doit être faite avec des marcottes à une distance de 0,75 m. sur rangée, introduites dans le sol jusqu'à une profondeur de 150 cm. Les rangées de peupliers doivent être placées perpendiculairement à la direction des vents nuisibles, à une distance de 10 m. entre elles.

Après trois ans, les peupliers seront assez hauts pour protéger contre la pulvérisation les sables des intervalles entre les rangées et on fera alors un labourage sur toute la surface des intervalles, extrayant la végétation herbue et sur le terrain aménagé on plantera des rejetons de pin bien développés. Le sable autour des rejetons sera couvert de paille. On créera de cette manière en deux reprises un peuplement de pin sous la protection du peuplier. Plus tard, il restera seulement le pin, qui protégera le sable et donnera de la valeur à une grande surface de dunes, actuellement improductives.

Parallèlement à ces recherches sur les dunes, on a étudié aussi les possibilités d'augmenter la productivité des cultures forestières des dépressions entre les dunes. Le régime d'humidité est ici favorable, mais le sol pauvre en argile. Dans les cultures pures plus anciennes *Alnus glutinosa* (L.) Gaertn. a donné les meilleurs résultats. A l'âge de 17 ans, le volume par ha. est de 156 $m.^3$ en réalisant donc une moyenne de l'accroissement en volume de 9,1 $m.^3$. Les troncs sont droits complètement élagués. Les peupliers noirs hybrides (*Populus* x *euramericana* (Dode) Guinier (*Regenerata* et *serotina*)) toujours en cultures pures ont réalisé un accroissement égal à celui de l'aune. Dans les cultures mixtes de *Alnus glutinosa* et peupliers, la taille atteinte par les peupliers est beaucoup plus grande. Par exemple, le volume de l'arbre moyen du peuplier noir est dans certains cas quatre fois plus grand que celui des cultures pures.

Il résulte que l'aune a une influence sur le développement des peupliers noirs hybrides et que dans un mélange rationnel de peupliers noirs et *Alnus glutinosa* on pourra obtenir un volume d'au moins 17 $m.^3$ par an et par ha. à l'âge de 17 ans, tandis qu'on ne réalise maintenant que 9 $m.^3$ par les cultures pures constituées des deux espèces.

RESUMES

Methods of Planting Forests in the Sandy Soil of Semiarid Regions on Ecological Bases

The principal ecological factors that affect the existence of forest stands in the sandy soil of semiarid regions are analyzed. On the basis of much research, it has been found that, on the sand dunes of the Rumanian shore of the Black Sea, the main factors limiting forest vegetation are the moisture in the soil and the heat on the surface of the stand.

By judiciously using the results of this research shown in chronoisoplettes, we have employed a suitable method of forestation eliminating the disadvantages existing on the surface of the sand and utilizing the favorable conditions in the lower layers of the soil.

Two different phases are involved in the effort to obtain a desired stand.

For the depressions between dunes, where the moisture conditions are favorable but the soil is poor, we find that the *Alnus glutinosa* (L.) Gaertn. has a stimulating effect on the growth of hybrid black poplars (*Populus* x *euramericana regenerata*). By a rational mixture of *Alnus nigra* and *Populus regenerata*, the productivity of this land has been increased from 9 cubic meters annually per hectare to approximately 17 cubic meters annually per hectare.

Métodos de Reforestación de Terrenos Arenosos en Zonas Semiáridas sobre Bases Ecológicas

Se analizan los factores ecológicos principales que han de afectar la existencia de cultivos forestales en los terrenos arenosos de las zonas semiáridas. Como resultado de numerosas investigaciones se ha comprobado que los principales factores que limitan la vegetación forestal en las dunas arenosas del litoral rumano junto al Mar Negro son el régimen de humedad del suelo y el régimen térmico de la superficie arenosa.

Utilizando cuidadosamente los resultados de estas investigaciones, expresados en "cronoisoplanos," se han usado métodos para una reforestación adecuada, habiéndose evitado las condiciones desfavorables existentes en la superficie de la capa arenosa y aprovechándose las más favorables existentes en las capas inferiores del suelo.

En el proceso de reforestación se pasa por dos fases diferentes.

Entre las depresiones entre las dunas, donde existen condiciones favorables de humedad pero donde el suelo es pobre, se ha comprobado que el *Alnus glutinosa* (L.) Gaertn. estimula el crecimiento de álamos híbridos negros (*Populus euramericana regenerata*). Como consecuencia de una combinación racional del *Alnus nigra* y del *Populus regenerata*, la productividad de estos terrenos ha aumentado de unos 9 $m.^3$ por año y hectárea a aproximadamente 17 $m.^3$ por año y hectárea.

La Reforestación con Quebracho Colorado (Schinopsis balansae Engl.) Y Algunas Normas Silvícolas Relacionadas con su Aprovechamiento Racional

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El quebracho colorado, *Schinopsis balansae* Engl., es una especie arbórea indígena perteneciente a la familia de las Anacardiáceas. El género *Schinopsis* cuenta con cuatro especies indígenas, quebracho colorado chaqueño (*Schinopsis balansae* Engl.), quebracho colorado cordobés u horco quebracho (*Schinopsis lorentzi* var. *marginata*), quebracho colorado santiagueño (*Schinopsis lorentzi*), y quebracho colorado mestizo (*Schinopsis heterophylla*), nueva especie descripta por los Ingenieros Agrónomos Arturo Ragonese y Julio Castiglioni.

El quebracho colorado se encuentra formando bosques mixtos y en algunos casos isletas puras, en la zona oriental húmeda del parque chaqueño, en la que se registran los más altos valores de las precipitaciones pluviales. Penetra en el noreste de la Provincia de Santa Fé donde forma una manga que alcanza hasta la mitad de dicha Provincia. En las de Corrientes y Entre Ríos se encuentran pequeños manchones sin importancia industrial.

La práctica agrícola ganadera ha ocasionado la desaparición de los quebrachales en la Provincia de Santa Fé, notándose cada vez con mayor intensidad este proceso regresivo en la Provincia del Chaco. Las fábricas de tanino realizaron la explotación de las masas de esta especie sin la correspondiente repoblación artificial, ni favoreciendo, mediante las normas silvícolas más elementales, la repoblación natural; una vez explotados los quebrachales destinaron los campos a la ganadería, actividad que exige la quema de los pajonales y espartillares para obtención de pastoreo y destrucción de garrapatas. Estas quemazones destruyen los brinzales de quebracho colorado que se desarrollan al amparo del espartillar, iniciándose de esta manera el proceso de regresión en las masas arbóreas, aparte del daño que causa sobre las mismas la acción directa del fuego.

La principal aplicación de esta especie es su utilización como materia prima para la obtención del extracto tánico, el que es motivo de un importante comercio de exportación, siendo por consiguiente fuente de recursos para la economía argentina y precisamente en esta circunstancia radica su importancia.

Por desconocerse la técnica a seguirse en los trabajos de reforestación en gran escala, la Administración Nacional de Bosques inició la correspondiente experimentación con el fin de establecerla, creándose los Establecimientos de Reforestación ubicados en General Obligado y posteriormente Capitán Solari, en la Provincia del Chaco.

Los sistemas de reforestación con esta especie son los siguientes: plantación, siembra directa y regeneración natural.

Reforestación por Plantación

Este método responde a las normas clásicas y consiste esencialmente en lograr las plantas que deben plantarse en un recipiente adecuado, para poder realizar la plantación con pan de tierra.

La técnica de reforestación seguida en General Obligado y Capitán Solari, es la que se detalla a continuación. En primer lugar, se colocan las macetas de barro crudo en canchas de un metro de ancho y del largo que se estime más conveniente. Estas canchas deben prepararse en forma tal, que permitan colocar las macetas bajo nivel hasta la mitad de su altura, arrimando tierra mullida hasta su nivel superior en todo el contorno de la cancha.

Una vez colocadas las macetas en la forma indicada, se llenan con tierra de monte cernida, la que se deberá comprimir ligeramente llenándose asimismo los espacios que dejan las macetas entre sí. Se procede luego a dar un riego con el fin de asentar la tierra, llenándose inmediatamente después con tierra cernida hasta que se logre el asentamiento total de la misma.

Después se realiza la siembra colocando cinco semillas en cada maceta de barro, cubriéndolas apenas con tierra cernida y sobre ésta espartillo, procediéndose inmediatamente a dar un abundante riego el que se repetirá en el mismo día.

Se continúa con dos riegos diarios hasta lograr la germinación, la que se produce aproximadamente entre los ocho y quince días, según la época de siembra. Producida la germinación en el 60% de las macetas se destaparán las canchas, continuándose los riegos para evitar la formación de una capa dura en la superficie de las macetas en las que aún no han nacido las plantas.

La mejor época de siembra es inmediatamente de realizada la cosecha, es decir, en la segunda quincena de febrero. También pueden hacerse siembras de primavera, pero en este caso es necesario aumentar proporcionalmente la cantidad de semillas por maceta pues el poder germinativo disminuye rápidamente, hasta ser de sólo 30-40%.

Los cuidados posteriores son los relativos a la limpieza y "movida" de las macetas, revistiendo esta última tarea especial importancia, pues el quebracho es muy sensible al corte de las raíces, secándose las plantas que se mueven cuando se han posesionado mucho del suelo, es decir que se deberán mover las macetas apenas se note que empiezan a pasar las raíces y tantas veces como sea necesario. Generalmente hay que mover las canchas 5 ó 6 veces en el período comprendido entre febrero y octubre.

La "movida" de las macetas depende de las temperaturas y precipitaciones que se registren en dicho período, pues en los inviernos suaves son necesarios más movimientos. Después de cada movida de las macetas en las canchas, se riegan abundantemente realizándose el deshierbe y clasificación de las plantas.

La plantación se realiza preferentemente en el mes de octubre, época en que las plantas han alcanzado una altura media de 20 a 30 cms. La distancia más comunmente usada es de 2 m. en todo sentido, realizándose en terreno preparado en fajas, caballones hechos con el arado dando dos tumbas opuestas y mejorando el lugar donde se colocará la planta, con una pala. La preparación del terreno se realizará con por lo menos tres meses de anticipación, para permitir la descomposición de la vegetación tumbada y evitar la formación de espacios vacíos. Este sistema mejora el desagüe por la zanja que deja el arado al borde del caballón. La plantación en caballones es aconsejable en los campos bajos con suelos arcillosos del sur de la Provincia del Chaco y norte de la de Santa Fé, no siendo necesario en la zona norte de la primera con suelos altos y arenosos, donde se realizará a nivel. Una vez realizada la plantación será repasada periódicamente a fin de efectuar la inmediata reposición de las fallas. Las macetas deben moverse unos 8-10 días antes de ser llevadas al lugar definitivo, en forma tal que no sufran ningún corte de raíz al ser sacadas de las canchas y por otro lado hayan reaccionado perfectamente a este tratamiento. Antes de llevar las plantas al lugar en que deben plantarse, se riegan abundantemente, con lo que se logra que tengan a su disposición una importante reserva de humedad. Al realizarse la plantación, la parte superior de la maceta debe colocarse por lo menos 2 cms. bajo el nivel del suelo para conservar la humedad y conseguir que, con el asentamiento de los caballones después de las lluvias, queden a nivel.

En las plantaciones realizadas en los meses de marzo y abril en Reforestación Gral. Obligado, se ha podido establecer la importancia que reviste mantener las plantas protegidas por la vegetación espontánea durante los meses de junio, julio, agosto y primera quincena de septiembre, pues durante estos meses puede ocurrir la destrucción de la parte aérea de las plantas jóvenes por la acción de las heladas, debiendo mantenerse limpias las hileras durante los restantes meses del año. En todos los casos no son necesarios los riegos, pues las lluvias normales de la zona son suficientes.

Reforestación por Siembra Directa

La reforestación por siembra en el lugar definitivo, ha sido experimentada con buenos resultados en Reforestación Gral. Obligado y Reforestación Capitán Solari.

Este método consiste en la siembra en el lugar definitivo, donde se desea instalar el monte. Puede realizarse en líneas o a golpes.

La siembra se efectúa en líneas, en surcos bajo nivel, en los campos altos con suelos arenosos y a golpes, distanciados 30 cms. y sobre caballones en los terrenos bajos de suelos arcillosos. En ambos casos es aconsejable tapar la semilla con hojarasca, espartillo picado u otro material similar para proteger los cotiledones de los golpes de sol y evitar la excesiva evaporación que se opera después de las lluvias; también puede realizarse la siembra directa a nivel, cuando la composición física del suelo lo permita.

Una vez lograda la germinación y cuando las plantas hayan alcanzado suficiente desarrollo, se procederá a la plantación de las partes donde se note falta de plantas, a fin de conservar las líneas bien pobladas.

Las líneas se mantendrán carpidas, pero no las entrelíneas, pues la faja de terreno cubierta por la vegetación herbácea espontánea deberá proteger a las jóvenes plantitas de los golpes de sol y posteriormente de las heladas. Se permitirá la invasión de las líneas por las malezas durante el período invernal, meses de julio, agosto y primera quincena de septiembre; después se realizarán los trabajos necesarios para mantener limpio el cultivo.

La protección de las plantitas puede lograrse también utilizando especies forrajeras, las que se sembrarán entre las líneas en los meses de marzo y abril.

La época de siembra más oportuna es la de los meses de febrero y marzo, por la disponibilidad de abundante semilla fresca con buen poder germinativo. Las siembras realizadas en la primavera, meses de septiembre y octubre, han dado muy buenos resultados y tienen la ventaja de que las plantas logradas entran al invierno después de un activo período vegetativo, con un buen sistema radicular. La principal dificultad de esta época radica en el bajo poder germinativo de las semillas, lo que obliga a emplear mayor cantidad de semilla por hectárea.

Se sembrarán 60 kg. aproximadamente por hectárea, en líneas separadas por dos metros entre sí y treinta centímetros entre golpes, a razón de treinta y cinco o cuarenta semillas por golpe cuando se realice la siembra a fines del verano con semilla de reciente cosecha, debiendo aumentarse proporcionalmente dicha cantidad en la siembra de primavera, por la sensible disminución del poder germinativo. Estas cifras tienen carácter experimental y por lo tanto son susceptibles a modificación a medida que la práctica del método así lo aconseje.

Reforestación por Regeneración Natural

Ha sido posible establecer la regeneración natural de esta especie, concretándose los ensayos a una clausura de aproximadamente 200 hectáreas, establecida en Reforestación Gral. Obligado en el año 1949. Se trata de campos altos con cubierta viva de espartillo (*Elyonurus* sp.), en los que se desarrollan, en un 50% de su superficie, isletas de monte alto natural, con una participación de quebracho de 10-15 portagramos por hectárea en alguna de sus partes mejor pobladas por esta especie. Entiendése por campos altos en la zona, aquellos cuya cubierta viva la constituye el espartillo. Este tipo de campo se cubre de agua durante las lluvias de verano, pero esta permanece durante 10-15 días, siendo su profundidad de sólo 5 cms. aproximadamente.

La coincidencia entre la maduración de los frutos del quebracho colorado y los más altos valores de las lluvias y las temperaturas, hace posible la germinación y el posterior desarrollo de los frutos diseminados oportunamente, es decir que las condiciones ecológicas son favorables para su multiplicación.

En los campos sometidos a este sistema regenerativo, debe excluirse rigurosamente la ganadería y con mayor razón la quema de los campos, factores estos que han impedido hasta el presente que el quebracho colorado complete naturalmente su ciclo biológico. La disposición de fajas guardafuegos, hechas con rastra de discos, evitan la propagación del fuego a la zona reservada, cumpliendo además la función de caminos internos. La cubierta viva formada por el espartillo, protege además, a las plantas jóvenes durante el verano de los golpes de sol y durante el invierno de las heladas.

A fin de obtener una regeneración más uniforme, es necesario sembrar los lugares donde se observan fallas.

Normas para el Aprovechamiento del Quebracho Colorado

Para la correcta aplicación de los tratamientos silvícolas a que se someterá una determinada masa forestal, es necesario el conocimiento de las exigencias biológicas de la o las esencias que la forman, razón por lo que estimo oportuno hacer referencia a las principales características del quebracho colorado.

Se trata de una especie de temperamento heliófilo, exigente en agua y calor, factores estos de fundamental importancia durante la primera época de su vida (del primero al segundo año). Las heladas causan la destrucción de su parte aérea, No. 3 de la escala propuesta por el suscripto para valorar este daño*, debiendo considerarse como especie medianamente sensible este fenómeno.

Soporta perfectamente los golpes de sol, los que no le causan ningún daño, salvo cuando la planta es jóven, un año o menos de edad, o cuando se carpe en los meses del verano, descubriendo bruscamente las plantas jóvenes. Dada su sensibilidad a las heladas, es necesario que se permita en las plantaciones la invasión de las malezas que forman la cubierta viva natural, al finalizr el verano, para que se forme la necesaria protección contra este fenómeno; pasado el peligro se deberá proceder a carpir las líneas, las que se mantendrán limpias hasta el próximo verano.

La floración se inicia en el mes de diciembre, estando en condiciones de realizarse la cosecha, durante el mes de febrero. La permanencia de los frutos en el árbol es breve, produciéndose su diseminación a medida que maduran, siendo arrastrados por los vientos dominantes durante esa época del año. Se trata de una especie de diseminación anemófila, produciéndose la caída de los frutos durante el mes de febrero cuando los valores de las precipitaciones son los más altos.

Un kilo de semillas contiene 10.000 unidades aproximadamente. Su poder germinativo alcanza al 85%, disminuyendo después de un año hasta el 30-50%, cuando son conservadas las semillas en condiciones naturales.

Las semillas son cosechadas en la zona, cortándose las ramas y bajándolas del árbol mediante una soga, una vez en el suelo, se depositan sobre un lienzo donde se procede a la extracción de la semilla, luego se dejan orear exponiéndolas al sol en capas de poco espesor.

La caída de las hojas se produce en el mes de agosto, como consecuencia de las heladas, iniciándose inmediatamente la brotación que se generaliza en el mes de septiembre. Este fenómeno se observa en los ejemplares más expuestos, pues los individuos agrupados o protegidos por el monte natural no voltean las hojas.

La regeneración natural de los quebrachales se cumple normalmente en los espartillares, siendo especie colonizadora. El factor adverso más importante lo constituye la quema de los espartillares por los ganaderos, razón por la que debe ordenarse el aprovechamiento ganadero en los lotes forestales o excluirse definitivamente la ganadería. La presencia de brinzales en las tierras blancas se debe principalmente a que los incendios se cortan en estos suelos por la falta de vegetación. Los quebrachales del parque chaqueño se encuentran actualmente en evolución progresiva, es decir, que es posible la conservación a perpetuidad de las masas constituidas por esa importante especie forestal, la cual cumple su ciclo biológico completo, siendo posible la instalación del jóven repoblado cuando las masas son tratadas convenientemente. Por lo tanto es silvícolamente normal el aprovechamiento de los individuos maduros e instalación del repoblado que asegurará la perpetuidad de la masa. En la hidrosere chaqueña la formación de los quebrachales acompañado de aromito, tusca, algarrobo, toro ratai, etc., constituye una etapa intermedia entre el espartillar y el monte alto.

Es durante la quema de los espartillares que son destruidas todas las plantas jóvenes de quebracho colorado que se desarrollan al abrigo de esta gramínea que forma la cubierta viva de las pampas altas del Chaco; sólo escapan a la acción del fuego aquellas plantas que creciendo en las tierras blancas no son alcanzadas, pues el incendio se corta en esta zona por falta de material combustible. Esta circunstancia ha hecho que los pobladores de las zonas forestales atribuyan al quebracho colorado preferencia por este tipo de suelo, afirmación dudosa, pues en zonas reservadas donde no se quema el espartillar, se observa la regeneración del quebracho colorado al abrigo del mismo.

La característica de masas mezcladas, constituidas por varias especies, no todas de valor industrial, hace que los establecimientos dedicados a la fabricación de tanino se vean abocados al problema del exclusivo aprovechamiento del quebracho, que no constituye el principal elemento del bosque chaqueño, circunstancia que hace necesario un tipo de aprovechamiento selectivo que ocasiona el empobrecimiento de las masas por la extracción de la esencia de mayor valor económico. Pero, por el relativamente

* No. 1. Las heladas queman solamente las hojas y ramas finas.
No. 2. Las heladas queman las hojas y el 10% del tallo.
No. 3. Las heladas queman del 10 al 40% del tallo.
No. 4. Las heladas queman del 40 al 70% del tallo.
No. 5. Las heladas queman más del 70% del tallo.

escaso número de individuos, la extracción, para que resulte económica, debe realizarse sobre todos los ejemplares de quebracho, quedando de esta manera la masa forestal empobrecida, al extremo de no dejarse en pié el número necesario de portagranos. La solución de esta situación puede buscarse en una fuerte restricción de los aprovechamientos, siendo necesario en este caso radicarlos sobre grandes superficies para poder suministrar la materia prima que exigen las fábricas. Esta técnica tiene el inconveniente de encarecer el costo.

La restricción de las extracciones permitiría la regeneración de las masas antes de realizar nuevos aprovechamientos en la misma zona. Durante el período de regeneración es imprescindible evitar la quema de los campos y el pastoreo en las áreas que se regeneran; será sólo factible en las zonas ya repobladas y cuando los individuos del bosque hayan adquirido el desarrollo suficiente como para que los animales no les causen daño, reforzándose la regeneración mediante la siembra directa o plantación en las zonas donde la regeneración natural no sea suficiente. En esta forma las futuras masas se instalarían en los lugares que reunan las mejores condiciones ecológicas y económicas, proximidad a las fabricas, poblaciones, "vías de saca," etc.

También resulta muy favorable la asociación del quebracho colorado con otras especies. En experiencias realizadas en Reforestación Gral. Obligado, se asoció al quebracho colorado con algarrobo sp., tratándose actualmente dicha parcela por cortas a clareos sucesivos hasta dar plena posesión del lote al quebracho colorado.

También en Reforestación Capitán Solari se realizó la siembra directa al abrigo de un quebrachal natural.

En este caso se sigue el mismo criterio, una vez desarrollado suficientemente el brinzal pueden iniciarse las cortas a clareos sucesivos de las masas adultas que actualmente cumplen función de protección.

De acuerdo con experiencias actualmente en ejecución en una parcela de quebracho colorado asociado con aromito, se aplicó el método de cortas a clareos sucesivos, con el objeto de mantener una cubierta suficiente para evitar la acción de las heladas, realizándose la corta final una vez que el jóven repoblado haya alcanzado un desarrollo tal que pueda soportar la acción del medio ambiente, entre los cinco y diez años, según sitio. También se aplicó en la misma parcela el método de cortas a tala rasa en fajas alternas. Estas fajas son lo suficiente angostas como para lograr la protección lateral del jóven repoblado. La siembra se produciría, en el caso de quebrachales puros, por diseminación anemófila de los árboles que crecen al borde de las fajas taladas, durante el mes de febrero, o en su defecto, se recurriría a la siembra directa a golpes a 0,30 por 1 metro o plantación a 2 x 1 metro.

En las pampas altas, espartillares, el quebracho colorado se comporta conjuntamente con el algarrobo y aromito como esencia colonizadora, siendo suficiente la protección que ofrece el espartillar, las especies acompañantes citadas y las masas de monte natural próximas.

Otra posibilidad importante de aprovechamiento de los quebrachales, la constituye la utilización de la hoja como posible sustituto del zumaque. Esta circunstancia haría posible el aprovechamiento de los raleos de las parcelas de quebracho colorado establecidas a gran densidad con la finalidad de iniciar su aprovechamiento destinando los productos obtenidos a la elaboración del tanino de hoja.

La distancia entre plantas podría ser de 0,50 por 1 metro, lo que representa una densidad de 20.000 plantas por hectárea realizándose los raleos necesarios con el fin de mantener el lote en buen estado y lograr materia prima. Además permitiría la extracción posterior de árboles jóvenes que constituyen material de buena calidad para la elaboración de tanino, realizándose la corta final cuando el resto de los ejemplares de la masa hayan alcanzado su completa madurez. Estos aprovechamientos parciales permiten acortar el turno de los quebrachales, principal inconveniente con que se tropieza en la reforestación con esta esencia, ya que los productos obtenidos en los raleos podrían ser industrializados.

Las cortas a clareos sucesivos aplicadas al monte natural hacen posible la utilización de los productos obtenidos en la elaboración de carbón y leña principalmente, realizándose además la eliminación del subbosque y cubierta viva. La repoblación se hace por siembra directa o plantación con el objeto de iniciar la regeneración de la masa tratada; posteriormente, cuando los individuos del bosque inicien la fructificación, la regeneración natural será suficiente para lograr este objetivo, la que solamente será reforzada por la repoblación artificial en las fracciones donde es deficiente. Esta técnica ha sido puesta en práctica en Reforestación Capitán Solari en el año 1958, realizándose la repoblación con plantas de quebracho colorado, lapacho (*Tecoma* ipe) y jacarandá (*Jacaranda acutifolia*) y siembra directa de urunday (*Astronium balansae*), y espina corona (*Gleditsia amorphoides*), siendo la más aconsejable para el mejoramiento de los bosques del Chaco.

Las observaciones de carácter técnico que anteceden dan las bases para la implantación de una política forestal de protección de los quebrachales, ya que el principal factor regresivo lo constituye el aprovechamiento irracional de los campos con bosques de esta especie, primero por una ganadería extensiva como consecuencia de la cual es de imprescindible necesidad quemar los espartillares y segundo, por las extracciones selectivas realizadas en las masas naturales, sin respeto a las normas silvícolas fundamentales.

Conclusiones

En el presente trabajo se describen los métodos para la reforestación con quebracho colorado, ensayados en Reforestación General Obligado y Reforestación Capitán Solari, Provincia del Chaco.

Con respecto a la regeneración natural esta se cumple normalmente en las áreas donde las condiciones ecológicas son aptas para la especie tratada, estableciéndose la etapa de la hidrosere más conveniente (espartillares).

Se establecen como los tratamientos más aconsejables para el aprovechamiento racional de los quebrachales, las cortas a clareos sucesivos y las cortas a tala rasa en fajas alternas orientadas de este a oeste, en base a ensayos que se conducen en Reforestación General Obligado y Reforestacion Capitán Solari.

También resulta muy conveniente la asociación del quebracho colorado con otras esencias de temperamento más robusto tales como el algarrobo, el aromito y el monte natural convenientemente raleado, no habiéndose ensayado hasta ahora otras especies.

En todos los casos se hace necesaria la repoblación artificial dada la escasez de portagranos y la característica de bosques entremezclados—donde la participación del quebracho colorado es baja—las condiciones de excesiva densidad de estas masas y la cubierta viva de cardo que entorpece su regeneración en el monte actual.

Los factores limitantes son, cuando la planta es jóven (un año o menos de edad), los golpes de sol, las heladas y las precipitaciones excesivas.

Las causas de regresión de los quebrachales, de origen animal o provocadas por el hombre, son el pisoteo y ramoneo de la hacienda y principalmente la quema de los espartillares.

En el monte natural, la extracción selectiva sin repoblación artificial, dando cada vez mejores condiciones de vida a las esencias no aprovechadas por los aserraderos o fábricas de tanino. La actividad forestal que debe favorecerse es la de la elaboración de leña y carbón con las esencias del subbosque y ejemplares sobre maduros, decrépitos o enfermos de las utilizables en los aserraderos y fábricas de tanino y extracción obligatoria del cardal, técnica que permite limpiar las masas y disminuir su densidad, creando mejores condiciones vegetativas a las principales esencias forestales de la zona de los quebrachales, quebracho colorado, quebracho blanco, urunday, guayaibí, lapacho, espina corona, guayacan, etc.

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RESUMES

Reforestation With Quebracho Colorado (Schinopsis balansae *Engl.*) *and a Few Procedures Related to Its Rational Management*

This paper discusses artificial reforestation with *Schinopsis balansae* in the humid section of the Chaco park and the possibilities of natural regeneration of its stands. It describes the most suitable stage of moisture conditions for its introduction.

On the basis of recent experiments conducted at establishments of the National Forestry Administration, the author describes the forestry methods most suited to the management of such forests, such as shelterwood cutting and clearcutting in alternate strips. In most cases, the reforestation has to be done by direct seeding or planting, owing to the scarcity of seed trees.

Le reboisement avec le quebracho colorado (Schinopsis balansae *Engl.*) *et quelques méthodes sylvicoles relatives à son utilisation rationelle*

Le mémoire porte sur le reboisement artificiel du quebracho colorado du Chaco dans la zone humide du parc du Chaco et sur les possibilités de régénération naturelle de ses peuplements. Il examine la phase la plus appropriée de conditions d'humidité pour son implantation.

En se fondant sur les travaux expérimentaux effectués assez récemment dans des établissements relevant de l'Administration nationale des forêts, l'auteur décrit les méthodes sylvicoles convenant le mieux à l'aménagement de ces forêts, telles que coupes à éclaircies successives et coupes à blanc en bandes alternées. Dans la plupart des cas, le repeuplement doit être effectué par ensemencement direct ou par plantation, en raison de la pénurie de porte-graines.

Informaciones sobre el Crecimiento en la Argentina De Varias Especies del Género Pinus

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Se refieren a masas cultivadas de las siguientes especies: *Pinus caribaea, P. elliottii* var. *elliottii, P. halepensis, P. hondurensis, P. radiata, P. taeda;* de la primera y la cuarta especie, de muy reciente introducción en la Argentina, sólo se aportan datos estadísticos preliminares al solo efecto informativo.

Pinus caribaea Morelet; *Pinus hondurensis* Loock

Especies de muy reciente introducción (2-3 años); la segunda de identidad botánica aún no del todo aclarada. La escasez de plantaciones de ambas, y lo reciente de las mismas, no permite efectuar comentarios de importancia. Destácase no obstante el singular crecimiento inicial de *P. hondurensis* que sobrepasa todo lo imaginable en cuestión de crecimiento de pinos, puesto que alcanza a ser de 15 cm. mensuales, en 21 meses de estudio, contra los mayores comprobados en *P. radiata* (8, 9 cm. mensuales) y *P. elliottii* (7, 8 cm. a 11 cm.), para edades comparativamente iguales. En apariencia no demuestra igual desarrollo inicial que el de especies afines, que dedican el primero y segundo año de plantación a extender su sistema radicular, con poco acrecentamiento aéreo, y luego recién elévanse rápidamente en altura. El *P. caribaea* exhibe un acrecentamiento de 7 cm. mensuales.

Ensayos por mayor tiempo indicarán los resultados con ambas especies de pinos.

Pinus halepensis Mill.

Sólo se pudo realizar una determinación de crecimiento, pese a resultar un pino muy cultivado en las zonas secas de la Argentina. Considerando la escasa densidad del bosque examinado (400 árboles/ha.), su incremento medio anual (durante 18 años) de 14,6 m³/ha. no es despreciable, pudiendo compararse al del *P. radiata* cuando éste crece en condiciones poco satisfactorias.

Pinus radiata D. Don

De esta especie se examinaron varios bosques, pero sólo es posible ofrecer resultados de valor para los primeros años de crecimiento, puesto que más tarde (desde los 5 años) su cuadro de desarrollo está perturbado por la acción de variados factores que no permiten comparaciones dasométricas. Tanto en las zonas de óptimas condiciones ecológicas de clima y suelo, como en las menos propicias, el *P. radiata* exhibe un similar acrecentamiento inicial aéreo relativamente rápido y sin transición de uno a otro año; entre 1,00 a 1,40 m. son sus acrecentamientos anuales, con promedio general de 1,20 m.; esto se comprueba incluso en regiones tropicales, como las de Misiones, o las del Brasil, donde promedia hasta 1,30 m. por año. A partir de los 5 años de la plantación, el acrecentamiento se reduce a veces notablemente; en regiones poco propicias el ritmo anual decrece a 0,60-0,80 m., y desde los 10 años disminuye más, lo que permite concluir que al décimo año de la plantación, el promedio general sea de 1,00 m. En regiones de ecología más favorable, el acrecentamiento posterior a los 5 años sigue siendo elevado, entre 1,00 a 1,20 m., disminuyendo gradualmente con el correr de los años hasta promediar a los 25 años, un metro anual.

En términos de volumen de producción de madera, el incremento medio anual hasta el décimo período se puede calcular a un promedio de 20 m.³ por hectárea, en las mejores condiciones de crecimiento, incluida la corteza.

Pinus elliotti Engelm. var. *elliottii*

Es la especie con mayor literatura dasométrica de las cultivadas en la Argentina, por lo extendido de sus cultivos y por la plasticidad que demuestra a terrenos y climas. Se caracteriza porque durante el primero y segundo años de plantación exhibe un lento desarrollo aéreo, mientras se dedica a extender su sistema radicular, midiendo entonces al término de este período 1,50-2,00 m. de altura (incrementos anuales de 0,75-1,00 m.); pero luego se recupera e inicia un rápido crecimiento apical que llega a ser de hasta 2,00 m. por año. Al décimo año de la plantación el incremento medio anual oscila entre 1,20-1,50 m.; entonces disminuye este ímpetu, manteniéndose en los años sucesivos en 1,00-1,20 m. Con los datos recogidos, año tras año, en 17 bosques, no se aprecia una significativa diferencia en las magnitudes de altura como consecuencia de diferentes espaciamientos entre plantas; así, por ejemplo, bosques de alrededor de 1000 árboles por hectárea muestran incrementos similares a los de bosques del doble o aun superior densidad. En cambio, la calidad de la estación de crecimiento o las condiciones ecológicas de la zona afectan profundamente los incrementos; así hay gran diferencia entre los cultivados en tierra alta de las islas húmedas del delta del río Paraná, y los de iguales islas pero en lugares bajos, teniendo los primeros incrementos anuales de 1,40 m., y los segundos de menos de 1,00 m., y también entre bosques de estas islas y los plantados en la Provincia de Misiones, donde se registran crecimientos de 1,00 m., o los cultivados en tierra firme de la Provincia de Buenos Aires, con iguales magnitudes anuales que los de Misiones.

En cuanto al acrecentamiento en diámetro (incluida la corteza), es de 2,00 cm. anuales en los bosques del delta del Paraná, bajando a 1,4 cm. en los de Misiones; tratándose de los primeros y hasta los 7 años primeros, el incremento promedio llega hasta una pulgada anual, pero luego disminuye a 1,7-1,4 cm. Por supuesto que en bosques de alta densidad inicial el incremento diametral es inferior, y así tenemos que un bosque de 2800 árboles/ha. tiene crecimiento de 1,8 cm. anual.

Por fin, los incrementos en volumen, si bien dependen de la densidad, de la edad y de la calidad del sitio, fundamentalmente lo son con relación a este último factor; así por ejemplo, en tierras altas de las islas en el delta del Paraná y a los 10 años de crecimiento, se registran promedios de 30-40 m.³ por ha., en bosques con espaciamiento de 2 x 2 m., mientras que con espaciamientos iniciales de 2,50 x 2,50 m. ó 3,00 x 3,00 m. el acrecentamiento promedio desciende a 25 m.³ por ha.

Evidentemente que de estas comparaciones dasométricas revélase la zona del delta del Paraná, en terrenos altos (albardones), como la más propicia para el cultivo del *P. elliottii,* jugando un papel principal el alto grado de disponibilidad de agua de que goza en forma permanente, que duplica y hasta triplica los aportes directos por efectos de lluvias (de 1.000 mm. anuales).

Pinus taeda L.

Es una especie bien cultivada en la Argentina, pero pocas veces formando bosques densos y grandes; así sólo se pudieron realizar mediciones dasométricas en tres de ellos. Posee caracteres de incrementaciones dendrométricas similares al *P. elliottii,* exhibiendo al igual que éste un crecimiento pausado en altura durante sus dos primeros años de plantación, y recién entonces progresa más rápidamente, aunque un tanto menos que *P. elliottii* en lo que respecta a la altura, disminución compensada en cambio por un leve mayor incremento en diámetro (1,00-1,20 m. en altura; 2,00-2,20 cm. en diámetro). Es por tales motivos que en iguales condiciones de medio, calidad de estación, y densidad de plantación, los incrementos en volumen resulten aproximados a los expuestos para *P. elliottii,* notándose no obstante tendencia a ser superiores los de éste. Sin embargo, corresponde mencionar que los pocos autores que publicaron mediciones de ambas especies, ofrecen resultados inversos, es decir superiores en *P. taeda,* hasta en un 20 por ciento.

RESUMES

Data on the Growth in Argentina of Several Species of the Genus Pinus

This is a brief summary of a more complete paper prepared by the author, which is a compilation of all the studies published in Argentina on the measurement of growth of cultivated pines in commercial woodlands, all the growth and tree measurement data on the forests studied up to now, etc. A total of 30 cultivated forests were studied, from some of which measurements were taken every year, situated in the so-called Littoral and Argentine Mesopotamia region, extending from Misiones in the north, which

is hot and humid (rain forest) to Buenos Aires, which is temperate and semihumid. The species studied are: *Pinus caribaea*, *P. elliottii* var. *elliottii*, *P. halepensis*, *P. hondurensis*, *P. radiata* and *P. taeda*.

All the growth data shows that *Pinus elliottii*, after completing the initial period of slow development, attains an extraordinary average annual growth of 35 to 50 cubic meters per hectare, which drops to about 25 cubic meters in less fertile areas, and to 18 to 20 cubic meters in very poor areas. At present, it is the chief resource of the coniferous plantations of the Argentine Littoral. *P. taeda* shows similar growth conditions, but it is a less adaptable species. *P. radiata* does not exhibit the slow initial growth of the above two species, but it is much less adaptable to climate and soil. It grows very well during the first five years, but then declines rapidly except in places that are ecologically very favorable, where it attains an average annual growth of 20 cubic meters per hectare, and therefore barely equals the results of the above species when they are growing on very inferior land. *P. halpensis* registered a growth of about 15 cubic meters per hectare a year, approximating the growth of *P. radiata* when grown on rather unproductive soil. Since *P. caribaea* and *P. hondurensis* are two species that were introduced into Argentina very recently, the results obtained from them do not permit conclusions of any value to be drawn; the second, after growing for nearly two years on a site of a quality between average and good, in a subtropical, humid climate (Misiones), exhibits an extraordinary height growth (15 cm. a month), which surpasses all the epidometric data recorded on pines to date.

Renseignements sur la croissance en Argentine de diverses espèces du genre Pinus

Le présent document est une brève synthèse d'une étude plus importante effectuée par l'auteur et qui comprend une compilation de toutes les études publiées en Argentine sur la sylviculture des pins cultivés dans des forêts commerciales, et de toutes les données sur les forêts examinées jusqu'à présent. Au total, trente forêts cultivées ont été étudiées, dont plusieurs ont fait l'objet chaque année de mensurations successives. Ces forêts sont situées dans la région dite du littoral et de la "mésopotamie" argentine, de la province de Misiones, au nord—forêt chaude et humide (rain forest)—jusqu'à Buenos Aires—forêt tempérée et semi-humide. Les espèces examinées sont : *Pinus caribaea*, *P. elliottii*, var. *elliottii*, *P. halepensis*, *P. hondurensis*, *P. radiata* et *P. taeda*.

L'ensemble des données dendrométriques a permis de constater que *P. elliottii*, une fois la période initiale de lent développement dépassée, atteint des dimensions extraordinaires jusqu'à 35 ou 40 $m.^3$ par hectare et par an, d'accroissement moyen, baissant à 25 $m.^3$ environ aux emplacements de qualité inférieure, et à 18 ou 20 $m.^3$ aux emplacements les plus pauvres; cet arbre constitue actuellement la principale ressource du littoral argentin pour ses plantations de résineux. *P. taeda* se développe à un rythme analogue, mais est moins adaptable. La croissance initiale de *P. radiata* n'est pas aussi lente que celle des deux espèces précédentes, mais s'adapte plus difficilement aux climats et aux sols. Il se développe très bien pendant les 5 premières années, mais le rythme de sa croissance ralentit ensuite sensiblement, sauf dans les stations où les conditions écologiques sont particulièrement favorables et où son taux de croissance annuel atteint 20 $m.^3$ par hectare, égalant à peine les résultats obtenus avec les espèces précédentes croissant sur des terrains de qualité très inférieure. *P. halepensis* a enregistré des augmentations de quelques 15 $m.^3$ par hectare et par an, analogues à celles de *P. radiata* qui croît sur des terres peu productives. *P. caribaea* et *P. hondurensis* sont deux espèces qui n'ont été acclimatées que récemment en Argentine, ce qui ne permet pas encore de tirer des conclusions valables des données obtenues; la seconde de ces espèces, après avoir poussé depuis près de deux ans à une station d'une qualité assez satisfaisante, dans un climat subtropical et humide (Misionares), a fait preuve d'un taux de croissance en hauteur extraordinaire (15 em. par mois), supérieur à toutes les données épidométriques enregistrées jusqu'à présent en matière de pins.

OTHER SPECIAL PAPERS IN THE FIELD OF SILVICULTURE AND MANAGEMENT

The Silviculture Experiment Station of Florence, Italy

Direzione Generale per l'Economia Montana
e per le Foreste

Italy

The Silviculture Experiment Station was established in 1922-23 by Prof. Aldo Pavari as a department of the National High Institute of Florence. In 1929 it became an independent institute (like other Italian Agricultural Experiment Stations). Between 1923 and 1929 it was possible to develop only a modest activity, owing to the scarcity of funds and staff. From 1939 to 1948 the activity and work were hindered by World War II and its repercussions. Only in these last years has the Experiment Station regained its former activity.

The aims, methods, programs of work and of forest experimentation have been described in Publication No. 1 of the Silviculture Experiment Station (1932). It is to be remembered that the Institute has been established only as a Silviculture Experiment Station and not as a whole Forest Research Institute. For this reason, its work and researches deal chiefly with silviculture problems in the forests and but little with laboratory research. Today, about forty years later, we can rapidly summarize the main problems and work which have been accomplished in several fields of research. More than 500 reports, notes, and studies have been published during this period by the Director and the assistants. Here is a very rapid summary of activities.

1. *Research on forest ecology*. First of all to be remembered is Pavari's classification of climatic forest zones: several important researches and studies have been made, and particularly important are those on the influence of Mediterranean forests on climate. More recently, many researches on ecology in the high stands on the Alps have been published by L. Susmel.

2. *Research on reafforestation* and on suitable tech-

niques for different ecological environments. Very different problems were existing in special environments in the Southern Apennines, Sicily, and Sardinia, where much experimentation has been undertaken. A major contribution to the solution of these problems has been made by A. de Philippis, with his research on different methods of reafforestation in hot, dry climates.

3. *Research for the improvement of wood production* in Italian forests, particularly on alpine coniferous high stands (silver fir, spruce, and larch); on chestnut coppices; on beech, oak, and silver fir forests in the Apennines; and on coppice conversion.

4. *Research and experiments on forest nurseries management* to improve techniques and results.

5. *Several studies and monographs on particular species* have been made: (a) on cypress in Tuscany, by A. Pavari; (b) on *Quercus cerris*, by A. de Philippis; (c) on larch in the Italian Alps, by L. Fenaroli and R. Morandini; (d) on chestnut, by L. Fenaroli; (e) on poplars, by A. Pavari and E. Allegri; and (f) on black locust, by E. Allegri.

Several other smaller contributions on Italian forest flora have been published in several forestry magazines.

6. *Studies on forest genetics:* General problems in forest genetics, its importance and its application, have been subjects of intensive studies by A. Pavari. Among the many specific studies undertaken, chiefly on races and provenances of seed, the following are especially significant: (a) on *Pinus sylvestris* (in collaboration with IUFRO), in Lombardy; (b) on *Abies alba*, in two experimental plantations in the Apennines; (c) on *Larix decidua* (in collaboration with IUFRO), in the Apennines; (d) on *Pseudotsuga douglasii* at Vallombrosa; and (e) on *Eucalyptus* spp., in several places.

7. The future of Italian silviculture has been given a special significance with the preparation of a *National Book of Seed Forests*, based particularly on the work of R. Morandini. The best stands in the Alps, in the Apennines, and on the plains, where seeds are collected for use in Italian Forest Service nurseries for starting new plantations, are registered in this book.

8. *The introduction of exotic species* has been the first aim of the Institute. More than 220 species have been tested. Several of these are now widely used in reafforestation and industrial planting, e.g., *Pseudotsuga douglasii, Abies cephalonica, Larix leptolepis, Chamaecyparis lawsoniana, Pinus insignis,* and *P. strobus*. Experimentation on *Eucalyptus* is still going on. A. Pavari and A. de Philippis have made a large report on this subject.

9. *Windbreaks and Shelterbelts*. Research studies, both singly and in collaboration with other institutes, have been made to solve the problems of the influence of windbreaks. At the same time large plantations have been started in new land reclamation projects, with very good results, e.g., at Latina, near Rome, and at Arborea in Sardinia.

10. *Poplars*. A large contribution to the development and improvement of poplar cultivation has been made by the Institute in close collaboration with the Italian Poplar Experiment Institute, with publications, studies, and participation in national and international meetings. Several experimental plantations have been established in Tuscany, and experiments with *Populus alba* are presently going on.

11. *Chestnut Blight control. Endothia parasitica* was noticed in Italy for the first time in 1938 near Genoa and Udine. To control this dangerous disease, which has spread all over the country, an experimentation project was undertaken in collaboration with Phytopatological Services and the Forest Service.

Nurseries, experimental plots, special arborets, artificial inoculation, hybridization, grafting, forestry treatments, and the introduction of exotic and hybrid chestnuts were tried. Happily, after about 15 years, the development of a resistance has been observed, so this problem, although still serious, is no longer as important as it was 20 years ago.

12. *Chestnut Study Center*. The National Council of Researches founded a special Center of Studies and Researches on Chestnut at the Silviculture Station. The Center's aims have been: morphological and biological studies, inventories of chestnut stands, monographs, researches on utilization, etc.

13. *Forest Botany*. Great attention has been given to the establishment of arboreta: the oldest is at Vallombrosa (10 hectares), where more than 2,000 species of *Castanetum, Fagetum* and *Picetum* are cultivated. Another (2 hectares) has been established in Florence to collect species of *Lauretum*. The Aboretum Taurinense (37 hectares) in Turin, which is also under the supervision of the Silviculture Experiment Station, is becoming one of the most important in Europe; there are two other small ones at Monte Carpegna and at Passo del Furlo, Pesaro.

A Dendrological Museum and a herbarium, which were destroyed during World War II, had been established at Vallombrosa.

14. Also *didactic activity*, by the staff of the Silviculture Station, by the Forestry Faculty of the University of Florence, and by other University Institutes, is not to be forgotten.

RESUMES

La station expérimentale de sylviculture de Florence (Italie)

La Station expérimentale de Sylviculture a été créée à Florence en 1921, par le Professeur Aldo Pavari. Son objectif est d'assurer une meilleure connaissance et une amélioration générale de la sylviculture italienne.

Après une quarantaine d'années d'existence, nous pouvons aujourd'hui classer les problèmes existants sous cinq catégories principales de recherche:

a. Ecologie, botanique et génétique des forêts;
b. Monographie de diverses espèces (chêne, cyprès, mélèze, châtaignier, peuplier, etc.);
c. Sylviculture, techniques sylvicoles, reboisement et amélioration de la production forestière en Italie;
d. Introduction d'essences exotiques et développement de la culture d'arbres à croissance rapide; et
e. Contrôle de la carie des châtaigniers.

Il est bon de noter que cet institut a été créé seulement à titre de Station expérimentale de sylviculture et non pas en tant qu'institut complet de recherche forestière. Pour cette raison, ses travaux et ses recherches portent principalement sur l'écologie et la sylviculture dans les forêts et comportent peu de travaux de laboratoire.

Plus de 500 rapports, notes et études ont été publiés depuis l'origine de la Station par le Directeur et ses assistants.

Au cours de ces années, la plupart des activités de la Station expérimentale ont été concentrées sur des recherches en matière d'écologie forestière et sur l'introduction d'essences exotiques. On

peut citer tout d'abord la Classification des zones climatiques forestières de Pavari, qui doit être considérée comme le point de départ, le fondement même de l'école forestière naturaliste italienne. Cette étude fut suivie d'une série d'enquêtes sur l'influence des forêts méditerranéennes sur le climat.

Des expériences ont été faites avec plus de 200 essences exotiques, dans le but de trouver des essences à croissance rapide (et notamment des résineux) qui seraient introduites principalement dans les zones climatiques de Castanetum et Fagetum, dans le massif Apennin. De nos jours, grâce aux efforts du Professeur Pavari, *Pseudotsuga douglasii* est très répandu et est planté avec succès; d'autre part, *Abies cephalonica, Chamaecyparis lawsoniana, Pinus insignis*, etc. donnent des résultats satisfaisants, outre des peupliers, des acacias et des eucalyptus hybrides.

Les travaux réalisés comprennent la contribution apportée à la génétique forestière par les recherches effectuées sur les lignées et les origines (*Pinus sylvestris, Pinus pinaster, Pinus halepensis, Abies alba, Larix decidua, Pseudotsuga douglasii, Eucalyptus* spp., etc.) et la préparation d'un *Livre national des forêts à semence*, dans lequel sont enregistrés les meilleurs peuplements, dans les Alpes, dans les Apennins et dans la plaine: dans ces forêts sont recueillies les semences nécessaires au Service forestier d'Italie.

La Estación Experimental de Silvicultura en Florencia (Italia)

El profesor Aldo Pavari estableció la Estación Experimental de Silvicultura de Florencia en el año 1921. Su finalidad es la de permitir la adquisición de mayores conocimientos y un mejoramiento general de la silvicultura italiana.

En la actualidad, después de cuarenta años de existencia, podemos clasificar los problemas de acuerdo a cinco grupos principales de investigación:

a. Ecología forestal, botánica y genética.
b. Monografías sobre especies determinadas (robles, cipreses, alerces, castaños, álamos, etc.)
c. Silvicultura, dasocracia, plantación de bosques y mejoramiento de la producción forestal italiana.
d. Importación de especies exóticas y desarrollo de cultivos de árboles de crecimiento rápido.
e. Lucha contra el añublo del castaño.

Debe tenerse presente que esta institución ha sido establecida únicamente en calidad de Estación Experimental de Silvicultura y no como un Instituto de Investigaciones Forestales. Ello es el motivo fundamental de que sus trabajos e investigaciones se relacionan principalmente con la ecología y la silvicultura en los mismos bosques, y muy poco con trabajos de laboratorio.

Desde su creación, el director y sus ayudantes han publicado más de 500 informes, notas y estudios.

Durante estos años, la mayor parte de la labor de la Estación Experimental se concentró en las investigaciones en el campo de la ecología forestal y en la introducción de especies exóticas. En primer lugar, podemos recordar la Clasificación de Zonas Climáticas Forestales, de Pavari, que debe considerarse como punto de partida y base de la escuela naturalista italiana de silvicultura. A continuación se hicieron diversos trabajos de investigación sobre la influencia de los bosques mediterráneos en el clima.

Se han realizado experimentos con más de 200 especies exóticas; el objetivo de tales trabajos fue hallar especies de crecimiento rápido (particularmente coníferas) para ser llevadas a las zonas climáticas de Castanetum y Fagetum en los Apeninos.

Gracias a los esfuerzos del Profesor Pavari, en la actualidad se plantan en amplias zonas con buenos resultados especies tales como la *Pseudotsuga douglasii.* Asimismo, dan resultados satisfactorios el *Abies cephalonica, el Chamaecyparis lawsoniana, el Pinus insignis*, etc.; además de álamos híbridos, acacias y eucaliptos.

Entre los demás trabajos se hallan los aportes hechos a la genética forestal, con trabajos en el estudio de clases y orígenes (*Pinus sylvestris, P. pinaster, P. halepensis, Abies alba, Larix decidua, Pseudotsuga douglasii, Eucalyptus* spp., etc.) y la creación de un *Libro Nacional de Bosques para Semilla* en el que se registran las mejores existencias en los Alpes, los Apeninos y las llanuras. En estos bosques se recogen las semillas para satisfacer las necesidades del Servicio Forestal de Italia.

Mode et temps d'emploi de certains appareils mécaniques au cours de quelques opérations de culture appliquées aux pépinières de peupliers et aux peupleraies

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On connaît l'importance croissante que la culture du peuplier a prise dans le cadre de l'économie agraire privée ou collective; on connaît aussi les efforts accomplis, d'abord sous la direction et l'initiative de la Société anonyme des Papeteries Burgo, puis continués et développés par l'Organisme national pour la Cellulose et le Papier (Ente Nazionale per la Cellulosa e per la Carta) avec une remarquable ampleur de vues et de moyens, dans la recherche de nouvelles formes clonales susceptibles d'un rendement ligneux élevé et biologiquement résistantes à quelques-unes des plus graves attaques parasitaires.

A l'ample expérimentation biologique relative au peuplier, aux expériences pratiques continuelles et toujours en évolution, effectuées avec des moyens toujours plus modernes, s'ajoutent les relevés et les résultats économiques qui tracent le cadre de la populiculture et montrent à quel point cette culture est dynamique et susceptible de variations sensibles.

Cet article a pour seul but de faire connaître les résultats de quelques opérations de culture dans l'espoir de suggérer une enquête et une expérimentation ultérieures afin d'obtenir des critères et des moyens toujours plus propices à une culture économique.

Indiquons tout d'abord que les résultats rapportés ici sont relatifs aux opérations effectuées sur la propriété expérimentale "Mezzi," annexe de l'Institut d'Expérimentation pour la populiculture "Casale Monferrato" et que, par conséquent, ces résultats n'ont pas une portée générale, mais sont donnés à titre d'information.

Pour faire mieux comprendre la signification des chiffres que nous rapportons ici, faisons une brève description du milieu pédologique dans lequel on a opéré. L'établissement agricole "Mezzi" est formé de terrains alluviaux récents; ce sont des dépôts sédimentaires successifs des eaux du Pô en crue et, du point de vue physique, de composition et de structure sensiblement différentes d'une zone à l'autre.

Des analyses physico-mécaniques effectuées sur de nombreux échantillons prélevés en des zones diverses, il résulte que le terrain le plus largement représenté a la composition physique suivante:

sable (de 2 à 0,05 mm.)	81%
limon (de 0,05 à 0,01 mm.)	12%
argile (< 0,01 mm.)	7%

Il s'agit donc de terrains qui, par leur forte teneur en sable, sont friables, légers, et en tant que tels, offrent une relative résistance à la pénétration des outils dont ils produisent une forte usure.

Pour mieux représenter le milieu, rapportons quelques observations phytosociologiques faites par le professeur R. Tomaselli et publiées dans le volume XXXV (année 1959) des "Archives Italiennes de Botanique et de Biogéographie."

"L'analyse phytosociologique de la végétation constituant la couche herbacée montre une notable différence entre les deux zones observées, en rapport avec le type du sol et les différences de développement des peupliers. . . ."

"Du point de vue phytosociologique, il apparaît clairement que, sur un sol défavorable à la croissance du peuplier, il se développe un tapis herbacé à dominance d'Erigeron canadensis, et, sur le sol favorable, de Solidago seretina."

Et le docteur Tomaselli conclut:

"Sur la base des résultats écologiques réunis dans la présente étude—qui doit être considérée comme préliminaire—on peut dire que les caractères les plus importants pour distinguer les zones qui se prêtent bien à la culture agraire du peuplier sont: un terrain friable, de composition moyenne (sable avec limon et argile, à faible teneur en gravier) humide, avec une nappe d'eau oscillant jusqu'au niveau de la rhizosphère, plutôt neutre, avec une certaine teneur en carbonates et bien aéré."

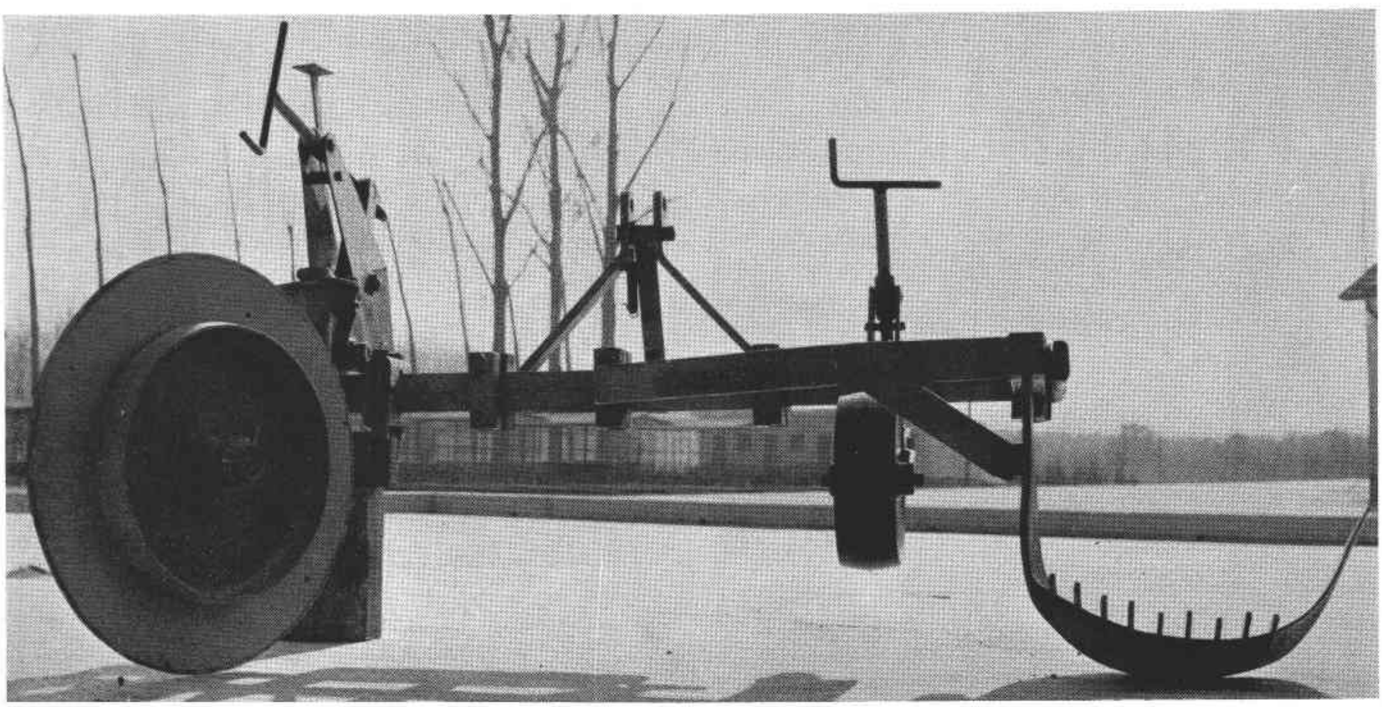
Ces conditions sont celles de la meilleure partie des terrains de l'établissement "Mezzi," tandis que l'analyse rapportée ci-dessus reflète la moyenne des caractéristiques physico-mécaniques du terrain sur lequel on a opéré.

Pépinières

Extirpation des jeunes peupliers

On a attaché une importance toute particulière à la rationalisation et à l'uniformisation des opérations d'extirpation des jeunes peupliers. A l'extirpation à la main, moyen lent et assez coûteux, on a substitué l'extirpation mécanique menée avec un outillage de plus en plus apte à garantir des opérations correctes et économiques. Aujourd'hui dans les pépinières de l'"Ente Nazionale per la Cellulosa e per la Carta" sont en fonction, tirés par des véhicules (tracteurs) des engins spéciaux qui prennent les noms de "lame-taupe" (lama-talpa) et de charrue "Populus". Le premier appareil, construit par la C.E.M., Via Aurelia 678, Rome, en collaboration avec les techniciens de l'"Ente Nationale par la Cellulose e per la Carta", est monté sur un tracteur à chenille, tandis que le second, construit par l'entreprise S.A.F.I.M.A., Via Stazione 13 A, Crema, est appliqué à des tracteurs sur pneus.

Dans les deux cas, il s'agit d'un corps tranchant constitué par une lame recourbée vers le haut (un C couché)



Charrue "Populus" pour l'extirpation mécanique des jeunes peupliers.

qui, pénétrant à 30 ou 35 cm. de profondeur, garantit une bonne coupe des racines autour des jeunes peupliers de telle façon que leur déplacement à la main est rendu très aisé.

Pour démontrer le bénéfice économique que l'introduction de l'extirpation mécanique a apporté à l'industrie des pépinières, nous rapportons les résultats relatifs à:

—l'extirpation à la main
—l'extirpation au moyen d'une charrue normale équipée à cet effet
—l'extirpation au moyen de la charrue "Populus".

Extirpation à la main des jeunes peupliers. A la suite de nombreux relevés, il résulte qu'un homme peut extirper en moyenne 11 jeunes peupliers à l'heure. Ce chiffre peut varier même sensiblement surtout selon le développement des jeunes peupliers et de leurs appareils radicaux, et selon la nature du sol; en effet, sur un pourcentage élevé de sujets appartenant à la catégorie extra (plus de 15 cm. de circonférence à 1 m. de hauteur) ce chiffre diminue, car l'opérateur manuel se trouve aux prises avec une plus forte résistance offerte par un plus robuste appareil radical du jeune peuplier.

En moyenne, pour 1.000 jeunes peupliers, il faut 110 heures d'ouvriers manuels.

Extirpation au moyen d'une charrue équipée à cet effet. Il s'agit d'une charrue normale à un seul soc, munie de manches orientés de manière que les ouvriers manuels (2 ouvriers) puissent conduire l'engin tiré par le tracteur. Les temps relatifs à la seule extirpation de 37.984 jeunes peupliers sont les suivants:

—nombre d'heures de travail pour le conducteur du tracteur 41
—nombre d'heures de travail pour les ouvriers (No 2 x 41) 82
—nombre d'heures de travail pour le tracteur 41

D'où l'on déduit que pour extirper 1.000 jeunes peupliers il faut:

1^h 1′ en moyenne pour le conducteur du tracteur;
2^h 2′ en moyenne pour les ouvriers manuels (No 2);
1^h 1′ en moyenne pour le tracteur;

Extirpation au moyen de la charrue "Populus". Appliquée à un tracteur sur pneus d'une puissance de 50 cv environ, la charrue "Populus" réclame l'intervention d'un conducteur de tracteur et d'un ouvrier manuel, ce dernier ayant pour tâche de corriger la position des peupliers qui pourraient éventuellement être endommagés par le corps tranchant de la charrue.

Des nombreux essais effectués dans la propriété Mezzi, dans des conditions normales de terrain, il résulte que le nombre moyen de jeunes peupliers extirpés en une heure est de 1.500. On a donc:

—0^h 40′ de travail pour le tracteur et pour 1.000 jeunes peupliers extirpés;
—0^h 40′ de travail pour le conducteur du tracteur et pour 1.000 jeunes peupliers extirpés;
—0^h 40′ de travail pour l'ouvrier manuel et pour 1.000 jeunes peupliers extirpés.

Nous dirons donc que: La comparaison des prix de revient des procédés d'extirpation décrits ci-dessus, pour 1.000 jeunes peupliers de 2 ans, ressort clairement dans le tableau ci-dessous, où on a transcrit les indices calculés sur la base du coût d'une heure de travail de l'ouvrier manuel égal à 100, auquel on a rapporté le coût d'une heure de travail du conducteur et du tracteur, et où on a multiplié l'indice de base et les indices calculés comme nous l'avons dit, avec les heures de travail respectives de la main-d'oeuvre, du tracteur et du conducteur pour l'extirpation de 1.000 jeunes peupliers selon les 3 procédés indiqués précédemment.

	à la main	**avec une charrue normale**	**avec la charrue Populus**
Main-d'oeuvre	11.000	203	67
Conducteur		105	68
Tracteur		226	148
	11.000	534	283
Pourcentage	100%	4,85%	2,57%

Les pourcentages rapportés sur ce tableau soulignent les progrès réalisés dans la recherche d'un outillage d'emploi toujours plus économique, et indiquent que le prix de revient du travail d'extirpation effectué dans l'unité de temps au moyen de la charrue "Populus" est égal à 1/40 environ du travail effectué à la main, et à un peu plus de ½ de celui effectué au moyen d'une charrue normale pourvue des manches disposés à cet effet, que nous avons précédemment mentionnés.

Traitement antiparasitaire

La défense phytosanitaire de la production des pépinières a été mise en oeuvre par l'annexe de l'Institut d'Expérimentation pour la Populiculture grâce à l'emploi du pulvérisateur Kiekens Dekker type 508 D, pourvu d'un moteur indépendant de 12 cv, tiré par un tracteur de 25 à 30 cv. Sans nous appesantir sur la description de l'appareil, nous passons à l'indication des résultats relatifs aux traitements exécutés durant la mi-septembre 1958 sur la pépinière de lère année de végétation où les sujets, espacés de O m., 80 sont disposés sur des files établies à 1 m., 80 l'une de l'autre.

—9 ha., 58 traités avec 66.000 jeunes peupliers du clone I-214.
—Insecticides employés: Thiogamme normal 20% kg. 48 solution au 1% Arséniate de plomb SIPCAM kg. 96 solution au 2% } total solution au 3%.
—Eau fournie hl. 47,60.
—Durée du traitement 15 heures (y compris le temps employé au nettoyage des gicleurs).
—Hauteur moyenne des arbustes: 4 m.
—Surface totale moyenne du feuillage pour chaque arbre (surface de la face inférieure + surface de la face supérieure) 23,4 m.² environ.
—Vitesse du tracteur variable de 2 km. à 2,500 km.
—Distribution au moyen de 8 gicleurs disposés en éventail.
—Passage du pulvérisateur: une allée sur trois.

Nous reportons ici les résultats concernant:

	consommation d'eau	**consommation d'insecticide**	**temps**
1 hectare	4,97 hl.	15 kg.env.	$1^h 33'$
et encore:			
1 peuplier	0,072 l.env.	2,2 gr.env.	

Pour un traitement insecticide exécuté à la même époque sur une pépinière de 2ème année de végétation, où les sujets sont espacés de 2,20 m. x 0,60 m. les résultats sont les suivants:

—4,50 ha. traités avec 34.000 jeunes peupliers du clone I-214.
—Insecticides employés: Thiogamme normal 20% kg. 17,5 solution au 1% Arséniate de plomb SIPCAM kg. 35 solution au 2% } total solution au 3%.
—Eau fournie 17 hl.
—Durée du traitement 5h 30′ (y compris le temps de nettoyage des gicleurs).
—Vitesse du tracteur 4 km. environ (vitesse rendue possible par la grande distance entre 2 files et par l'absence de basses branches, celles-ci ayant été taillées pour permettre les opérations d'enveloppage de garantie pour lesquelles une bonne visibilité du jeune peuplier est indispensable).
—Distribution par gicleur unique à cause de la hauteur des peupliers (8 m. environ).
—Passage du pulvérisateur dans chaque allée.

Nous reportons ici les résultats concernant:

	consommation d'eau	consommation d'insecticide	temps
1 Hectare	2,45 hl.	13,1 kg. env.	1h30′
et encore:			
1 peuplier	0,05 l.	1,5 gr. env.	

Si nous pensons à tous les insectes qui s'installent dans la pépinière, en en compromettant l'état sanitaire, il apparaît évident que pour assurer une protection efficace il faut intervenir à temps, et à plusieurs reprises, de façon à porter à terme les opérations avant que les insectes ne se trouvent en mesure d'échapper à l'action de l'insecticide.

Par conséquent, seul un outillage adéquat et un personnel spécialisé pourront permettre une protection du vivier rapide et efficace, de telle façon que les dégâts causés par les insectes soient maintenus dans des limites tolérables.

Peupleraies

Examinons la protection des cultures de peupliers contre les attaques du *Stilpnotia salicis* lépidoptère qui, infestant des superficies toujours plus grandes, provoque d'importants dégâts aux peupliers et éveille de légitimes inquiétudes chez les populiculteurs.

Nous rapportons ici les résultats du traitement effectué dans les établissements agricoles "Mezzi" en août 1959. L'envahissement du Stilpnotia sur 63 ha. env. était si intense qu'il aurait causé un défeuillement complet des arbres si l'on n'était intervenu à temps par l'aspersion de solutions insecticides.

La lutte a été menée au moyen du pulvérisateur K. D. Goliath tiré par le tracteur Landini de 45 cv.

L'appareil susdit a les caractéristiques suivantes:

a. un moteur indépendant Perkins de 65 cv. actionnant un ventilateur de 90 cm. environ;
b. un réservoir de la capacité de 1 m.^{3} de solution insecticide;
c. un tuyau de lancement unique orientable horizontalement et verticalement;
d. une faible consommation d'eau (de 600 à 1.200 litres à l'heure).

Etant donné la puissance élevée du moteur la solution insecticide réduite en minuscules gouttelettes est soulevée par la colonne d'air jusqu'à une hauteur d'environ 30 m. et peut ainsi atteindre la cime des peupliers adultes.

Pour le traitement effectué sur 16.500 arbres environ, on a employé l'arséniate de plomb uni à un adhésif et on a procédé de telle façon qu'à chaque passage de l'appareil soit traitée une file entière d'arbres espacés de 6 m. sur 6 m. ou de 6,50 m. x 5,63 m.

Nous reportons ci-après les relevés effectués:

—nombre d'heures de traitement avec le Goliath = 59½
—nombre d'heures de tracteur = 82½
—consommation d'eau = 475 hl.

Consommation de l'insecticide:

—arséniate de plomb SIPCAM 11,05 ql.
—adhésif SIPCAM 0,225 ql.
—concentration de la solution: variable du 2% au 2,5%

Résumons les résultats relatifs à:

	Consommation d'eau	Consommation d'insecticide	Temps Goliath	Temps tracteur
1 hectare	7,54 hl	17,53 Kg.	Oh,56′	1h,18′*
1 arbre	2,88 l.	67 gr.		

*la différence de 22 minutes entre les temps d'emploi du pulvérisateur et du tracteur est représentée par le retour à la ferme pour remplir le réservoir avec la solution insecticide et de l'aller jusqu'à la peupleraie pour la poursuite du traitement.

Soulignons le fait que durant l'année 1959 des surfaces d'infection étendues le long de la vallée du Pô ont été signalées et que, à cause de l'insuffisance ou du manque absolu d'outillage, d'ailleurs plutôt coûteux, de larges régions plantées de peupliers apparaissaient au début de l'été dans un état navrant de défeuillement dont l'influence sur la croissance des arbres est facile à imaginer.

Pour les peupleraies, comme pour les pépinières, se pose donc le problème de la protection économique contre les dégâts, très importants et dont on n'a souvent pas assez conscience, et provoqués par une action des insectes, persistante, insidieuse et qui parfois ne se manifeste pas immédiatement.

La faculté de se procurer un outillage toujours plus moderne et plus rationnel et en même temps, la faculté d'emploi d'insecticides toujours plus efficaces, permettront une expérimentation destinée à réaliser une organisation de la protection phytosanitaire de la production adaptée à l'importance que la populiculture revêt dans l'économie de notre pays, et surtout à une intervention "rapide" de manière à pouvoir enrayer l'invasion des insectes dès les premières manifestations.

RESUMES

Method and Time of Using Certain Mechanical Equipment During Some Operations in Poplar Nurseries and Plantations

The development and improvement of mechanization in agriculture has also benefited the work of digging up two-year-old poplar trees for transplanting. In fact, the use of a special grubbing plow called "Lamatalpa" mounted on a caterpillar tractor, or of the "Populus" plow on a rubber-tired tractor, has

afforded considerable savings, in addition to speed and timeliness, in performing this work.

Tests made in the loose, light soils of the Mezzi acreage adjoining the Poplar Culture Institute at Casale Monferrato, Italy, showed that when the "Populus" plow is used for the digging, the cost in time is about 1/40 that of the operation by hand and slightly more than ½ that of the operation by an ordinary plow equipped with suitable steering handles.

Considerable progress in protecting seedling beds and industrial poplar plantations from the attacks of various insects has been made through the use of small-capacity atomizers. When of the proper size and power, these atomizers now make it possible to keep the beds or plantations in a healthy condition at a low cost, since speed and timeliness of intervention are essential to effective protection against plant parasites.

In fact, with the equipment tested, a one-hectare bed of 1- and 2-year-old seedlings can be sprayed in 1½ hours, and one hectare of adult poplars in about one hour.

However, protection will be really effective only if it is carried out by an efficient organization that is ready to take action at the first sign of insect infestation.

Modo y Tiempo de Emplear Ciertos Aparatos Mecánicos en el Curso de Ciertas Operaciones de Cultivo Aplicadas a Viveros y Almácigas de Alamos

El desarrollo y mejoramiento de la mecanización de la agricultura ha aportado sus ventajas también a los trabajos de transplante de los álamos de dos años. En efecto, la aplicación de un cierto arado, el llamado "Lamatalpa," empleado con los tractores a oruga, o del arado "Populus" con los tractores de ruedas, ha hecho posible una considerable economía, como también una celeridad y oportunidad notables en los trabajos de transplante.

De los relieves ejecutados en los terrenos sueltos y finos de la Granja Messi, anexa al Instituto de Cultivación de Alamos de Casale Monferrato, Italia, ha resultado en que con el arado "Populus" el costo del transplante por unidad de tiempo sea igual a 1/40 aproximadamente del transplante a mano, y poco más de la mitad cuando se emplea el arado normal equipado de manceras adecuadas para la dirección.

En el campo de la protección de la producción de semilleros y de las plantaciones de álamos destinadas a uso industrial, contra los numerosos ataques de parásitos, ha habido mucho progreso en el empleo de los pulverizadores de bajo volumen. Estos, de potencia indicada, hoy permiten asegurar una sanidad excelente en los cultivos arriba mencionados sin gastos exagerados, así como también la intervención rápida y oportuna, condiciones estas que son fundamentales para una defensa eficaz contra los ataques de parásitos.

Efectivamente, con los equipos experimentados es posible tratar una hectárea de una almáciga de semilleros de 1 ó 2 años en cerca de una hora y media, una hectárea de álamos adultos en cerca de una hora.

Al mismo tiempo, la defensa será realmente activa si se efectúa sobre la base de una organización eficiente que permita una rápida intervención al primer brote de las infestaciones de insectos.

Quelques aspects de l'aménagement au Portugal

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Pour l'aménagement d'une forêt il est indispensable de tenir compte de la biologie des peuplements et ce principe se maintient même si l'on crée des conditions artificielles de production. Par conséquent, on ne peut pas envisager l'aménagement comme un fait isolé, mais on doit étudier le problème de manière que la sylviculture et l'aménagement se complètent mutuellement.

Pour mieux encadrer les matières que nous allons exposer, concernant quelques problèmes forestiers du Portugal continental et qui, par conséquent, se rapportent à la zone tempérée et semi-aride, nous analyserons séparément les forêts sous l'administration directe des Services officiels et celles qui appartiennent à des propriétaires privés.

Deux raisons nous incitent à faire cette spécification: l'importance que prend au Portugal la forê privée et le fait que normalement à chacun des cas mentionnés correspondent des exploitations se proposant des buts différents.

En ce qui concerne les forêts sous l'administration des Services officiels, nous ne nous occuperons que de celles des dunes du littoral et des régions montagneuses.

Dans la bande sous l'influence maritime, on trouve des conditions assez favorables au développement du *Pinus pinaster* Sol. ex Ait., mais la formation d'alios que l'on y a constaté peut toutefois compromettre la manutention de ces peuplements. On essaie de résoudre ce problème, et ce n'est que grâce aux résultats obtenus que l'on pourra déterminer l'orientation à suivre.

Les méthodes d'aménagement adoptées dans ces forêts suivent l'école française, mais sont basées sur l'école allemande. Bien que présentant quelques inconvénients, dont le principal est une certaine raideur, il nous semble, pour des raisons que l'on exposera plus loin qu'on doit continuer à les adopter mais en essayant toujours de les rendre plus souples.

Le régime adopté est celui de la futaie. Grâce aux résultats obtenus, on a constaté les avantages d'un traitement régulier par des coupes rases, suivi de la préparation du terrain et de l'ensemencement artificiel; la régénération naturelle des peuplements s'effectue en des conditions déficientes, déterminant une mise-à-profit incomplète du capital-terre et l'obtention d'arbres d'utilisation réduite, l'exploitation devenant alors, par ce fait, peu rentable.

Pour bien comprendre l'intérêt que ces peuplements présentent au Portugal, il suffit de dire qu'ils produisent la presque-totalité du bois de bonne qualité et de grandes dimensions. On sera ainsi en mesure de comprendre la manière dont il faut envisager l'exploitation et tout l'avantage que présentent les pratiques artificielles. Conformément aux principes énoncés, on adopte l'exploitation économico-sociale, la révolution étant fixée entre 80 et 90 années puisque après ce délai les individus sont menacés d'être détruits par le *Trametes pini* (Brot.) Fr.

Toutes les opérations culturelles ont pour but l'amélioration de la qualité des produits et ainsi, jusqu'au commencement de la futaie, les peuplements sont très denses, ce qui retarde la croissance mais permet l'obtention d'un bois de meilleure qualité.

Dans les forêts littorales on envisage toujours la constitution des zones de protection ayant pour but de réduire les dégâts que les vents maritimes pourraient occasionner dans les peuplements susceptibles d'être exploités. La nature du sol rendant difficile la régénération, il ne faut pas dénuder le terrain dans ces zones de protection.

En ce qui concerne les régions montagneuses, on n'exécute actuellement que des travaux préliminaires d'aménagement, ces peuplements, n'ayant pas atteint, d'une manière générale, l'âge normal d'exploitation. Ici encore, on remarque la prédominance du pin maritime. Si l'on considère les conditions écologiques de ces régions et surtout le fait que les sols sont souvent très dégradés, on comprendra aisément les motifs qui ont présidé au choix de cette espèce comme pionnier. Le pin maritime est en effet au Portugal l'une des espèces les plus rustiques et les plus adaptables, ce qui lui permet d'atteindre des zones en dehors de son habitat.

Quand les conditions écologiques sont nettement défavorables, cette espèce ne peut pas dépasser 50 ans dans des conditions sanitaires satisfaisantes, mais, au cours de ce délai, elle remplit le rôle qui lui a été assigné, rendant possible sa substitution par d'autres espèces présentent plus d'intérêt. On affectue alors graduellement des coupes successives permettant de la remplacer par des espèces plus appropriées, en n'éliminant tout à fait le pin maritime qu'après avoir complètement constitué ces peuplements.

Ces travaux sont d'ailleurs réalisés avec des plans établis au préalable.

Il ne faut pas, toutefois, déduire de ce que nous venons d'exposer que l'on a exclusivement employé le pin maritime dans le reboisement des régions montagneuses. Chaque fois qu'il était possible de le faire, on a introduit d'autres espèces tant par ensemencement artificiel que par plantation, et nous avons aujourd'hui des peuplements d'espèces autochtones et exotiques telles que le *Quercus* spp.; *Castanea sativa* Mill.; *Pseudotsuga menziesii* (Mirb.) Franco; *Pinus sylvestris* L.; *Larix decidua* Mill.; *Betula celtiberica* Rothm. et Vasc.; *Abies alba* Mill.; *Pinus radiata* D. Don et d'autres encore.

En adoptant une politique de protection efficace alliée à un ensemble de pratiques culturelles favorables, on a pu aussi développer quelques forêts climatiques.

En tenant compte des aspects que nous avons mentionnés, c'est au technicien qu'il appartient de décider quelle sera l'orientation à suivre.

En ce qui concerne le pin maritime, il nous semble qu'il serait préférable, le tempérament de l'espèce ne permettant pas la régénération naturelle des peuplements, en plus de la méthode de substitution que nous avons mentionnée, d'effectuer des coupes rases dans des zones restreintes pour permettre l'introduction de nouvelles espèces, ou alors la régénération de la forêt de pins quand les conditions ne semblent pas propices à l'adoption de la première méthode mentionnée. On obtient aussi, par un traitment régulier, quelques-uns des avantages d'un traitement irrégulier. Sur les essences exotiques nous ne possédons pas, en ce moment, d'éléments nous permettant d'établir une orientation précise. On croit possible d'envisager, dans certains cas, le traitement irrégulier et il faut alors le mettre à exécution. Pour d'autres cas comme, par exemple, le bouleau, il faut prévoir un régime de taillis présentant des avantages considérables dans les régions montagneuses.

Il est, du reste, évident, que l'exploitation devra être fonction de certains facteurs surtout ceux qui se rapportent à la conservation du sol. Quant les conditions deviennent extrêmement défavorables, il faut envisager la constitution de forêts de protection.

Dans la culture forestière, on ne pourra remédier aux erreurs commises que longtemps après.

Au Portugal, où la propriété forestière privée prend une telle importance, il nous est absolument indispensable d'avoir une législation adéquate si l'on ne veut pas se trouver en face de problèmes vraiment très graves.

Bien que l'on se soit efforcé depuis longtemps d'établir des dispositions tendant à protéger la forêt, la législation en vigueur est encore, sauf en ce qui concerne le liège, bien insuffisante.

Les inconvénients qui en résultent sont encore aggravés par le fait que la propriété forestière est, dans la plupart des cas, très morcelée, ce qui crée des problèmes techniques difficiles pour l'exploitation et ne permettant pas de la considérer rationnellement dans son ensemble. Pour être en mesure d'orienter cette exploitation, il faudrait envisager le remaniement de la propriété forestière—problème qui est déjà, d'ailleurs, à l'étude.

Pour les propriétés dont l'étendue assez vaste permet de les considérer comme des unités indépendantes d'exploitation, il faut absolument qu'elles soient soumises à des plans individuels, ayant pour but l'adoption de procédés techniques conduisant à une meilleure productivité.

Il faut, toutefois, dans les deux cas envisagés, pour éviter un déséquilibre entre la production et la consomation, que l'exploitation soit intégrée dans le cadre d'un plan national.

Nous allons maintenant rapporter quelques aspects de l'exploitation de la propriété privée. La nature même de ce rapport ne permettant pas des références détaillées à toutes espèces forestières, nous analyserons seulement le cas du pin maritime, du chêne-liège (*Quércus suber* L.) du chêne-vert (*Quercus Ilex* L.), la première étant une espèce d'importance fondamentale au nord du fleuve Tejo ou prédominent les propriétés d'aire très réduite et les deux autres intéressant une vaste zone au sud du même fleuve ayant des caractéristiques écologiques bien définies et où ces espèces jouent un rôle capital.

Et il nous semble, d'ailleurs, que quelques-uns des problèmes énoncés à propos de la propriété privée présentent plus d'acuité en ce qui concerne ces espèces. L'exploitation des peuplements de pin maritime est, d'une manière générale, assez mal orientée, tendant presque toujours à une exploitation absolue ou financière.

On adopte le plus possible la méthode de régénération naturelle des peuplements surtout dans les cas où leur superficie très réduite rend difficile l'emploi d'autres méthodes mais sans, toutefois, tenir compte du fait que cette espèce ne s'adapte pas bien à un traitment irrégulier.

Les peuplements présentent donc ce que l'on pourra considérer simplement comme une tendance au jardinage; ils sont peu denses et la distribution des arbres suivant leur âge n'est pas faite d'accord avec les règles établies, ces facteurs conduisant nécessairement à une mise-à-profit technologique insuffisante.

Il est nécessaire de souligner que, comme on le sait, même en des conditions favorables, le traitement irrégulier exige une technique plus spécialisée et par ce fait même, plus onéreuse.

Dans la plupart des peuplements, on pratique le gemmage ce qui représente une contribution importante au revenu de la forêt de pins, la production moyenne par acre étant évaluée à deux kilogrammes.

En ce qui concerne le chêne-liège et le chêne-vert, il faut remarquer que les peuplements ne sont pas en général nettement forestiers; ce qui existe c'est surtout une association agro-forestière de la forêt et de la culture agricole où l'aire couverte par hectare est inférieure à ce qui est établi comme normal (et qui pour le chêne-liège par exemple, est évalué à 5.800 ou 5.900 mètres carrés).

Cette solution n'est pas à conseiller surtout dans les stations moins favorables, étant donné que les pratiques indispensables à la culture des céréales favorisent l'érosion et détruisent la régénération naturelle. On n'a aucun avantage à maintenir ces cultures qui parfois ne représentent aucun avantage et qui contribuent à la dégradation du sol. Pour la production du liège et du fruit on adopte l'exploitation du type extra-forestier. Dans les conditions où ces espèces poussent au Portugal, on doit adopter comme règle le régime de futaie avec traitement irrégulier étant donné que la régénération naturelle—assez satisfaisante surtout en conséquence de la densité réduite—est le procédé le plus économique et efficace pour assurer la continuité des peuplements. Ce traitement serait avantageux surtout parce que l'obtention du bois n'est pas l'objectif principal. Quand les peuplements commencent à produire, la seule opération culturelle que l'on y effectue est l'élagage, opération fondamentale pour créer des conditions favorables au type d'exploitation adoptée. Ces élagages doivent se faire avec modération, mais malheureusement dans certains cas on procède à des élagages excessifs ayant pour but l'obtention d'une meilleure qualité de bois et qui affectent considérablement le bon développement des arbres. Au Portugal, la manière la plus avantageuse d'exécuter le décorticage est de l'effectuer en une seule fois, les arbres supportant mieux cette opération que sa répétition à brefs intervalles, c'est-à-dire la récolte étagée.

D'accord avec la législation en vigueur, le décorticage se fait à des intervalles de 9 ans. On doit exécuter cette opération de la fin mai au commencement d'août, cette époque étant considérée comme la plus favorable.

L'exploitation ne doit pas dépasser 150 ou 200 ans, car après ce délai, la manutention des peuplements n'est plus rentable. La production moyenne annuelle du liège par hectare est d'environ 240 kilogrammes. Par rapport au fruit on peut évaluer les productions moyennes annuelles par hectare à 180 et 80 kilogrammes, respectivement, pour le chêne-vert et le chêne-liège.

Il nous faut donc conclure de ces observations sur l'exploitation de la propriété privée que l'on n'y a pas toujours adopté la technique la plus favorable. On doit, toutefois, remarquer qu'aux environs des forêts administrées par les Services officiels, l'exploitation est nettement plus satisfaisante.

Actuellement, les forêts industrielles ou intensives suscitent le plus grand intérêt. C'est même une tendance sylvicole actuelle nettement marquée, et en conséquence de ce fait la culture de l'eucalyptus, surtout le *Eucalyptus globulus* Labill., prend une importance croissante. Ces peuplements sont, d'une manière générale, sous le régime de taillis avec des révolutions moyennes de 9 à 10 ans, les productions moyennes étant de 10 à 15 mètres cubes par an et par hectare.

Plus récemment, les peuplements de clones améliorés de peuplier ont joué un rôle de plus en plus important, leur culture étant considérée très prometteuse.

RESUMES

Some Aspects of Management in Portugal

The authors state why they consider management and silviculture interdependent and explain the reasons that led them to treat aspects concerning privately owned woodlands separately from those concerning forests under the direct administration of government agencies.

In discussing the latter, they take up first of all coastal forests and state why artificial regeneration of stands is more advantageous and mention the cultural practices adopted, pointing out the existence of protective areas near the sea.

In analyzing the problem of stands in mountainous regions, the authors describe their present condition, indicating some possible future solutions, taking into account the characteristics of these stands and the need to resort, in extreme cases, to protection forests.

The authors show the importance of private ownership of woodlands in Portugal and point out the need for incorporating the utilization of such woodlands into a national program.

They describe certain deficiencies noticed in the utilization of species that are of most interest to private ownership and the favorable effect of techniques adopted by governmental agencies.

Finally, they take up intensive and industrial forests, which are obviously the trend in silviculture today, describing some aspects of *Eucalyptus globulus* and improved clones of the poplar.

Varios Aspectos de la Administración de Bosques en Portugal

Los autores exponen las razones que les hacen considerar la administración y la silvicultura como interdependientes y explican las que les condujeron a tratar aparte los aspectos relativos a los bosques particulares y los bosques administrados directamente por los servicios oficiales

En este último caso, tratan, en primer lugar, los bosques del litoral y las razones que hacen más ventajosa la regeneración artificial de las poblaciones arbóreas, así como los sistemas de cultivo adoptados, y destacan la existencia de zonas de protección cercanas al mar.

Al analizar el problema de las poblaciones de regiones montañosas, presentan una relación de su aspecto actual e indican varias soluciones posibles en el futuro, teniendo en cuenta las características de las poblaciones y la necesidad de recurrir, en casos extremos, a bosques de protección.

En lo referente a la propiedad particular de bosques, exponen la importancia que ésta tiene en Portugal e indican la necesidad de integrar obligatoriamente su explotación en un plan nacional.

Recalcan deficiencias que se observan en la explotación de especies que más interesan a la propiedad particular y la influencia favorable de las técnicas adoptadas por los servicios oficiales.

Finalmente, tratan de los bosques intensivos e industriales que, evidentemente, son tendencia de la silvicultura actual e indican varios aspectos del *Eucalyptus globulus* y de los conjuntos de las plantas provenientes de la multiplicación vegetativa.

Modificación de los Tratamientos Silviculturales En Bosques Subtropicales Argentinos

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En los bosques subtropicales argentinos el tratamiento común de reproducción forestal natural es la entresaca, que comprende el corte y extracción de árboles que superan un diámetro determinado como límite inferior de madurez o cortabilidad.

Como se trata de bosques con muchísimas especies de mayor y menor valor comercial, entremezcladas uniformemente, la entresaca abarca sólo los individuos de valor, dejándose en pié los demás. Al no reponerse las primeras, aumenta comparativamente el número y volumen de las segundas, y como esa disminución de las especies de valor se produce en forma incesante, se llegará un momento a su completa desaparición.

En las llanuras de las Provincias de Santa Fé, Chaco, Santiago del Estero y Formosa, las principales especies valiosas son "quebracho colorado chaqueño" (*Schinopsis balansae*), "lapacho negro" (*Tabebuiaipe*), "urunday" (*Astronium balansae*), "guayaibí" (*Patagonula americana*), "guayacán" (*Caesalpinia paraguariensis*), "quebracho blanco" (*Aspidosperma quebracho-blanco*) "quebracho colorado santiagueño" (*Schinopsis lorentzi*), "algarrobo blanco" (*Prosopis alba*), etc., y en la Provincia de Misiones, "cedro misionero" (*Cedrela tubiflora*), "cancharana" (*Cabralea oblongifoliola*), "grapia" (*Apuleia leiocarpa*), "pino paraná" (*Araucaria angustifolia*), "guatambú blanco" (*Balfourodendron riedelianum*), "guatambú amarillo" (*Aspidosperma olivaceum*), "incienso" (*Myrocarpus frondosus*), "loro negro" (*Cordia trichotoma*), etc.

La regeneración natural de la mayoría de dichas especies, prácticamente no se produce en los bosques subtropicales, tupidos y enmarañados. Los lugares en que se han efectuado cortas, no se recuperan tan fácilmente como sería de desear, por la gran competencia que existe entre tantas especies. En estas circunstancias hace falta la intervención de la técnica forestal, para dirigir artificialmente la reproducción de los árboles que más interesen.

El método más común y bien conocido para ello, es la tala rasa de todos los árboles, seguida por la plantación de las especies convenientes. Pero en los bosques subtropicales este método es de éxito inseguro y por lo tanto no recomendable, debido a la acción perjudicial de los fuertes rayos solares y de las frecuentes heladas, que queman las plantas jóvenes, expuestas a ellos sin protección alguna sobre grandes superficies cortadas a tala rasa.

Vemos entonces que la plantación y regeneración de árboles en los bosques subtropicales se encuentran amenazadas e imposibilitadas por dos factores extremos, que son la falta de luz cuando se aplica la entresaca, y la luz perjudicial, por exesiva, cuando se emplea la tala rasa.

En los bosques de clima templado, existen también estos dos inconvenientes, y para contrarrestarlos se aplica el método conocido por "cortas a clareos sucesivos," que dá protección a las plantas jóvenes, igualmente como sucede con la "entresaca." De estos dos métodos, el primero no se puede aplicar en los bosques subtropicales argentinos debido a que en su mayor parte no están constituidos por masas arbóreas regulares coetáneas, y por lo tanto no se dispone de número suficiente de árboles portagranos de valor, bien distribuidos por cada extensión de corta a fin de facilitar la diseminación y abrigo de las plantas. La entresaca tampoco conviene, ya que, como hemos dicho precedentemente, conduce a la paulatina degradación de la existencia forestal, al reducir las especies de valor.

De esta manera la reproducción natural resulta imposible en los bosques subtropicales de estructura irregular disetánea, habiéndose introducido, para resolver el problema, el método de reforestación artificial combinado con la protección que brindan los árboles adultos reservados con este fín.

Con ese propósito se realizaron en Establecimientos Forestales de la Administración Nacional de Bosques, ensayos aplicando este método, obteniéndose resultados satisfactorios, lo que permite utilizarlos en escala más amplia, es decir, directamente en los bosques. A continuación se explica brevemente la técnica empleada en dos casos distintos, en superficies con árboles y en terrenos desarbolados.

En Superficies con Bosques

1. Se realiza el corte de los árboles en dos etapas, extrayéndose primeramente aquellos que no serán necesarios para abrigo del futuro nuevo repoblado, dejándose sin cortar los pies aptos para protección, teniendo presente su distribución adecuada y uniforme sobre toda la extensión de la corta. Las especies no aptas para industrializar, se utilizan para elaboración de carbón y como leña, progresando cada vez más su producción.

2. Bajo la protección de esos árboles reservados se realizan siembras directas de semillas de especies de valor ("lapacho," "quebracho," "urunday," "guayaibí," etc.). Para ello, con una azada se hacen pequeños hoyos, se prepara luego el suelo de esos sitios, removiendo y desmenuzando la tierra hasta una profundidad de 10 cm. y

por último se colocan las semillas (4-5) que se cubren superficialmente con pasto seco, hojarascas o tierra fina.

Conviene que los lugares donde se efectuan las siembras no se encuentren muy distanciados entre sí para permitir que las ramas laterales de las plantas nacidas, al ser pequeña esa longitud (1-1,50 m.), se junten en el más breve tiempo, formando así una cubierta sobre el suelo, lo que impide el desarrollo de la vegetación perjudicial (malezas y especies no deseadas), por falta de luz. Este simple procedimiento de siembra es relativamente poco costoso, y por eso es factible sembrar a esas distancias reducidas.

3. Cuando la función protectora de los árboles reservados no sea más necesaria, se los corta y extrae del monte.

Como puede observarse, el método que se ha explicado, es una modificación del de cortas a clareos sucesivos, en el cual se redujo a dos las etapas y se cambió la diseminación natural efectuada por los árboles portagranos, por la siembra artificial directa. Los árboles reservados, si bien no cumplen la función diseminatoria, mantienen la de protección de las plantas jóvenes cultivadas artificialmente.

En Superficies sin Arbolado (Pampas o Calveros)

En los calveros donde existe alto pajonal de "espartillo" (*Elyonorus* sp.), puede éste funcionar como protector de especies heliófilas no muy sensibles a las heladas y al sol (por ejemplo "quebracho colorado," "quebracho blanco," "algarrobo blanco," etc.), protección que abarcará los primeros meses de vida de las mismas.

Otras especies más sensibles, como "lapacho," "urunday," etc., también pueden plantarse en "pampas" pero necesitan la protección de árboles que con este propósito se han implantado previamente.

La técnica seguida en estos dos casos es:

1. Siembra directa de semillas bajo protección de pajonal alto. Con el arado se hacen surcos de 15 a 20 cm. de profundidad, en dirección Oeste-Este para mayor protección contra los rayos del sol de mediodía, distanciados 1,50 metros uno de otro. En el fondo de cada surco se realiza la siembra directa de las semillas de las especies antes mencionadas ("quebracho colorado," "quebracho blanco," "algarrobo blanco," etc.), a distancia de 1,50 metros, previa preparación del suelo en cada sitio de siembra.

Las semillas de "lapacho" y "urunday," se siembran inmediatamente después de haberse realizado la cosecha de las mismas (noviembre y enero respectivamente) pues pierden rápidamente su poder germinativo. En general, las especies de crecimiento lento se siembran en primavera.

2. Siembra bajo protección de árboles previamente plantados. Como especies que se utilizan para proteger plantas sensibles, pueden mencionarse "tipa blanca" (*Tipuana tipu*), "algarrobo blanco," "eucalipto" (*Eucalyptus saligna*), "fumo bravo" (*Solanum auriculatum*), y otras, y algunas de ellas además de su función protectora que puede iniciarse a los 5 años, tienen un gran valor económico, pues la madera es de excelente calidad.

Se ara el terreno, distanciando los surcos 3-4 metros uno de otro, y en el fondo de los mismos se efectúa la plantación (en el caso de eucaliptos), o bien la siembra (tipa, algarrobo, etc.), en lugares distantes 1,50 metros entre sí, previa preparación del suelo de esos sitios.

Cuando estas plantas tengan más o menos 5 años de edad (dependiendo ello de la posibilidad de protección que ya puedan ofrecer), se realiza otra siembra directa de semillas, pero esta vez de las especies sensibles (lapacho, urunday, etc.), en la mitad de la distancia existente entre las filas de plantas protectoras y distanciando 1,50 metros los lugares de siembra dentro de las nuevas hileras.

Después de otros 5 años, cuando ya no es más necesaria la función protectora de los primeros árboles, se los corta y extrae. Cuando para los fines de protección se utilizan especies que pueden aprovecharse económicamente, esa corta se efectúa a ras del suelo en la época de descanso vegetativo con el fin de que las cepas vuelvan a brotar, sirviendo entonces esos rebrotes para que cumplan una función de competencia, estimulando el crecimiento en altura de los árboles anteriormente protegidos y sin la formación de gajos laterales.

De esta manera en el futuro se formará un monte medio, del cual se podrá obtener un gran rendimiento cuali y cuantitativo.

RESUMES

Modification of Silvicultural Practices in Argentine Subtropical Forests

In the dense, tangled, subtropical Argentine forests, where a great many species are uniformly mixed, utilization by thinning, a practice commonly employed, causes the gradual disappearance of valuable species, the only kinds that are cut, since they cannot reproduce naturally because the young trees, which are heliophiliac, are covered and oppressed by the remaining trees of worthless species. Often their seeds cannot even reach the soil owing to the thick carpet of vegetation that covers it.

Therefore, it is necessary to introduce artificial reforestation in these forests. In several establishments under the direction of the National Forestry Administration experiments in silvicultural practices were conducted with satisfactory results, which makes it possible to try them successfully in forests. This practice consists in cutting all trees in two stages. In the first stage, part of them are removed and the others are left to protect future plants resulting from direct seeding in the forest. Later, when this protective function is no longer necessary, the reserved trees are also cut (second stage). This, then, is a modification of the well-known method of natural regeneration by the shelterwood system, replacing natural dissemination (which is impossible in subtropical forests) with direct artificial seeding in certain places in the forest after the soil in those sites has been prepared.

The reserved trees do not act as seed trees, but merely protect the young plants against the sun and frost.

In clearings, species that are not so sensitive to sun and frost are planted first to serve as protectors of the delicate species. Esparto grass (*Elyonorus* sp.), which grows in treeless areas, can be used to protect the sensitive species during the first few months. Also, the white "tipa" (*Tipuana tipu*), white locust (*Prosopis alba*), eucalyptus (*Eucalyptus saligna*), and, "fumo bravo" (*Solanum auriculatum*) are being used successfully for this purpose. After five years, when protection is no longer needed, these species are cut down. But, if economically profitable, they can be allowed to grow again, to form in the future the so-called "monte medio" (composite forest) known for its excellent qualitative and quantitative yield.

Modification des traitements sylvicoles dans les forêts subtropicales argentines

Dans les forêts subtropicales argentines, épaisses et enchevêtrées, où se trouvent uniformément entremêlées de nombreuses espèces, l'utilisation par coupes sélectives qui y est couramment appliquée conduit à la lente disparition des essences de valeur, car celles-ci forment l'unique objet des coupes et ne peuvent pas se régénérer par la voie naturelle, du fait que les jeunes plantes, qui sont héliophiles, demeurent couvertes et écrasées par les arbres appartenant à des espèces sans valeur restés sur pied. Bien des fois,

leurs semences n'arrivent même pas à prendre contact avec le sol, en raison de l'épais tapis herbacé dont il est recouvert.

Il est donc nécessaire et inévitable d'introduire dans ces forêts le reboisement artificiel. On a procédé, dans divers établissements relevant de l'Administration nationale des Forêts à des essais de traitement sylvicole avec des résultats satisfaisants, ce qui permet d'appliquer ce traitement aux forêts avec succès. Ledit traitement consiste à couper la totalité des arbres en deux étapes. Dans la première, on en enlève une partie, en ménageant les autres pour la protection des plantes futures provenant de semailles effectuées directement en forêt. Plus tard, une fois cette fonction devenue inutile, ces arbres réservés sont coupés à leur tour (deuxième étape). Il s'agit donc d'une modification de la méthode connue de régénération naturelle par coupes à éclaircies successives, la dissémination naturelle (impossible dans les forêts subtropicales) étant remplacée par l'ensemencement artificiel direct de certains endroits déterminés de la forêt, après une préparation préalable du sol.

Les arbres réservés n'ont pas pour mission de servir de porte-graines, mais uniquement d'offrir aux jeunes plantes une protection contre le soleil et les gelées.

Dans les clairières on plante tout d'abord des espèces moins sensibles aux rigueurs du soleil et aux gelées, afin qu'elles servent de protectrices aux espèces délicates. Pour protéger ces espèces sensibles pendant les premiers mois de leur existence, on peut utiliser la sparte (*Elyonorus* sp.) qui croît dans les parties dénuées d'arbres. Comme couverture, on emploie avec succès la "tipa blanca" (*Tipuana tipu*), le caroubier blanc (*Prosopis alba*), l'eucalyptus (*Eucalyptus saligna*), et le "fumo bravo" (*Solanum auriculatum*). Au bout de cinq ans, quand la protection n'est plus nécessaire, ces espèces sont coupées. Mais quand elles s'avèrent profitables du point de vue économique, on peut les laisser repousser, de façon à former à l'avenir ce que l'on appelle la forêt intermédiaire réputée pour son rendement élevé en qualité et en quantité.

La Silvicultura del Delta del Paraná Y Sus Posibilidades Industriales

SANDOR MIKLER

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El Delta del Paraná se extiende entre los grandes brazos de este río, llega hasta el Río de La Plata y penetra en su seno hasta colocarse a la vista de la ciudad de Buenos Aires. Es una serie de islas que emergen del agua, cuyas extensiones se estiman entre 600.000 a un millón de hectáreas, entrecruzadas por 207 ríos, arroyos y canales, que, puestos en una línea, representan más de dos mil kilometros de vías navegables para las embarcaciones típicas de la zona, si bien los ríos grandes pueden ser navegados inclusive por transatlánticos.

Las condiciones agroecológicas son favorables para cualquier cultivo, pero todo está sujeto a las condiciones hidráulicas del Paraná y sus afluentes, así como del Río de La Plata que está sometido a las condiciones dinámicas del mar y de los vientos.

La naturaleza de este medio se ha ido mostrando favorable a ciertos tipos de árboles que nacen y se desarrollan aquí espontáneamente en medio de una vegetación lujuriosa.

Se desarrollaron así primitivamente, extensos montes espontáneos en todas las riberas, en general de variedades subtropicales muy entremezcladas, con algunas esencias valiosas, que en la época colonial atrajo el interés de los hombres y sugirió la idea, la posibilidad, de dedicar estas tierras al cultivo forestal y en parte frutícola.

Desde hace cerca de un siglo se empezó a plantar aquí árboles maderables de todas las variedades que toleran el medio húmedo, predominantemente sauces y álamos, por más que prosperan aquí muy bien algunas variedades: cipreses, pinos, plátanos, robles, fresnos, eucaliptos, citando solamente los ejemplos más frecuentes, en grandes cuadros y rodales.

El Río Paraná crece con cierta regularidad dos veces por año, por más que pocas veces alcanza un nivel molesto para el desenvolvimiento de las actividades cotidianas.

Buena parte del Delta está bajo la influencia más directa del Río Uruguay y finalmente el estuario Rio de la Plata con los flujos y reflujos que le comunica el océano y los impulsos que recibe cuando los vientos soplan contra su corriente.

En abril de 1959 se dió el caso por primera vez, que se recuerda, de coincidir dramáticamente, una creciente del Paraná y del Uruguay con una creciente eólica del Río de la Plata que levantó el nivel de las aguas a más de dos metros sobre las tierras más altas de toda esta extensión que en cifras redondas tiene 200 kilómetros de largo por 150 kilómetros de ancho.

Fué una experiencia tremenda, pero dejó el saldo favorable de la comprobación que las salicáceas pueden sobrevivir perfectamente una prueba así, en un suelo cubierto por las aguas en partes, durante más de tres meses.

Dentro de este cuadro agro-hidro-meteorológico, las cinco mil familias que pueblan estas riberas, todas de origen europeo, han desarrollado una técnica especial para plantar árboles maderables.

Va a ser un siglo que la población isleña fué haciéndose al cultivo de las salicáceas.

El más primitivo fué el cultivo del sauce llorón (*Salix babylonica*) para leña y otros menesteres caseros. Paralelamente se fué desarrollando el cultivo del álamo carolino (*Populus deltoides carolinensis*) que alcanzó gran difusión hasta la segunda década de este siglo, cuando todos los montes sufrieron un virulento ataque de roya (*Melampsora* sp.) que detuvo su crecimiento y dió lugar al desenvolvimiento del álamo criollo (*Populus nigra*) que a su vez fué atacado por una roya con carácter virulento, y dió ocasión al cultivo intenso de sauce álamo (*Salix alba*) a su vez afectado ahora por una Marsonina.

Pese a todos estos inconvenientes se ha llegado a plantar en el Delta alrededor de cien mil hectáreas. El 80% de éstas son sauces, una buena cantidad son todavía sauces álamos, pero la mayoría son sauces híbridos, seleccionados empíricamente por los productores más progresistas.

Los álamos, que se plantan en las tierras más altas, son los híbridos italianos importados; entre ellos predomina el Alamo A.M. (*Populus euro-americano*) I-154 y el 214.

Al presente, ya tenemos la perspectiva de contar con nuevas variedades, seleccionadas por los ingenieros agrónomos Arturo E. Ragonese, Director del Instituto de Botánica Agrícola y José Valega, Director del Instituto de Fitotécnia, sin perjuicio de la acción experimental que viene desarrollándose en la Estación Forestal Domingo F. Sarmiento, a cargo de la Administración Nacional de Bosques, así como en la Estación Experimental del Delta, dependiente del Instituto Nacional de Tecnología Agropecuaria.

El cultivo sistemático de sauces y álamos se fué desarrollando al calor de las necesidades de proveer de envases a las distintas industrias nacionales y a la producción de frutas y hortalizas.

Al comienzo de este siglo se desarrollaron grandes aserraderos que, para la época, podían pasar por grandes fábricas de cajones. Pero paralelamente se fué extendiendo el empleo de cajas de cartón corrugado, que paulatinamente viene desalojando a la madera del renglón de envases.

En esta lucha prolongada, los grandes aserraderos fueron perdiendo terreno, segmentándose en alrededor de 300 pequeños establecimientos, de los cuales la mayoría no pasan de ser talleres caseros.

A la falta de evolución técnica se sumó negativamente una política de dirigismo económico que padeció el país durante más de una década.

Aquella política económica, mediante el control de cambios, subvencionó virtualmente la importación de maderas, al punto que el pino "de primera" se vendió en plaza a un precio inferior al costo de producción nacional de sauces y álamos.

Se dió el mismo trato preferencial a la importación de papeles y pastas para la fabricación de papel, que desarmó todas las voluntades fabriles de encarar en el país la fabricación de papeles a partir de las maderas de salicáceas.

La situación del Delta puede resumirse así:

1. Contamos con cinco mil familias que alcanzaron gran experiencia en el cultivo forestal.

2. Tenemos cien mil hectáreas plantadas y podríamos llegar a duplicar esta cantidad si consequimos ensanchar el mercado para estas maderas.

3. Al presente su mercado sigue siendo la cajonería y solo en muy poca proporción se emplea en la fabricación de pasta mecánica para papel.

4. El empleo de las maderas de salicáceas en la fabricación de papel no llega al 5% del total que se corta, pero las posibilidades de su incrementación, alrededor de la cual se hace mucha publicidad, alienta a muchos a improvisarse en el cultivo de sauces y álamos.

5. A la estrechez del mercado se suma así una expansión del cultivo, inclusive en los mejores suelos agrícolas del país. Se estima que se plantó así unas 40.000 hectáreas más, que ya entran a competir con la producción del Delta.

6. El turno de corte en el Delta es de diez años. A esa edad rinde de 100 a 150 toneladas de madera por hectárea.

7. De las cien mil hectáreas que tenemos en el Delta podríamos cortar diez mil hectáreas anuales, pero el mercado no alcanza a absorber más de cinco mil hectáreas.

8. Hay así un gran excedente a la espera de la radicación de fábricas de papel, con instalaciones apropiadas para elaborar este tipo de madera.

9. Se puede lograr este propósito por el camino de la semi-celulosa.

10. Aunque se cubriesen todas las necesidades papeleras del país, de los númerosos tipos que se pueden fabricar con semi-celulosa, quedaría siempre un gran excedente para abordar la fabricación de tablas de partículas (chipboard) que tiene un mercado ilimitado, debido al gran déficit de maderas para la carpintería y construcción.

11. La oportunidad para instalarse a la vera de estos macizos de salicáceas se presenta ahora óptima, porque existen todavía espacios a lo largo de la ribera, que permiten ubicar las plantas fabriles con frente a los ríos o canales navegables y al fondo conectado con la carretera, desde 30 kilómetros de Buenos Aires.

12. Hay en esta línea posibilidades de contar con fluído eléctrico de la super-usina de San Nicolás.

13. De instalarse a la vera de los ríos Luján o Paraná de Las Palmas, podría la empresa elegir, a su conveniencia, el transporte por carretera o por agua hasta el centro de Buenos Aires o hasta Rosario, segunda gran ciudad de la Argentina.

RESUMES

Silviculture of the Paraná Delta and Its Industrial Possibilities

In the Delta we have 5,000 families, experts in tree planting who have planted 10,000 hectares of poplars and willows to date.

Box-making is the principal market for these trees, for not more than 5% of the wood is being used at present to manufacture paper.

An estimated 10,000 hectares of woodland are ready for cutting each year, and the absorption capacity [of the market] is scarcely half that amount.

To this may be added large planted areas in the rest of the country, estimated at 40,000 hectares.

Thus, there is a large surplus of salicaceous wood that can encourage the establishment of mills for the manufacture of paper with semicellulose, and mills for the manufacture of chipwood, which can be built 30 kilometers from Buenos Aires, near navigable rivers and highways leading to the large consumer centers.

La sylviculture dans le Delta du Paraná et ses possibilités industrielles

Il y a, dans le Delta, 5.000 familles expertes dans l'art de la culture forestière qui, jusqu'à ce jour, ont planté cent mille hectares de peupliers et de saules.

La fabrication de caisses fournit le principal débouché, car le volume du bois employé à la fabrication du papier ne dépasse pas 5 pour cent du volume total.

On peut estimer à 10.000 hectares par an les surfaces boisées remplissant les conditions nécessaires pour la coupe, alors que la capacité d'absorption atteint à peine la moitié de ce volume.

A cela, il convient d'ajouter les grandes surfaces plantées dans tout le reste du pays, sur une étendue estimée à 40.000 hectares.

Il existe donc un grand excédent de bois de salicacées dont la présence peut encourager l'établissement de papeteries, en passant par la semi-cellulose, et de fabriques de panneaux de particules qui pourraient s'installer à 30 km. de Buenos-Aires près des eaux navigables et des routes qui conduisent aux grands centres de consommation.

Les conceptions actuelles de la sylviculture roumaine concernant la régénération naturelle et artificielle

A. Marian, G. Marcu, et St. Purcelean

Roumanie

Le territoire de la République Populaire Roumaine se trouve sous l'influence de trois climats différents: de l'Europe Centrale, avec influence maritime; est-européen, au caractère continental très prononcé; et enfin, méditerranéen. Cette incidence climatique alliée à une grande variété de formes du relief, détermine l'existence d'une végétation forestière très riche et variée. Grâce à ces conditions géographiques naturelles, il y a sur un espace relativement réduit de nombreuses formations forestières pures et mélangées.

Malgré ces particularités qui influencent le développement de la végétation forestière, notre sylviculture a été axée tant sur la régénération naturelle que sur les cultures artificielles. Cette orientation fut imposée sur de grandes étendues restantes non régénérées qui devaient être reboisées dans un délai relativement court. La pratique des monocultures fut remplacée petit à petit par la création de peuplements artificiels mélangés.

Des réalisations pratiques particulières, en ce qui concerne la création de peuplements mélangés, ont été obtenues dans les forêts de chênes, les hêtraies et, dans une plus petite mesure, dans les pessières.

Parallèlement au développement de cette vaste activité pratique pour la création de peuplements par voie artificielle, on a accordé une attention croissante à la régénération naturelle des peuplements, surtout dans les forêts qui jouent un rôle particulier de protection.

Actuellement, la sylviculture de la République Populaire Roumaine, ayant exclu les solutions stéréotypes, est orientée vers l'exploitation différenciée des peuplements en rapport avec le rôle fonctionnel des forêts dans l'économie nationale, les nécessités écologiques des espèces caractéristiques de chaque type naturel ou d'un groupe de types naturels de forêts, et pour les terrains libres, en fonction de la nécessité des types naturels identifiés dans les régions destinées au reboisement. La régénération naturelle et la culture artificielle permettent d'augmenter la productivité des forêts et d'améliorer les fonctions de protection des peuplements. Elles sont donc appliquées de la manière suivante:

Les pessières en général seront à l'avenir régénérées artificiellement, parce que, chez nous, l'aplication des traitements basés sur la régénération naturelle se heurte à des difficultés dues aux vents qui abattent les arbres et au relief accidenté. La régénération artificielle de l'épicéa est réalisée par des plantations et, dans le cas des situations favorables, par des ensemencements directs (sur des versants ombrés et abrités, sur des pentes douces). La composition des futurs peuplements doit comprendre l'épicéa comme espèce principale, mélangée à différentes espèces feuillues et résineuses (sapin, mélèze, sapin de Douglas, hêtre, érable sycomore de montagne, sorbier des oiseleurs, etc.). A de grandes altitudes, où la plus grande partie de ces espèces ne donne pas de bons résultats, on conservera la monoculture de l'épicéa, introduisant dans certaines situations l'érable sycomore et le sorbier des oiseleurs.

Dans les forêts jouant un rôle particulier de protection, on tend à l'application des traitements basés sur la régénération naturelle (coupes successives aux bords des massifs, coupes de jardinage).

Les mélanges de hêtres avec des résineux (épicéa et sapin) et les hêtraies, grâce au tempérament d'ombre ou demi-ombre des espèces composant le tout, continueront à l'avenir d'être régénérés par voie naturelle en appliquant des coupes successives et progressives et le traitement en futaie jardinée.

Les hêtraies pures d'une productivité inférieure doivent être améliorées ou remplacées par l'introduction de l'épicéa ou du pin sylvestre, espèces qui sont plus productives dans la situation actuelle.

Les hêtraies de productivité supérieure sont très facilement régénérées par voie naturelle et donnent un matérial ligneux de bonne qualité; malgré cela, dans certains cas elles seront améliorées par l'introduction de bonnes espèces à croissance rapide: (le sapin de Douglas, pin Weymouth, mélèze, chêne rouvre, chêne rouge, etc.).

Dans les sapinières pures et mélangées, en général le sapin se régénère très bien par voie naturelle et par l'application de coupes de jardinage.

Les chênaies de chêne rouvre seront régénérées par voie naturelle par l'application du traitement des coupes progressives et d'un traitement combiné: coupes successives uniformes combinées avec des coupes progressives en trouées. En vue d'améliorer le sol et d'augmenter la productivité, on introduira dans certains cas le chêne rouge, le pin Weymouth, le pin sylvestre, le hêtre, etc.

Les chênaies de *Quercus frainetto* et les chênaies de chêne chevelu traitées en futaies seront régénérées par le traitement combiné des coupes successives uniformes et progressives en trouées.

La sylviculture roumaine doit faire face à un problème difficile en ce qui concerne les chênaies de chêne pédonculé, les chênaies mélangées, situées dans la plaine ou dans les anciens lits majeurs des rivières, et une partie des chênaies de chêne rouvre, parce que dans ces types de forêt se manifeste, sur les grandes surfaces, le phénomène du dessèchement de ces espèces de chêne. Dans ce cas, nous serons obligés d'avoir recours à la régénération artificielle en utilisant en même temps les semis naturels de chêne et de chêne rouvre. Dans les situations favorables, on pourra procéder à l'application de coupes en trouées avec un ensemencement artificiel de chêne.

Dans les forêts de la silvosteppe, composées en grande partie de *Quercus pedunculiflora* et de chêne pubescent, en raison des conditions climatériques très dures et à l'état de ces forêts, la régénération artificielle sera la méthode utilisée à l'avenir.

Les taillis, constitués en grande partie de différentes espèces de chêne, sont en train d'être convertis en futaies, sauf les réservations cynégétiques, les chênaies de chêne chevelu et les chênaies de *Quercus frainetto* de la région de plaine. Ces dernières continueront à être traitées à l'avenir en taillis simples, parce qu'elles ne permettent pas une grande production à un âge avancé.

Les forêts de saules et de peupliers, situées dans les lits majeurs des rivières, seront améliorées par l'introduction, sur une grande échelle, des clones sélectionnés de saules et de peupliers. Les peuplements de peupliers noirs hybrides seront régénérés par voie artificielle en utilisant des clones sélectionnés. Le robinier sera régénéré par l'application du taillis simple avec coupes au ras du sol, car les peuplements provenant des drageons sont plus viables et produisent plus que ceux des rejets. Après un certain nombre de générations, ils seront renouvelés par des plantations de plants élevés dans les pépinières.

La sylviculture roumaine tend, en général, à utiliser au maximum les méthodes de régénération naturelle, en respectant toutefois les particularités naturelles historiques et économiques de chaque forêt.

On passera à la régénération naturelle en appliquant les traitements indiqués, basés sur ce genre de régénération, sans pourtant réduire le quantum annuel de coupe par espèces. On intensifiera, cependant, les travaux aidant à la régénération naturelle; dans les années qui suivront, ces travaux auront trois ou quatre fois plus d'envergure qu'actuellement. En outre, on introduira une série d'espèces de valeur et à croissance rapide.

Il faut préciser que de nos jours on introduit un plus grand nombre de plants par hectare qu'autrefois (dans les pessières, on plante de 7.000 à 10.000 plants par hectare; dans les chênaies, de 10.000 à 13.500 plants par hectare.

RESUMES

Present Concepts in Rumanian Silviculture Concerning Natural and Artificial Regeneration

In the Rumanian People's Republic, most of the species of which the natural forests of our country are composed are fir, Norway spruce, beech, English oak, etc.

This situation favors the application of forest practices based on natural regeneration (shelterwood system, selection felling, etc.).

The trend in Rumanian forestry toward intensified use of natural regeneration occurs in conditions of diversified exploitation of stands in relation to type of forest, its functional role, site type, etc. In the years to come, cultural operations to aid natural regeneration will be from three to four times as great as they are today.

Los Conceptos Actuales de la Silvicultura Rumana Respecto a la Regeneración Natural y Artificial

En la República Popular Rumana la mayoría de las especies de árboles que componen los bosques del país por medios naturales son: abeto, pícea (abeto del norte), haya, roble común, etc.

Estas condiciones favorecen la aplicación de tratamientos forestales basados en la regeneración natural, tales como cortes progresivos, cortes de selección, etc.

La orientación de la silvicultura rumana hacia el aprovechamiento intensivo de las regeneraciones naturales se efectúa en condiciones de cultivo distinto del arbolado en relación con las clases de bosques, su papel funcional, la clase de medio estacional, etc. En el curso de los años venideros las operaciones de cultivo destinadas a estimular la regeneración natural serán tres o cuatro veces mayores que en la actualidad.

The Use of Prescribed and Controlled Fire In the Silviculture of North American Conifers

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My attention was first called to the importance of fire as affecting the reproduction of longleaf pine on the Kaul Lumber Company's holdings in Southern Mississippi near Mobile in 1908. There was a very heavy seed crop the previous fall. Seeds were so numerous that every worm hole in the trunks of dead trees lying on the ground had been hit by a seed and sprouted a seedling. But on a two-year layer of needles, the radicals of the seeds could not establish themselves in the ground, while on a grass rough of similar age, they were prevented from reaching the ground.

By contrast, on ground that had been burned, removing grass rough or pine needles, abundant seedling reproduction had taken place. It was as if nature had prepared an exhibit for the instruction of the observer, and the lesson was not lost.

Then in 1917 on Henry Hardtner's forest at Urania, Louisiana, further vital evidence was obtained demonstrating the absolute necessity of prescribed fire in the successful attainment of healthy reproduction of this species. A parasitic disease, *Septoria pini* or brown spot, which had been previously described in Florida, made its appearance on a fenced quarter-acre plot, namely, the Roberts Plot, and proceeded to defoliate the seedlings. Mr. Hardtner's partner, Tannihill, expressed the opinion that this was a natural process, but the needles normally remain on these seedlings for three years. I studied the effect of this rust on unburned areas and found over a period of years that it would stunt and prevent the height growth of the seedlings until they had lost their vitality and were worthless. The rust operated in a vertical zone of about 4 feet with scattered infection about this point. But if the area was burned over completely and thoroughly, it was disinfected for the time being. Such fire, while defoliating the seedlings, did not kill the bud. I believe that the foliage expels a non-inflammable gas which protects the bud. Cigarette papers laid on the bud were not consumed, though the needles were burned within an inch of them.

The longleaf seedling stores food in its root and in the following spring puts forth a new crop of needles which remain comparatively free from infection from the ascospores, but the disease has another weapon named teliospores, which are windborne and will reinfect an area within about three years. The conclusion was obvious that following the preliminary ground-clearing fire, the pine must be burned at three-year intervals to control this disease.

Height growth does not start until the stem at the root collar attains a diameter of 1 inch, at which time its bark is able to resist ground fires. Within another three-year period it is practically fireproof. Another reason for burning soon became evident. The longleaf pine seedling is entirely intolerant of shade; even that of a sweet fern bush will kill it, and the shade of hardwood sprouts is fatal. Fire kills back these shade producing plants, giving the longleaf full exposure to the sun.

The necessity for fires every three years continues through the whole stage of growth. It happened that when Mr. Hardtner fenced his longleaf area against hogs, he had been instructed by members of the U.S. Forest Service to exclude fires. He had obtained abundant longleaf reproduction for the reason (which he did not realize) that the annual fires which had previously burned over the area had temporarily eliminated the brown spot disease. Under complete fire protection, a heavy grass rough, with inflammable bushes, established itself beneath the pine. It was inevitable that fires would occur, and they did. These summer fires killed the longleaf poles, 40 feet high, and even destroyed the remaining seed trees, leaving only a fragment of the original stands unburned. When this rough is burned at three year intervals during the winter months, the pine is not damaged. These fires and my insistence finally sold the idea to Mr. Hardtner. There was a belt of pine, next to the highway and bordered by a swamp, which had not been burned. Hardtner, passing by with Tannihill, his assistant, said "Milton, I am going to burn this area." Tannihill hastily exclaimed "I have not any matches." Hardtner said "Well, I have," scratched one on the seat of his pants and threw it over the fence. That was the first match that a southern forest owner had ever intentionally applied to his timber land.

In its ultimate effect on southern forest economy, it was comparable to "the shot heard round the world" at the battle of Lexington.

In 1918, while serving as Chief of Management for Region 3 of the U.S. Forest Service at Albuquerque, New Mexico, I had the privilege of escorting F. A. Leete, Conservator of the Forests of Burma, retired, on an inspection trip in Arizona. During this trip, Leete gave me some most interesting information, which had a direct bearing on the problem of the use of fire. It seems that the British Forestry Administration in Burma had espoused a policy of eliminating all fire from the Burmese forests, but a young forester by the name of H. Slade took exception to this policy, claiming that unless fire were used, competing evergreen growth would prevent teak from reproducing itself. This met with great disfavor, and the young man's promotions were withheld. He was given an obscure post in a remote district where he died of a tropical fever. This was some 20 years previous to Leete's visit to me. Leete then stated that on making examination of the teak forests in Burma, they had found an almost complete lack of teak reproduction on unburned areas, while on burned areas it was present, thus confirming the assertions of young Slade. The dense carpet of evergreen shrubs which prevented teak reproduction could only be subdued and controlled by fire. From then on, the practice of burning was established for the teak forests.

In still another species, sal, Leete stated the species was equally dependent on fire for its survival against encroaching evergreen jungle thickets. He also described the conditions in the chir pine forests of the lower Himalayas. When fire was excluded from these forests, dense reproduction took place, which was then burned with great damage by the hill people to improve the grazing. The British substituted the practice of controlled burning from the hilltops downwards, which thinned out the dense reproduction, permitted grazing, and prevented the destructive conflagrations.

This information came to me during my campaign for the adoption of fire as a silvicultural measure for southern pines and was greatly appreciated.

In order to get this practice adopted by the profession of forestry it was necessary completely to reverse the universal teachings of the schools to the effect that fire in the forest was an unmitigated evil. In some types of northern forest, such as spruce and northern hardwoods, it was just that, and fears were entertained that if the doctrine of fire use were accepted for southern pines, it would be wrongly applied to northern types. Also, there existed extensive annual burning in these southern forests, which, of course, killed off the seedling reproduction, which required protection for a three-year period.

About this time, the American Forestry Association, under the guidance of Ovid Butler, launched an extensive educational campaign in the South, whose objective was the elimination of fire from that area. Had this effort been successful to any degree, it would ultimately have resulted in the complete destruction of the stands by uncontrollable summer fires similar to those that Hardtner experienced at Urania. This is exactly what happened to Alex Sessions in southern Georgia, who, after a few years of fire exclusion, suffered the almost complete destruction of his forest property by these uncontrollable summer fires.

As had been explained, the fire rotation for longleaf pine was established as three years. For slash pine, the first fire must be postponed until the sixth year. Loblolly pine required a still different treatment, which consisted of a hard burn in the fall of a seed year before the seed fell, to kill back the hardwoods which, if given a two year start, would completely suppress the pine. But if the pine and hardwoods started together after the fire, the pine would outgrow the hardwoods.

The second southern forest owner to adopt the use of fire was Mr. Ed Gates of the Jackson Lumber Company at Lockhart, Alabama, in a longleaf pine type. Following my advice, Mr. Gates one day burned over a tract of about 1,600 acres. The area was occupied by considerable longleaf pine reproduction, which had been stunted for so long a period by brown spot that it had practically lost the ability to recover. The fire killed most of these stunted seedlings, but otherwise had the usual effect of encouraging disease-free seedling growth, and Gates became a leading advocate of fire in silviculture.

During this initial period of hostility and suspicion, it was the forest rangers, in contact with reality, who first actually applied the technique of burning on the National Forests in Texas and Florida. Progress was made when the members of the Regional Office of the Forest Service at Atlanta, Georgia, accepted the practice of their local rangers and authorized prescribed fire. The Washington Office had some diehards who held out for sometime, but finally this citadel surrendered, and controlled burning became the accepted practice on both public and private land holdings in the southern pine coastal region.

It was evident to me that a very long geological period must have elapsed to bring about these fundamental adaptations of longleaf pine to the occurrence of fire, and indeed its complete dependence upon fire for its continued survival as a species. This eliminated the possibility that fires caused by man had brought about this evolution, and left lightning as the sole cause of prehistoric fires. From local experience at Urania, the problem of how lightning could set fires, despite accompanying rains, was worked out. It was usually accomplished by a bolt igniting a dead snag from which the fire later spread. We found, too, that the grass or rough dried out rapidly after a rain and would carry fire while water was still on the ground. Before human habitation, the only natural firebreaks were streams and swamps, and a single fire might burn a large area unchecked. I then tested this lightning theory by obtaining data on fires set by lightning within several million acres of southern National Forests. There had been a large number of lightning fires within a few years time. Grass fires spread rapidly, and despite the protective organization, some of these fires had burned several hundred acres before being put out.

The technique of controlled burning in the South was rapidly developed. It was obvious that such fires should be confined to the winter months, at least for longleaf and slash pine. By plowing firebreaks at intervals of a few hundred yards, waiting for a northwest wind following a rain and burning at night against the wind, dangerous accumulations of inflammable brush could be successfully handled. One large company in Mississippi burned 60,000 acres in a single night, at a cost of a fraction of a cent per acre. Among other advantages, such areas were completely protected from summer fires occurring in dry seasons. The adoption of these fire techniques completely revolutionized the practice of silviculture throughout the southern pine belt. From a climatic standpoint, the climax forest in this region was not pine but hardwood, which on the sandy uplands, was so inferior in quality as to be practically worthless. It became the universal practice by large forest owners to undertake complete elimination of this hardwood understory by every available means so that when pine reproduction was desired, it could be obtained without hardwood competition. The necessity for this was evident. The hardwood roots had a superior capacity for absorbing soil moisture and depriving the pine of its needed supply. The Crossett Lumber Company, owning half a million acres of land in southern Arkansas and northern Louisiana in the loblolly shortleaf pine type, vigorously attacked the problem of eliminating hardwoods on upland soils and confining this type to the bottomlands on which it produced valuable growth. On a recent trip to Crossett, Arkansas, I observed the effectiveness of these methods. A recent plant had been established to utilize hardwoods in the manufacture of synthetic lumber. Extensive use was made of girdling, and poisoning was conducted by injections of arsenic by the use of the so-called Cornell tool, which injects doses at the base of the tree. Repeated winter fires were employed to keep down the small hardwood brush. The most interesting method was the use of a tank and sprayer employing the 2,4-D compound, which killed hardwoods but did not affect the pine reproduction. The object of all these measures was to clear the ground of competing hardwoods and enable the pines to reproduce without hindrance.

I made a calculation appraising the economic loss to the South, caused by initial failure to take proper measures for pine reproduction at the time of the first cutting. The sum approximated one billion dollars. But now with the measures being employed this region will get its billion dollars back. Aggressive measures of reforestation with the southern pines are being employed. A heavy machine is utilized which chops up the existing hardwood growth and prepares a seed bed for pines. Airplane seeding is employed successfully, using a bird repellent on the seed to prevent consumption by robins and blackbirds. It is found profitable to purchase land at $25 or more per acre, plus the necessary expense of soil preparation to grow even-aged crops of pine. Slash pine matures a crop suitable for pulp wood in 12 to 15 years. The net result of this revolutionary silvicultural practice has been the establishment of many new pulp and paper mills throughout the region, assured of a perpetual supply of raw material.

The use of fire is by no means confined to the southern coastal plain. The members of this Congress will be shown the methods of clear cutting in patches and brush disposal by burning employed in regenerating Douglas-fir, which methods were substituted for the complete failure of the method of selective cutting originally attempted, under which the fir was replaced by less valuable hemlock. Fire is also necessary in eliminating ribes and its attendant invasion of blister rust in white pine stands.

Another chapter in the use of fire in western types concerns the ponderosa pine. From time immemorable this type of forest had been subjected to fires set by lightning, which had the effect of keeping the stand fairly open, giving the surviving trees space in which to develop normally. When, under Forest Service administration, these fires were excluded, the result was a dense stand of reproduction which stagnated at an early age. A young man in the Department of the Interior, named Weber, advanced the theory that fire should be used as a means of reducing this stand density, and carried out some experiments in New Mexico to test this proposition. As was to be expected, the results were not uniform, in places destroying most of the reproduction, and in others not enough But as an effort to imitate previous natural conditions, it was worth while. The inducement for this use of fire was strengthened by the increase of an insect which fed upon the seed in the cones, breeding on the surface of the ground and which had apparently been kept under control previously by these fires.

The two species, respectively jack pine (*Pinus banksiana*) and the Rocky Mountain lodgepole pine are intimately related to fires. But the utilization of fire in the management of these species has not been solved; both have serotinous cones, which normally open when the stand is burned, sowing the seed in the ashes. This usually results in extreme overstocking, causing stagnation. In one instance, a lodgepole stand had reached the age of 70 years with 700,000 trees per acre and a height of but seven feet. This overstocking can be mitigated or avoided in clear cutting by keeping fire out of the slash, the cones near the ground receiving sufficient heat to open. When exposed to direct sunlight on bare ground, jack pine seedlings usually perish from exposure. They are saved from this fate by the shadows of the dead poles passing over the surface. Satisfactory techniques for natural reproduction are still in the experimental stage.

Eastern white pine in its original stands seems to have definite relations to fire. Maissurow has developed this subject. The species is naturally found in even-aged stands, varying from veteran to young. The explanation may be related to the leveling of considerable areas of northern hardwood forests by tornados which left veteran white pine seed trees standing, whose thick bark rendered them impervious to fire. Such instances occurred in the Menominee Indian Reservation in Wisconsin within recent years. It is probable that fire then swept these windthrown areas after which the pine seeded in, together with aspen, whose comparatively short life deleted it from the stand in between 70 and 80 years. For the most part, especially in New England second growth, white pine came up on old fields and could be reproduced by partial cutting.

RESUMES

Emploi de l'incendie réglementé et contrôlé dans la sylviculture des résineux de l'Amérique du Nord

La zone climatologique de la plaine côtière méridionale n'est pas naturellement favorable au pin, mais plutôt aux espèces feuillues qui, en l'absence d'incendies répétés, envahissent les hautes terres et produisent éventuellement un type de végétation naturelle de qualité inférieure.

Mais depuis des temps immémoriaux, des incendies causés par la foudre ravagent ces régions à peu près tous les trois ans en moyenne. La foudre continue à provoquer des incendies dans les forêts nationales de la plaine côtière.

Bien qu'elle s'accompagne de pluie, la foudre peut allumer ces incendies en mettant le feu à des souches d'arbres tués par les insectes, d'où il se propage aux hautes herbes qui sèchent rapidement.

Le pin à longues aiguilles produisait de fortes récoltes de graines à des intervalles variant de sept à huit ans. L'une de ces récoltes se produisit en 1908 dans le sud de l'Alabama. Il fut alors constaté que le sol nu était nécessaire à la germination de ces graines. La couche d'aiguilles de pins tombées au cours de deux années, ou les hautes herbes, de deux ans également, empêchaient la radicule d'atteindre le sol. Sur les terres incendiées, les jeunes plants abondaient, mais n'existaient pas ailleurs.

Dans la forêt de Henry Hardtner à Urania (Louisiane), sur la parcelle dite "Roberts Plot" établie par le Service des Forêts des Etats-Unis, le rapport entre la maladie appelée "rouille des feuilles" (*Septoria pini*) et le feu a été établi. Si cette maladie n'est pas combattue, elle cause chaque année la chute des aiguilles des jeunes plants qu'elle tue éventuellement. Le feu allumé en hiver tous les trois ans détruit le feuillage malade et les abondantes réserves nutritives accumulées dans les racines assurent une nouvelle croissance d'aiguilles saines.

L'emploi du feu contrôlé, allumé tous les trois ans en hiver, doit se poursuivre tout au long de la vie du peuplement afin d'éviter une accumulation de débris inflammables qui, s'ils brûlent pendant la sécheresse de l'été, peuvent entraîner la destruction complète de vastes peuplements, comme cela s'est produit dans les forêts d'Henry Hardtner à Urania.

Cette méthode d'emploi du feu par rotation est également nécessaire en raison du fait que les plants de pins à aiguilles longues ne supportent aucune ombre, pas même celle des broussailles de comptonia. Les pousses d'espèces feuillues doivent donc être supprimées, ce qui libère les jeunes plants.

La pratique du feu contrôlé a tout d'abord été employée par les forestiers des Forêts nationales du Texas et de la Floride, mais elle a été bientôt adoptée par le Bureau régional d'Atlanta (Georgie) et enfin par Washington, D.C. Elle est maintenant employée partout, dans les forêts publiques et privées de cette région.

Dans les forêts de sapins de Douglas de la région Pacifique Nord-Ouest, des bandes sont déboisées et brûlées aux fins d'ensemencement naturel par les peuplements voisins. Le feu est également préconisé pour les forêts de pin ponderosa en vue de réduire les débris inflammables et d'éclaircir les superficies où la reproduction est trop dense.

El Empleo de Incendios Prescriptos y Regulados en la Silvicultura de Coníferas Norteamericanas

La zona climática de los llanos costeros meridionales no es, por naturaleza, propicia a los pinos, sino más bien a las especies de hoja ancha que, ante la ausencia de incendios repetidos, se apoderan de las tierras altas y forman un tipo de gradación de baja calidad.

Pero desde épocas remotas, incendios iniciados por relámpagos han quemado estas superficies a intervalos de aproximadamente tres años. Las tormentas eléctricas continúan produciendo estos incendios en los Bosques Nacionales de los llanos costeros.

Si bien las tormentas eléctricas por lo general están acompañadas de lluvias, pueden iniciar estos incendios inflamando ramas y troncos muertos por insectos, de los cuales el fuego se extiende por el pasto que se seca rápidamente.

El pino de hoja larga produce cada siete u ocho años una voluminosa cosecha de semillas. Una de estas cosechas se produjo en 1908 en el Sur del estado de Alabama. En aquella oportunidad se observó que estas semillas requieren tierra despejada para poder germinar. Una capa de hojas de pino acumuladas durante dos años o un pastizal de igual edad impiden que la radícula llegue a la tierra. En terrenos quemados, las plantas nacidas de semillas eran abundantes, en otras partes había ausencia total de ellas.

En el bosque de Henry Hardtner, en Urania, Louisiana, en la parcela "Roberts," establecida por el Servicio Forestal de los Estados Unidos, pudo descubrirse la relación existente entre una enfermedad denominada mancha marrón (*Septoria pini*) y los incendios. Si no se la combate, esta enfermedad todos los años causa la caída de las hojas de las plantas jóvenes, lo que oportunamente conduce a su muerte. Incendios invernales que se producen a intervalos de tres años, eliminan el follaje apestado y las abundantes reservas alimenticias depositadas en las raíces aseguran el crecimiento de nuevas hojas sanas.

Esta práctica de incendios invernales regulados a intervalos de cada tres años, debe continuarse a lo largo de la vida del bosque a los efectos de impedir la acumulación de desechos inflamables que, de incendiarse durante los meses secos del verano, pueden causar la destrucción total de bosques de extensión considerable, tal como aconteció con el bosque de Henry Hardtner, en Urania.

Un motivo adicional para la aplicación de esta rotación de incendios es la circunstancia que las plantas jóvenes de pinos de hoja larga no toleran sombra alguna, ni siquiera la causada por los helechos miricáceos. Por igual motivo es menester eliminar los vástagos de especies de hoja ancha.

La práctica le incendios regulados fue aplicada por vez primera por los ingenieros de montes de los Bosques Nacionales en Texas y Florida, pero pronto este método recibió la aprobación de la Oficina Regional en Atlanta, Georgia, y finalmente de la Oficina Central en Washington, D.C. Esta práctica es actualmente general, tanto en los bosques públicos, como en los particulares de la región.

En la región Noroeste de la Costa del Pacífico, en los bosques de abetos Douglas, se aplica el sistema de corta rasa y luego los terrenos son quemados y sembrados con semillas de árboles adyacentes. El uso de incendios también se ha recomendado para el pino ponderosa (pino amarillo del Oeste), con el fin de eliminar materiales inflamables y ralear la reproducción excesiva.

Some Information Drawn From the Records of Thinning Trials Established in the Territory of Czechoslovakia, 1885-1892

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For the evaluation of thinnings, the experiments adequately established and carried out for many years are of great importance. Therefore, we set out to study the old documents relating to the thinning research plots established in the territory of Czechoslovakia since 1885 on the basis of the method published in 1884 by the Forestry Research Institute of Mariabrunn. In all, we have had at our disposal data (foundation books) from 21 research plots. The results from two of the research plots mentioned, i.e., No. 25 (Mosty and Jablunkov) and 32 (Nejdek and Zdár) were already published (Polansky, 1954). Detailed examination of the remaining 19 research plots showed that seven of them are unsuitable for further investigation. Therefore, only 12 of the research plots were studied, which are given below in the order of the problems solved and the degree of the preservation of the documents.

1. The influence of the time of the first thinning; research plots Nos. 26 (Mosty), 72 (Orlík), and 57 (Horovice).
2. The influence of different grades of thinning (intensity); research plots Nos. 19 (Bruntál), 92 (Polná), 61 (Kout), 51 (Horovice), 110 (Písek), and 15 and 16 (Vsetín).
3. The influence of the periods of thinning (intervals); research plots Nos. 55 (Horovice) and 71 (Orlík).

The evidence of the thinning plots mentioned ended before World War I (1913). The efforts to restore them after 1918 were unsuccessful because part of them were either destroyed or to a great degree damaged. The majority of experiments were established in pure spruce stands or in stands with a slight admixture of other tree species. Only plot No. 15 contained silver fir, and No. 16, beech. We have inherited in a good state of preservation very extensive, but only fragmentary data on this long-term research, and we have classified, controlled, and worked them out into a summary recapitulation, in order to make available material gathered within the 25-year period of observations.

The methodical instructions of the Forestry Research Institute in Mariabrunn on establishing and carrying out the thinning trials were of a high scientific level. However, from the standpoint of the present time, they are not above reproach. The definition of thinning and the concept of secondary stand are too wide, the trees on the research plots were not marked, and the individual subplots differed in the number of trees, in basal area, and in the growing stock, mostly from the very beginning of observations. Even the method of deducing the volume from a relatively small number of sample trees, as well as the evaluation of the stand and its environment are not reproachless. In spite of that, the Mariabrunn method is of great value, and regarding its completeness, it may form in many respects a basis for modern methods. The thinning techniques of these instructions is based on Kraft's classification of trees (1884). The grades of thinning are as follows:

a. light thinning (three trees of class 5b are removed);
b. moderate thinning (tree classes 5b, 5a, and 4b are removed);
c. heavy thinning (tree classes 5b, 5a, 4b, and 4a are removed);
d. "spacing"—opening thinning. In this case, tree classes 5b, 5a and 4b are removed, as well as all trees, the removing of which makes it possible to create a regular spacing of remaining trees (final crop) without substantially breaking up their canopy.

The growing (standing) trees were indicated as a final crop; the felled trees (removed by thinning), as a secondary crop. In the research of different thinning intensities the thinning period was fixed at five or ten years. The research plots were divided into four or five subplots per 0,25 ha.

According to this method, the beginning of thinnings had to be investigated in not yet thinned, unmixed stands on three subplots, whereby on subplot I, the thinning was started at once, on subplot II, after five years, and on subplot III, after ten years. The grade of thinning in all tree species was b (moderate), only in oaks was the thinning grade c (heavy). The thinning period was five or ten years.

Even the thinning period was followed on three subplots per 0,25 ha. It should be three years on the first, five years on the second, and ten years on the third subplot. The intensity of thinning was the same as at the start of the investigation of thinning. The whole method, including that of investigation, concerns generally only the low thinning.

In the study of the preserved documents, we have found that the establishment and carrying out of thinning research plots was not, from the methodical standpoint, always reproachless, and that the natural conditions, as well as the individuality of the research workers, played here an important role. We have tried to compile all important observations in the characteristics (description) and the analysis of individual research plots. After critical revaluation, the entire material was summarized into 14 tables and 3 representative graphs.

Because of the variability of starting conditions, some data were judged only relatively.

After total evaluation of results, we have arrived at the following conclusions:

1. The influence of early started, moderate thinning (age 21 to 25 years) on the growth and reproduction of the stand was favourable. In general, this effect was demonstrated in various environments and in different methods of stand constitution, and it was obvious in spite of some deviations from the original method, as well of the dissimilarity of starting conditions.

2. In nearly all cases, the influence of higher intensity was manifested by considerably higher intermediate yields and values (in money). The relative current periodic increment (related to the growing stock of the initial main stand) was mostly highest after light thinning (a). In some cases, however, the highest relative increment was attained after a more intensive operation (thinning by "spacing," d). In order to place in evidence the primary thinning treatment (of the "secondary stand") at the beginning of the experiment, we have established the notion of a relative value of thinning efficacy, i.e., a relative expression of the sum of the current periodic increment and the first treatment (of the secondary stand) in relation to the volume of the initial main stand. In the more intensive thinnings this value was mostly higher. The thinnings of higher grade (especially d) mostly result in a relative decrease of growing stock. However, these results are charged by some secondary influences.

3. The influence of variously long thinning periods showed no uniform results. In the first case, the shorter (initially 3 years) period was less favourable than the longer one (6 to 7 years). In the remaining two cases, on another plot, the six- to seven-year thinning period affected the increment more favourably than the fourteen-year period, but less favourably than the ten-year period. The results are charged by various unfavourable influences, and in the last two cases even by different initial thinning intensities.

We have tried to give a general evaluation of extensive fragmentary data of the old thinning trials, in order to make them at least partially available to the scientific public. We are aware, however, of the fact that the generally deduced conclusions are influenced by a series of imperfections in methods, execution, and evidence of this very embarrassing long-term research, and the detailed working out of the results from individual research plots will require thorough mathematical-statistical analysis. Nevertheless, the results achieved in this way will have only a limited validity regarding the intended investigation, i.e., for low thinning, for individual tree species, and eventually also for related conditions.

RESUMES

Renseignements extraits d'anciens documents portant sur des essais de coupes d'éclaircie effectués sur le territoire tchécoslovaque, 1885-1892

Les essais à long terme, effectués avec soin et faisant l'objet de relevés précis, jouent un rôle important dans l'évaluation des coupes d'éclaircie et des résultats produits sur les peuplements. C'est pourquoi nous avons entrepris l'analyse des anciens documents traitant des placettes destinées aux recherches sur les coupes d'éclaircie, pratiquées dans différentes régions de la Tchécoslovaquie entre les années 1885-1892, suivant la méthode publiée en 1884 par l'Institut des recherches forestières de Mariabrunn. Les conclusions qui découlent de cette étude peuvent se résumer de la façon suivante:

1. Des coupes d'éclaircie précoces mais modérées (21-25 ans) ont exercé une influence favorable sur l'accroissement et le rendement des peuplements forestiers. En général, cette influence peut être constatée lorsqu'il s'agit de conditions de site différentes aussi bien que de diverses méthodes de constitution des peuplements. Cette influence est également manifeste en dépit de certaines modifications apportées à la méthode originale et au manque d'uniformité constaté dans l'état des peuplements avant l'éclaircissage.

2. Dans presque tous les cas, l'influence des coupes d'éclaircie plus fortes s'est traduite par des rendements intermédiaires beaucoup plus élevés, tant du point de vue volume de production que du point de vue rentabilité. C'est à la suite d'une coupe d'éclaircie modérée que l'on a constaté l'accroissement périodique relatif le plus élevé (par rapport au principal matériel sur pied du peuplement original). Dans certains cas, toutefois, l'accroissement relatif le plus élevé n'a été obtenu qu'à la suite d'une coupe d'éclaircie intensive. Afin de pouvoir évaluer le volume désirable de la première coupe, nous avons établi une notion de la valeur relative de l'efficacité de la coupe d'éclaircie, c'est-à-dire l'expression relative de la somme des volumes de courant périodique et de la première coupe, en fonction du volume du peuplement principal original. Cette valeur était le plus souvent plus élevée lorsqu'il s'agissait de coupes d'éclaircie intensives. Ces dernières se sont également traduites par un décroissement relatif du matériel sur pied.

3. Les études faites sur l'influence des coupes d'éclaircie pratiquées à intervalles variables n'ont pas donné des résultats uniformes. Dans le premier cas, le plus court intervalle (3 ans au début) s'est révélé moins favorable que le plus grand intervalle (de 6 à 7 ans). Par contre, dans les deux autres cas, les coupes d'éclaircie pratiquées à intervalles de 6 à 7 ans ont exercé une influence plus favorable sur l'accroissement que celles pratiquées à intervalles de 14 ans, mais moins bonne toutefois que dans le cas de coupes d'éclaircie échelonnées de dix en dix ans.

Algunos datos derivados de ensayos de cortas de aclareo de bosques en Checoeslovaquia, 1885-1892

Los ensayos a largo plazo llevados a cabo con buen criterio y de los cuales se llevan registros cuidadosos, son de primordial importancia para evaluar la práctica del aclareo y su efecto en los bosques. Por lo tanto, nos hemos impuesto la tarea de analizar los viejos documentos que contienen la información refe-

rente a los ensayos que se realizaron sobre aclareo de bosques en varios lugares de Checoeslovaquia durante los años 1885-1892, a la luz del método que publicó en 1884 el Instituto de Investigación Forestal de Marianbrunn. Las conclusiones a que se llegaron mediante este estudio pueden resumirse asi:

1. El efecto del aclareo moderado y temprano (de 21 a 25 años) es favorable para el crecimiento y la producción de los bosques. En general, el efecto favorable se puede apreciar a a pesar de los diversos métodos empleados para la integración pesar de las diferencias que acusan las distintas localidades y de los bosques. El efecto también se puede observar a pesar de varias alteraciones que se hicieron al método original y a la falta de uniformidad en las condiciones de los bosques al comienzo de los ensayos.

2. En casi todos los casos, la intensificación del aclareo dió por resultado un aumento intermedio considerable en la producción de madera y en los ingresos. El mayor aumento periódico (con relación al material en crecimiento del bosque principal original) ocurrió después que se practicó un aclareo ligero. Sin embargo, en algunos casos, el mayor aumento se logró después de aclareos muy intensos (aclareos sumamente severos). Para poder determinar la intensidad del aclareo inicial hemos establecido el valor relativo de la eficacia del aclareo, estos es, el valor relativo del incremento periódico total y del primer aclareo en proporción con el volúmen del bosque principal original. Este valor es mayor según se aumenta la intensidad de los aclareos. A medida que se aumenta la intensidad del aclareo también se disminuye proporcionalmente el material en crecimiento del bosque.

3. Las diferencias de los períodos entre los aclareos no dieron resultados uniformes. En el primer caso, en que el aclareo se hizo a intervalos de 3 años, los resultados fueron menos favorables que en el segundo, en que se hicieron en períodos más largos (6-7 años). En los otros dos casos, por el contrario, el período de 6-7 años causó mayor incremento que el período de 14 años, pero menos que el de diez años.

Fir Forest In the Pacific Coast Mountains In the Next 100 Years

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This paper is concerned with fir (*Pseudotsuga taxifolia*) in those parts of its range where it grows in association with hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), balsam (*Abies amabilis*), yellow cedar (*Chamaecyparis nootkatensis*) and white pine (*Pinus monticola*).

It contains a suggestion as to how this fir forest may be harvested and at the same time developed so that it will produce some timber of high quality at the next cut. For the sake of brevity no description is given of the type of forest which will result from present methods of logging and present plans of management; nor is there any discussion of the very important and related matter of yield regulation.

To come quickly to the point, it is suggested that at the time of logging selected trees be left standing to put on increment while growing as an overwood above the succeeding crop of young trees. An ideal distribution for a particular zone is suggested in Table 1. The middle column gives the number of trees to be in the overwood on an average square mile.

If the stocking suggested in Table 1 is accepted as normal for managed forest, then on an average square mile, while the mass of timber is cut every 90 years, a few selected trees will be left. (The period of 90 years will not be debated in this paper; it is adopted because it has been suggested before: for example, the Sloan Report of 1956 on the Forests of British Columbia accepts a rotation of 90 years.) The selected trees will form an overwood of timber which will be very valuable at the next cut. The firs in the overwood will also be some insurance against fire, as their thick bark will enable them (or many of them) to survive a fire which will kill other and younger trees.

Table 1. Number of trees per average square mile in Zone A*

Overwood	Trees standing	Number of trees to be cut every 90 years (Less casualties)
Fir		
90 - 180 years	500	100
180 - 270 years	400	100
Over 270 years	300	300
White pine		
90 - 180 years	200	100
Over 180 years	100	100
Red or yellow cedar		
90 - 180 years	200	100
Over 180 years	100	100
Mass of timber		
Fir, pine, hemlock, cedar and balsam 0 - 90 years	Dense; Some thinned; Much not thinned	All except 500 fir, 200 pine and 200 cedar

*There may need to be a separate table for each of 2 or 3 different zones. For example, it may be the policy to have much more cedar in one of the zones; in another there may be no pine present.

It will not, of course, always be possible to leave fir for the overwood of the age-classes given in the table. But if, for example, all the fir in a stand to be logged are about 400 years old, it will still be possible to find 500 or a thousand of these trees per square mile of good health and with good crowns which can be left standing in clumps for another 90 or 180 years. No evidence has been put forward that these trees cannot go on producing timber at a satisfactory rate, and there is some evidence that they can. Ring counts and diameter measurements were taken on the butt log of a tree that had lived for about 9½ centuries; it was surrounded by firs which were about 400 years old, indicating that a fire or other catastrophe had occurred when the older tree was 5½ centuries old. At that age, its mean annual growth started to decline, perhaps because the tree had been scorched; but up to that age, the mean annual growth had been going up. This is an item of evidence that a fir growing in the mountains can produce timber at an increasing rate up to the age of 550 years or perhaps more, given suitable conditions.

Feasibility of Logging

While this paper is not concerned with the technical details of logging, it is fair to say that some difficulties in logging may result from the presence of the overwood trees, as these will have to be kept undamaged. However, the removal of a mass of timber at the already suggested age of 90 years, while leaving some selected trees to form an overwood, and at the same time cutting some trees from the existing overwood, seems to be not beyond the ingenuity of the logger. The presence of the overwood trees will increase the value of the next cut, and so enable him to spend more money then on equipment or on roads.

Evidence of Value of the Overwood

At this early stage it is only possible to consider some possibilities which can be tested at a later stage:

1. One is that the volume production from the mass of young timber plus the volume cut from a selection of the overwood trees is greater after a 90-year period than the production from the mass alone would have been, had there been no overwood;
2. Or, if it is difficult to believe that it is greater, it is reasonable to believe that it would be the same; and if the volume of the cut is to be the same, then the value of the cut is likely to be greater, as part of it is of selected trees.

The first is a possibility rather than a probability. It rests on the assumption that a bigger mass of roots in the soil and a larger leaf area will result in a bigger yield: in this case, the leaf area of the overwood will be added to that of the mass of timber.

The second hypothesis rests on the assumptions that if the presence of the overwood reduces the growth of the mass of timber below, this is balanced by the growth of the overwood trees themselves; and that the dollar value of the overwood timber is higher per thousand board feet than that of the younger and smaller timber of the mass. If there are unrecoverable casualties in the overwood, this balance will be upset. But assuming that casualties are few, these assumptions are reasonable.

The higher value of large timber of good quality is well known. The price per thousand feet board measure of No. 1 standard fir logs may be 10 to 20% higher than No. 2, and No. 2 may be 20% higher than No. 3.

The butt log of a tree cut on Vancouver Island at age 400, to take one example, was judged to have been a No. 1 log since the age of 350, a No. 2 between 150 and 300, and a No. 3 at age 100: so that its value increased more rapidly than its volume up to the age of 350 (according to log prices prevailing in 1950).

The mean annual growth of a tree in the same stand increased from 6.14 feet board measure at age 290 to 8.27 feet board measure at age 390: the volume from 1,858 to 3,229 feet board measure in the same period. (These measurements were made on the first 82 feet and do not include the top of the tree.) This increase of about 1,400 feet put on by a single tree in 100 years would be matched in volume, but hardly in value, in the same period by 200 square yards of young trees, had the tree been cut down 100 years earlier and been replaced by fir second growth.* (The site index in this case was between 80 and 100: the elevation, 2,000 ft. to 2,300 ft. above sea level.)

The conclusion from these and other measurements is that some fir trees between 100 and 400 years old in the Coast Mountains are increasing in volume and still more in value, at a rate which could not be achieved by any second growth which might succeed them. Clearly, therefore, they should not all be cut down to make way for a young crop to be grown on a short rotation. On the other hand, if too many individual trees were left, the logging would be unduly hampered. Table 1 suggests the number of overwood trees that might be left per square mile without hindering the logging too much. It is not suggested that these be evenly distributed. There may be patches of 10 acres or more with no overwood trees in what were the most disturbed areas at the last logging: they will be balanced by other areas where the overwood is doubly thick.

This type of forest, with an overwood of selected trees, will preserve at least something of the fir-cedar forest, which is one of the world's great timber assets, and which will be totally lost if logging is complete and the new crops are grown on a rotation of about 90 years.

RESUMES

Evolution de la forêt de sapin des montagnes du littoral du Pacifique au cours des cent années à venir

Cette forêt consiste de peuplements de sapins, (*Pseudotsuga taxifolia*), de sapins du Canada (*Tsuga heterophylla*), de cèdres rouges du Pacifique (*Thuja plicata*), de beaumiers (*Abies amabilis*), de cèdres jaunes (*Chamaecyparis nootkatensis*) et les pins blancs (*Pinus monticola*).

Là où l'on adopte une révolution de 100 ans ou moins, il semble rationnel de laisser des baliveaux sélectionnés (sapin, cèdre et pin) former, pendant deux ou trois autres révolutions, un étage supérieur (overwood). Dans ce cas, l'on reconnaît la nécessité d'adopter une méthode d'abattage mieux étudiée que celle qui est employée pour la coupe rase. Le tableau 1 donne, au mille carré, une densité moyenne d'étage supérieur qui ne gênera pas considérablement l'abattage, mais augmentera dans une large proportion la valeur de toutes les coupes qui suivront la première. La répartition d'étage supérieur peut se faire d'une manière irrégulière: plus serrée dans certains endroits et plus espacée dans d'autres. La cîme de ces arbres étant très distante du sol, la croissance de la masse des jeunes arbres—sapins, sapins du Canada, cèdres et beaumiers—poussant à un niveau inférieur se trouvera peu affectée. Pour l'étage supérieur, on ne sélectionnera que des arbres offrant un taux élevé d'accroissement, peu susceptibles de gêner les opérations d'abattage, et capables de résister au vent.

Selon certaines évaluations, un sapin peut croître à un taux toujours plus élevé jusqu'à l'âge de 400 ans ou plus et qu'un sapin âgé de 300 ans peut produire autant de bois de construction au cours des cent années suivantes qu'un peuplement de seconde

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*British Columbia Forest Service Yield Tables, 1947.

croissance de 200 yards carrés [167 mètres carrés] entre 0 et 100 ans.

Enfin, on fait observer que si dans le cas d'une révolution de 100 ans ou moins, on adopte la méthode d'abattage par coupes rases, la forêt mélangée (sapin-cèdre), dont la valeur est bien connue, ne se perpétuera pas.

Evolución de los Bosques de Abetos en las Montañas del Litoral Pacífico Durante los Próximos Cien Años

Estos bosques están integrados por abetos (*Pseudotsuga taxifolia*), abetos del Canadá (*Tsuga heterophylla*), cedros rojos del Oeste (*Thuja plicata*), abetos balsámicos (*Abies amabilis*), cedros amarillos (*Chamaecyparis nootkatensis*) y pinos blancos (*Pinus monticola*).

En lugares en los que se ha adoptado una rotación de 100 años o menos, se sugiere la conveniencia de dejar ejemplares seleccionados de abetos, cedros y pinos para formar una cubierta para otras 2 ó 3 rotaciones. Se reconoce que será necesario adoptar precauciones especiales durante las operaciones de tala. El Cuadro 1 sugiere la densidad promedio de cubierta por milla cuadrada, que no ha de crear mayores dificultades para la corta pero que ha de incrementar considerablemente el valor de todas las cortas posteriores a la inicial de existencias vírgenes. La cubierta puede ser distribuída en forma irregular, pudiendo ser más densa en algunos lugares y estar ausente en otros. Las copas de los árboles que forman la cubierta, por hallarse en gran altura sobre la tierra, retardarán muy poco el crecimiento de la masa de árboles jóvenes, abetos, abetos del Canadá, abetos balsámicos y cedros que crecen a sus pies. Los árboles seleccionados para formar la cubierta serán aquellos que prometen un elevado índice porcentual de incremento, que no ofrecerán mayores obstáculos para las operaciones de corte y que parecen ser resistentes a los embates del viento.

Se ofrecen algunas pruebas de que un abeto individual puede crecer y aumentar de volumen hasta los 400 años o más; y que un abeto que actualmente tiene 300 años, en los próximos 100 años puede desarrollar igual cantidad de pies tablares de madera que una segunda repoblación de 200 yardas cuadradas de extensión entre los 0 y 100 años de edad.

Finalmente, se señala que si se adopta una corta total en una rotación de 100 años o menos, el bosque mixto de abetos y cedros, cuyo valor es bien conocido, no ha de perpetuarse.

La subériculture au Portugal Situation et perspectives d'avenir

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D'accord avec sa distribution géographique naturelle, circonscrite pour ainsi dire à une bande accompagnant le bassin de la Méditerranée occidentale et limitée du côté italien par le méridien qui passe à 14°E. de Greenwich, là où les vents maritimes rendent les caractéristiques climatiques moins arides, le *Quercus suber* L. s'est installé au Portugal dans les régions soumises à une influence atlantique plus intense.

En effet, et mis à part le facteur humain qui aura fortement contribué à l'expulsion du chêne-liège des régions plus fertiles, les grandes altitudes où les basses températures de l'hiver (inférieures à-5°C.) ne sont pas propices à la vie de cette essence, les vallées trop humides qui provoquent l'asphyxie des radicules du chêne-liège et la trop intense alcalinité des terrains calcaires, c'est indubitablement l'indice d'aridité (coefficient de Emberger $K \leqq 50$) qui est surtout responsable de la distribution actuelle de cette espèce forestière au Portugal. On trouve ainsi une plus grande concentration de ces forêts dans les bassins des fleuves Tage et Sado dont les vallées sont directement exposées à la pénétration des brises maritimes, ainsi que sur toute la zone côtière au Sud du premier des deux fleuves cités, mais ici sans grande projection vers l'intérieur des terres en vertu des élévations, bien que peu importantes, qui accompagnent tout le litoral du Alentejo et de Algarve.

Le chêne-liège n'est réellement pas très exigeant quant à la nature du sol dont il dispose au Portugal et qui est de caractéristiques relativement diverses car, du moment que la pluviométrie annuelle ne descend pas au-dessous de 600 mm., il prospère presque aussi bien dans les sols de formation granitique, de roches cristallophiliques et de schiste où dominent les sols bruns sans calcaire et les sols bruns sans calcaire litosoliques, dans les grès argileux et les sables podzolisés du Pliocène et du Miocène ou encore sur les extraits schisteux du Carboniférien où la couche minérale, la seule existante et non différenciée, est bien souvent inférieure à 20 cm.

En vertu de ces divers facteurs on peut affirmer que, avec une fréquence plus ou moins grande, et soit constituant des peuplements étendus, soit réduit à des exemplaires quasi isolés, le chêne-liège surgit tout au long du territoire portugais bien que diminuant nettement vers l'Orient et vers le Nord.

En conséquence, et considérant la valeur importante de son principal dérivé—le liège—il devient évident que cette essence jouit d'une place importante dans l'ordre de la surface occupée, tout de suite après le *Pinus pinaster* Ait.

En effet, le chêne- liège est signalé dans la Carte de la Distribution du Chêne-Liège au Portugal récemment publiée, comme ayant une densité supérieure à 5 individus par hectare (sur 1.012.555 hectares couverts sur cette Carte, seuls 675.965 sont considérés comme occupés par cette essence), en se basant, pour réduire à des peuplements complets les zones de densité inférieure à 40 individus par hectare, sur la moyenne de 70 chênes-lièges par unité de surface, d'après le critérium établi lors de la dernière réunion du Groupe de Travail du Liège de la Sous-Comission de Coordination des Questions forestières méditerranéennes de la FAO et qui a eu lieu à Lisbonne au mois de Mai 1960.

L'aire virtuelle considérée correspond à 26% environ des peuplements forestiers de la métropole portugaise et à 7,5% de sa superficie totale; ceci traduit assez bien l'importance relative de la subériculture au Portugal et on peut y ajouter encore les indications suivantes dont la signification n'est pas moindre:

1. Pour 50.000 propriétaires de subéraies des dimensions les plus diverses, depuis celles occupant plus de 10.000 hectares jusqu'aux plus infimes parcelles, parmi lesquels l'État n'est pour ainsi dire pas représenté, le liège constitue un rendement annuel brut de l'ordre de 600 millions de Escudos auxquels correspondent plus ou moins 180.000 tonnes de ce produit.
2. Cette matière, après avoir été transformée dans le pays même (40%) ou tout simplement préparée (60%), est responsable d'une rentrée de devises de l'ordre de 1.300 millions de Escudos.
3. Ce dernier chiffre correspond à 16% de la valeur totale des exportations portugaises.
4. Le liège, en son cycle complet (production, commerce et industrie), absorbe annuellement environ sept millions de journées-travail d'ouvriers dont le plus grand nombre (66%) sont occupés dans le secteur industriel.

Comme indiqué plus haut, la constitution actuelle des peuplements de liège est loin d'être uniforme.

De cette même Carte de Distribution du Chêne-Liège au Portugal on déduit l'échelonnement en pourcentage des surfaces présentant un intérêt subéricole d'après les densités trouvées:

Nombre (N) de chênes-lièges par hectare	Pourcentage (%) des surfaces
N > 120	7
120 > N > 40	50
40 > N > 15	15
15 > N > 5	28

Ceci est dû non seulement au fait que le chêne-liège ne constitue souvent pas des peuplements purs mais forme plutôt des associations forestières où d'autres essences dominent (plus fréquemment le *Quercus ilex* L. et le *Pinus pinea* L., au Sud du Tage et le *Pinus pinaster* Ait., au Nord de ce fleuve), mais encore de l'association fréquente du chêne-liège et de cultures de céréales.

Du reste, des peuplements purs de chêne-liège déjà anciens, même les plus denses, en tant que forêt vierge, sont aujourd'hui très rares.

La pratique de la coupe ou de l'arrachage périodiques des broussailles est presque généralisée, avec l'objectif principal de diminuer le risque d'incendie, toujours à craindre dans des régions comme celles qui nous intéressent, dont les étés sont secs et prolongés, et à peine dans les terrains en pentes très inclinées et dans les sols trop pauvres où il n'est pas habituel de recourir à des labours, même plus ou moins espacés; ceux-ci se destinent d'une part à combattre les broussailles et à améliorer les pâturages, d'autre part à aider à rendre plus vigoureux les arbres ou même encore à rendre possibles des cultures intercalaires.

Parfois, en conséquence du choc physiologique dérivant du démasclage, ou encore parce qu'on désire ensoleiller la terre à cultures de céréales associées, l'élagage des houppiers est une pratique presque courante; d'une part, afin de donner aux cimes des jeunes arbres une forme plus en harmonie avec une bonne production et de faciliter l'écorçage; de l'autre, afin que l'équilibre physiologique soit maintenu le plus longtemps possible; enfin, et assez souvent, avec l'objectif tout simple de rendre la vitalité à des arbres affaiblis.

De l'ensemble de ces interventions humaines (coupe et arrachage des broussailles, labours, cultures agricoles intercalaires, pâturages, coupes, élagage et écorçage des arbres) utilisées de longue date, bien que pas toujours conduites de la façon la plus judicieuse, il est résulté un déséquilibre biologique progressif des peuplements avec tous les inconvénients qui en dérivent:

En vertu de cette sélection négative et des altérations du milieu, la *Quercetum Suberis* primitive est aujourd'hui très rare.

D'après le Prof. J. de Carvalho e Vasconcelos (de l'Institut Supérieur d'Agronomie de Lisbonne) l'association optimum du chêne-liège serait probablement constituée, dans les zones les plus appropriées, par les essences suivantes ou leurs congénères, ou leur ensemble:

Quercus suber L. (dom.)
Quercus faginea Lam. (co-dom.)
Arbutus unedo L.
Pinus communis ssp. Pinaster (L.) P. Cout.
Phillyrea latifolia L.
Rhamnus alaternus L.
Crataegus monogyna Jacq.
Juniperus oxycedrus L.
Quercus coccifera L.
Pistacia lentiscus L.
Pistacia terebinthus L.
Erica scoparia L.
Myrtus communis L.
Adenocarpus complicatus (L.) Gay
Daphne gnidium L.
Asparagus aphyllus L.
Ruscus aculeatus L.
Cistus salvifolius L.
Cistus crispus L.
Cistus ladaniferus L.
Cistus populifolius L.
Quercus lusitanica Lam. (*Q. fruticosa* Brot.)
Lavandula pedunculata (Miller) Cav.
Lavandula stoechas L.
Calluna vulgaris (L.) Hull
Genista triacanthus Brot.
Pterospartum tridentatum (L.) Wk.
Ulex spp.
Lithospermum diffusum Lag.
Thymus capitellatus Hoffgg. et Link
Halimium libanotis (L.) Lge.
Halimium umbellatum (L.) Spach
Halimium ocymoides (Lam.) Wk.
Halimium lasianthum (Lam.) Spach
Halimium halimifolium (L.) Wk.
Organum virens Hoffgg. et Link
Rubus ulmifolius Schott.
Rosa sempervirens L.
Lonicera implexa Ait.
Lonicera etrusca Santi
Lonicera periclymenum L.
Rubia peregrina L.
Avena sulcata Gay
Arrhenatherum erianthum Bss. et Reut.
Agrostis setacea Curt.
Asphodelus aestivus Brot.
Thapsia villosa L.
Tuberaria lignosa (Sweet) Samp.
Pulicaria odora (L.) Rchb.
Urginea maritima (L.) Baker
Rumex bucephalophorus L.
Ornithopus compressus L.
Tuberaria guttata (L.) Fourr
Linaria spartea (L.) Hoffgg. et Link

Cependant, il n'est pas rare aujourd'hui de trouver des zones où le tapis sous-arbustif des subéraies est pour ainsi dire constitué par les espèces des genres *Cistus, Halimium* et *Lavandula*.

En même temps, les sols ont souffert d'un appauvrissement semblable et sont aujourd'hui très différents des sols primitifs, mis à nu sous l'effet de labours périodiques qui facilitent l'action destructive des rayons du soleil ainsi que l'action érosive des eaux de pluie, mais sans jouir du bénéfice naturel de l'humus.

L'horizon A_0 une fois disparu et souvent encore l'horizon A_1 ayant été décapité, les profils se présentent peu développés et il n'est pas rare que, dans les régions de schiste et de granit, à "substratum" rocheux bien en surface, les agents physiques et chimiques aient sur leurs processus évolutifs une influence très marquée.

Toutes ces modifications ont agi au plus grand détriment de la sylviculture, avec perte de la vigueur végétative et de la longévité économique des arbres, entraînant régénération insuffisante et diminution progressive du couvert, allant jusqu'à une réduction de l'immunité naturelle aux maladies les plus communes.

Le rendement unitaire du liège a donc diminué, tout comme a été affectée la valeur fourragère du tapis végétal, si pauvre qu'il ne peut avoir aucune fonction utile et ne fait que concurrencer la forêt elle-même, allant jusqu'à rendre le sol stérile.

On assiste à une augmentation de l'intensité et de la fréquence avec laquelle surgissent les parasites végétaux et animaux, tels que les *Hypoxylon mediterraneum* (N. Ntrs.) Ces. et Ntrs. et *Endothiella gyrosa* Sacc., *Lymantria dispar* L., *Euproctis chrysorrhoea* L., *Periclista albipennis* Zadd., *Tortrix viridana* L., *Coroebus undatus* Fabr., *Coroebus fasciatus* Villers, etc.

Malgré l'énorme concurrence subie par le liège, en toutes ses applications, en vertu des nouveaux produits créés par la science et l'industrie chimique, la demande dont il est l'objet et sa valorisation se sont maintenues et ont même progressé dans certains secteurs où cette matière première avait été, pendant une courte periode, menacée par des produits concurrents.

Ceci est corroboré par la récente stabilisation des prix, vérifiée lors de la dernière levée des lièges, une des plus importantes du cycle de neuf ans que nous traversons, et dont le niveau en forêt s'est maintenu, par rapport aux deux levées précédentes (Escudos 62$00 les 15 kilos en 1957, 65$00 en 1958 et 1959, en moyenne, pour le liège de reproduction).

Le volume des exportations s'est également maintenu à une échelle nettement ferme, comme le montre le tableau ci-dessous.

Exportations de liège portugais
Tonnes

Année	Matière première	Manufacture	Total
1955	122.178	37.770	159.948
1956	104.985	37.997	142.982
1957	93.051	44.127	137.178
1958	107.305	39.155	146.460
1959	117.007	42.109	159.116
1960 (ler Semes.)	64.950	24.351	89.301

En vue de ces perspectives et parce que l'on a vérifié que la rentabilité du chêne-liège ne pourrait, dans des conditions semblables de milieu, être surpassée par l'utilisation d'autres espèces forestières, les autorités responsables ont résolu d'établir un vaste programme de valorisation subéricole.

C'est ainsi que, profitant des recommandations du Groupe de Travail du Liège de la Sous-Commission de Coordination des Questions forestières méditerranéennes de la FAO, une Comission nationale de Développement subéricole, parfaitement encadrée dans les Plans de Développement général du Pays, a été créée en 1955, laquelle réunit les efforts conjugués des organismes officiels (Direction Génerale des Eaux et Forêts et "Junta Nacional de Cortiça"), des propriétaires et des forestiers.

Ce programme prévoit l'occupation par le chêne-liège de terres jusqu'ici incultes ou à nettes aptitudes subéricoles bien qu'occupées par d'autres espèces, ainsi que l'amélioration des méthodes d'exploitation et de culture des subéraies existantes.

On prétend ainsi garantir la perpétuité du patrimoine subéricole actuel par le remplacement des chênes-lièges annuellement perdus, le développer si possible, améliorer la production et élever la productivité, sans oublier que, par la simplification progressive des méthodes de travail, on pourra réduire le prix de revient, faisant en sorte que le cours du liège devienne de plus en plus accessible, donc en mesure de supporter toute concurrence.

Il a donc été résolu de promouvoir d'une part l'intensification des études techniques et économiques, d'autre part d'augmenter l'assistance technique directe aux plus importantes pratiques culturales, ainsi que déncourager les propriétaires, soit en organisant des concours, soit en leur fournissant gratuitement des semences sélectionnées, aide qui s'étend du reste à tout le pays et comprend tous les travaux de repeuplement en forêts privées.

En ce qui concerne les travaux de recherche, les essais sur la propagation végétative du chêne-liège méritent un intérêt tout particulier, bien que cette essence, comme presque toutes les *Querci,* y soit assez réfractaire.

L'objectif principal est l'amélioration et l'uniformisation de la qualité des productions futures, ce qui serait pratiquement impossible par multiplication sexuée, en raison de la lenteur de développement et de l'hétérogénéité si accentuée du chêne-liège. Ce problème est d'autant plus important qu'il faciliterait la mécanisation des travaux de transformation du liège en permettant une simple opération de coupe.

La connaissance des parasites animaux et végétaux et la manière de combattre les maladies qui en dérivent, ont fait l'objet d'une attention des plus soutenues, en raison de leur rapide propagation et des dégâts causés, bien que, heureusement, il n'y ait à citer que les insectes ravageurs du feuillage et qui n'ont qu'une influence passagère sur la vigueur végétative des arbres.

L'amélioration de l'organisation des inventaires de toute la richesse subéricole a été le principal objet des études économiques.

Le but principal est d'établir des plans d'exploitation définis, surtout en ce qui concerne la régularisation de la production dont le déséquilibre actuel provoque des problèmes sérieux dans tous les secteurs d'activité relatifs au liège.

C'est dans le domaine de l'assistance technique directe au propriétaire que l'action de la Commission pour le Développement subéricole s'est surtout distinguée.

Bien que depuis longtemps déjà il existe une législation de protection du chêne-liège en ce qui concerne le déliègeage, les coupes et les élagages, on a intensifié l'enseignement et les visites d'inspection réalisés par des forestiers, en organisant un plus grand nombre de cours de formation rurale portant surtout sur les élagages, travaux qui exigent une plus grande compétence technique pour pouvoir s'adapter à la grande variété des circonstances qui se présentent.

Ce sont cependant les travaux concernant le sol qui ont fait jusqu'ici l'objet des études les plus approfondies.

En des régions aussi vastes que celle de la zone Sud-Ouest du Carboniférien, la nature schisteuse du sol, l'orientation des couches stratifiées, le relevé du terrain et les sols pauvres font que le revêtement par le chêne-liège ne peut que difficilement être couronné de succès, à moins que la préparation préalable de la terre n'assure aux jeunes plantes un minimum de conditions favorables à la possibilité de développement de leur système radiculaire par le volume de terre disponible et par la capacité de rétention des eaux.

Le même problème se pose quant à la plupart des peuplements adultes, où des travaux de restauration du sol s'imposent, la simple réserve totale préconisée par nos ancêtres étant insuffisante et de résultats incertains en des terrains dont le stade de régression est si avancé.

La technique moderne de restauration des sols au moyen de banquettes à niveau (sillons et bourrelets), procédé simple et économique pouvant s'adapter aux conditions les plus variées (ouvrages de rétention des eaux de pluie qui forcent leur infiltration totale, première phase de la formation progressive de terraces, accompagnée ou non d'amélioration du sous-sol selon le degré de perméabilité du terrain) a été essayée avec succès sur des étendues déjà considérables.

L'amélioration des conditions hydriques accélère une aération plus profonde du sol, favorise incontestablement l'état sanitaire des peuplements adultes ou naissants, rend plus facile les travaux pour l'enrichissement du tapis arbustif et herbacé favorable aux pâturages et à l'amélioration du sol. Ces travaux, l'orientation imposée à la distribution des arbres et des arbustes implantés sur les bourrelets primitifs qui deviendront plus tard les supports définitifs des talus sur lesquels reposeront les terraces, faciliteront la manoeuvre des machines destinées à travailler périodiquement les bandes intercalaires à niveler, et où les surfaces enherbées, par des améliorations successives, deviendront un complément indispensable de toute exploitation subéricole.

Des essais sont poursuivis en vue de combattre les espèces considérées inutiles, à protéger celles ayant une haute valeur fourragère et à introduire de nouvelles espèces indigènes ou importées, essais naturellement accompagnés de travaux de labour, de correction des sols et d'aménagement des pâturages, sans jamais oublier les principes basilaires de l'association végétale et même le parti à tirer du couvert plus ou moins dense des peuplements en question.

Voilà l'orientation suivie au Portugal avec enthousiasme et qui conduira à la modernisation de sa subériculture dans le sens de l'obtention de plus de pâturages en forêt ce qui permettra, on l'espère, d'obtenir un rendement maximum même en un milieu agro-climatique où une nature peu prodigue ne semblerait pas le permettre.

RESUMES

Cork Oak Cultivation in Portugal

This brief monograph deals with the situation, distribution, and composition of cork oak stands in Portugal in relation to the edapho-climatic requirements of this species.

The area occupied by the cork oak as well as the relative importance of these stands to the economy of the country and the technical possibilities for their expansion is indicated.

This paper is primarily a description of the traditional methods of cultivation and exploitation and their application to the stands in their present condition, a study which takes into consideration the degradation of plant cover and soil, the vigor of the trees, their longevity and regeneration ability, as well as the injuries and diseases to which the cork oak is subject.

The stability of cork demand and prices is mentioned. A committee has been established to study the increase in the area occupied by the cork oak, cultural and exploitation methods, a study based on the recommendations of the Cork Study Group of the FAO Subcommittee for Coordination of Mediterranean Forestry Questions. This committee is an integral part of the National Development Plan.

In conclusion, the paper contains a list of the most important bases of the Work Program, the stage of development reached, and the objectives of that Program.

El Cultivo del Alcornoque en Portugal

El tema de este breve ensayo monográfico se refiere a la situación, distribución y constitución de plantaciones de alcornoques en Portugal, en relación con las necesidades edafo-climáticas de esta especie.

Se señala la superficie ocupada por los alcornoques, así como la importancia relativa de las suberosas en la economía del país y las posibilidades técnicas de su expansión.

Este trabajo describe, principalmente, los sistemas tradicionales de cultivo y explotación y su proyección sobre el estado actual de los radales y tiene en cuenta la degeneración sufrida por la capa vegetal y por el suelo, el vigor de los árboles, su longevidad y su poder de regeneración, así como las plagas y enfermedades que atacan al alcornoque.

Se hace notar la estabilidad de la demanda y de los precios del corcho. Se ha integrado una comisión dedicada al estudio del incremento de la superficie ocupada por el alcornoque, y de las técnicas de cultivo y explotación basándose en las recomendaciones del Grupo de Trabajo del Corcho de la Sub-Comisión de Coordinación de Asuntos Forestales Mediterráneos de la FAO y que se encuentra perfectamente encuadrado en el Plan de Desarrollo Nacional.

Finalmente, se enumeran aquí las bases más importantes sobre las que descansa el Programa de Trabajo, su estado de desarrollo y los objetivos previstos.

Utilization of Light by Tree Species Depending on the External Conditions

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Light is the only source of energy for all the vital processes in autotrophic plants.

In accordance with the basic law of protochemistry the great Russian physiologist K. A. Timiryazev came to the conclusion that photosynthesis must depend on the amount of radiant energy absorbed by the assimilating leaf. As is known, photosynthesis is a typically endothermal process and only absorbed luminous energy is capable of doing the work to cause photochemical changes.

Photosynthesis is now universally recognized as the most characteristic and important process responsible for the crop yields of cultivated plants and for tree growth in forests.

Therefore, ensuring the highest intensity of photosynthesis per unit of photosynthesizing surface (with a maximum total leaf area per given plot of ground) is one of the most important tasks of present-day forestry and agriculture. This depends to a considerable extent on the amount of radiant energy absorbed.

The beneficial effect of optimum light conditions on trees has long ago been recognized in forestry. For a long time various kinds of maintenance fellings have been used in forestry practice, the chief purpose of which is essentially to ensure better access of light to the growing trees. In the USSR, maintenance fellings have a long and original history, dating back to the major treatise of G. F. Zyablovsky, a professor of Petersburg University, published in 1804 under the title of "First Elements of Forestry." This book was the first of its kind in world literature.

The history of the development of the theory of maintenance fellings in forests is beyond the scope of this report. At present, this is the main method used by the forester to influence the growing stock.

Light, as has been pointed out by L. A. Ivanov, is the only factor which can be changed directly by means of fellings. Naturally, the thinning of a forest by maintenance fellings brings a change in a number of other conditions of tree growth as well, namely, soil moisture, supply of nutritious matter in the soil, composition and activity of microorganisms, etc.

Experimental work has shown that improving the light conditions of a forest favours tree growth and increases the intensity of carbon dioxide assimilation. It has been established that, from the point of view of light utilization, the most advantageous arrangement of rows made for improving the light conditions in a forest is from north to south. With such an arrangement, tree growth may be as much as 30 per cent faster than with west-east rows, and they accumulate up to 20 per cent of additional wood mass per unit area.

This is due to the high intensity of photosynthesis in morning and evening light compared to midday light. Morning and evening light is relatively richer in long-wave rays.

It has also been established, that various fertilizers and optimum soil moisture conditions have a beneficial effect on the photosynthesis of tree species.

The above-indicated ways of stimulating photosynthesis are employed in forestry practice on the largest possible scale, depending on organizational and economic factors.

It is known that the green parts of plants absorb only a part of the solar radiation falling on earth. Scientists have long been working to determine the amount of radiant energy absorbed by a separate leaf, by a plant and by a forest as a whole. However, there is no uniformity of views in literature on the question of the degree of assimilation of incident radiation by the green surfaces of plants. Thus, the figures given in literature, for the amount of the light reflected, vary from 10 to 25 per cent of the total incident radiation, those for transmitted light are also between 10 and 25 per cent, while those for light absorbed fluctuate between 30 and 85 per cent.

Until recently, the reasons for these large fluctuations in estimating the amount of absorbed radiant energy were unknown.

The latest data on plant physiology, and some of the information accumulated by agrometeorology, obtained in aerial surveying practice and procured by the young branch of science known as astrobotanics, have given an insight into the reasons for these fluctuations in the degree of radiant energy absorption.

First of all, species distinctions even within a single group of plants (mesophytes, xerophytes, etc.) account for fluctuation of up to 25 to 30 per cent in the amount of radiation absorbed.

Accumulated information gives consistent indications of changes in the optical properties of needles and leaves. Thus, in the visible region of the spectrum, the brightness factors of young needles (first year) are almost four times as high as those of old needles. As the young needles grow older their brightness reduces, rapidly at first and then more slowly, approaching the brightness of the old ones. The optical characteristics of old needles also undergo regular changes in the course of the summer: beginning with spring, the brightness rises to a maximum in the first half of July and then gradually falls off. Similar seasonal changes are observed in the optical properties of deciduous tree leaves.

Agrometeorology has accumulated information on the change in the albedo value in the course of the day and throughout the vegetation period. In the course of the day, the albedo (integral) of agricultural plants changes regularly in good weather from a maximum in the morning through a minimum value at midday, and rises again in the evening. Daily albedo fluctuation may amount to 10 or 12 per cent.

This value changes just as regularly in the course of the vegetation period, the fluctuation in the course of a summer being twofold or more.

Hence, the time of vegetation, as well as the hour of the day, may give rise to a substantial correction in the accounted value of reflected radiant energy, as has been noticed both in integral and in spectral accounting.

To select the right type of photographic film to be used in aerial forest surveying and to ensure better deciphering of aerial forest photographs, the spectral reflectivity of the objects to be photographed must be taken into account.

In developing aerial surveying methods, scientists have put a great deal of effort into studying the reflecting properties of individual branches with their needles and leaves, whole crowns and stands. The studies were carried out on the ground, from specially built towers and by airplane. Particularly, studies have been made of the dependence of the spectral reflectivity of tree species on the geographical latitude of their location, on the growth conditions in the forest and on the phenological state of the trees.

The geographical factor has a substantial effect on the spectral reflectivity of tree species. Its chief manifestation is a lowering in the reflection of radiant energy with increasing severeness of the climate. The reflection decreases especially perceptibly in the long-wave part of the spectrum (red and near-infrared rays). For example, the spectral brightness of trees in the Tomsk Region is generally 15 to 25 per cent higher than in the Arkhangelsk Region in the visible rays, but 150 to 200 per cent higher in the near infrared-ray zone. This means that in the more northern latitudes trees reflect less and absorb more radiant energy than in the southern latitudes.

Worsening the growth conditions in the forest increases the reflectivity of the green surfaces of the trees, the maximum brightness shifting to the long-wave part of the spectrum.

A distinct picture has also been established with respect to seasonal changes in the reflectivity of leaves and needles. The brightness factors of young leaves and needles are considerably higher than those of old ones.

Hence, aerial forest surveying brings out another probable reason for the discrepancies in the data on investigations of the optical properties of leaves, this being that the phenological state of the plants under study, the conditions of their growth, and their geographical location are not taken into account.

In recent years, G. A. Tikhov and a group of coworkers have made a detailed study of the optical properties of the earth's vegetation growing under various environic conditions.

These studies have started a new branch of science, known as astrobotanics. A study, covering plants of various species and genera growing at various geographical latitudes from the far North to the far South, was made of the influence of vertical zonality and the change in optical properties of leaves and needles through the seasons.

As a result, numerous facts were obtained bearing evidence of a regular change in reflecting (and therefore absorptive) properties of the green surfaces of plants. It was established that the reflected part of the incident radiant flux decreases (especially greatly in the near-infrared region) with the severeness of the climate, with the altitude, towards the North, and in winter months (for conifers), as compared to the summer period.

It is curious that for most tundra plants no typical chlorophyl absorption band is observed in the red rays. In the spectra of coniferous species the main chlorophyl absorption band is also sometimes weak in winter during heavy frosts.

The data obtained suggest that the optical properties of plants, particularly their spectral brightness, vary, depending on the environic conditions.

Hence, astrobotanists have obtained numerous data confirming the lability of the optical properties of plants. This lability depends on the environic conditions.

Thus, meteorological, aerial surveying and astrobotanic data lead to the idea that the optical properties of leaves are unstable, that they vary in time and that, depending on the conditions of habitation and on the latitude of their locality, plants are capable of reflecting, transmitting and absorbing radiant solar energy differently.

Possibly, the above-mentioned major discrepancies in estimating the amount of radiant energy absorbed by tree species resulted from the failure to take into account the environic growth conditions of the test plants.

On the other hand, the conclusion that the optical properties of plants depend on the environment makes us want to find methods of stimulating light absorption by leaves, methods which are accessible to forestry and will place new tools in the hands of forest workers.

Higher light absorption is advantageous from an economic point of view, as it results in the activation of photosynthesis, improves growth and affects accretion, directly raising the calorific value of the plant matter.

Investigations carried out by us in recent years on the variations in optical properties of leaves depending on the latitude at which the forest is growing, on the soil and air temperature and on the kinds and amounts of mineral fertilizers added to the soil, as well as on the moisture content of the latter, have shown that these properties vary regularly.

The amount of radiant energy absorbed by the leaves of tree species increases distinctly as the climate grows more severe in moving from southern districts to more northern ones. A similar increase in the absorption of radiant energy by leaves is observed when the plants are grown under conditions of artificial cooling of the environic soil and air.

Studies of the optical properties of the leaves of a number of tree species which were given various fertilizers showed that unfertilized plants reflect and transmit the greatest amounts, but absorb the smallest amounts of luminous energy. Introduction of fertilizers decreases reflection and transmission but increases absorption.

Plants which have received abundant quantities of phosphorus show especially great increases in the amount of light absorbed. Assimilation of light can also be influenced by regulating the moisture content in the soil. Experiments have demonstrated that the highest radiant energy absorption is observed at optimum moisture conditions. Both deficiency and excess of soil moisture increase the reflectivity and transmissivity and lower the absorptivity of light.

Thus, other ways of stimulating greater light absorption can be found in addition to maintenance fellings. The most feasible of these are the use of fertilizers and adjustment of soil moisture conditions.

These facts suggest that ways of influencing growing trees may be found which, being economically advantageous, will stimulate higher radiant energy absorption. We hope that this will make for a rise in the utilization factor of the energy of solar rays.

RESUMES

Utilisation de la lumière en sylviculture, suivant les conditions ambiantes

L'une des tâches les plus importantes de la sylviculture et de l'agriculture modernes est d'assurer la plus haute intensité possible de photosynthèse par unité de surface de photosynthèse. Ceci est déterminé dans une grande mesure par l'absorption de l'énergie de rayonnement.

On applique depuis longtemps déjà, en sylviculture, diverses méthodes de coupes d'éclaircissage, le but essentiel étant d'assurer aux arbres en croissance le meilleur accès possible à la lumière.

C'est un fait avéré qu'une certaine proportion seulement des rayons solaires qui atteignent la terre sont absorbés par les parties vertes des plantes. Jusqu'à présent, la documentation existante à ce sujet indique des opinions différentes en ce qui concerne le degré d'assimilation de rayonnement solaire par les feuilles vertes. Pour la lumière réfléchie, nous constatons des proportions variant de 10 à 25 pour cent du rayonnement solaire total; pour la pénétration lumineuse, les proportions varient également de 10 à 25 pour cent, et pour la lumière absorbée, de 30 à 85 pour cent.

Certaines données sur la physiologie des plantes, l'agrométéorologie, données recueillies par la photographie aérienne, ou obtenues grâce à l'astrobotanique—nouvelle branche de la science—permettent de comprendre la cause de ces fluctuations du niveau d'absorption de l'énergie de rayonnement.

L'instabilité des propriétés optiques des feuilles a déjà été établie selon les conditions de croissance et la latitude géographique de la localité.

Cette conclusion suscite le désir de rechercher des méthodes propres à stimuler l'absorption de la lumière. Une absorption maximum de la lumière présente des avantages économiques, étant donné qu'elle s'accompagne d'une photosynthèse plus active, qu'elle stimule la croissance, et qu'elle se traduit par une amélioration de la qualité de la plante, en augmentant sa caloricité.

Les travaux de recherche que nous avons effectués depuis quelques années sur les variations des propriétés optiques—d'après la latitude géographique des forêts, la température du sol et de l'air, et d'après le genre et la proportion d'engrais minéraux appliqués au sol, et l'humidité du sol—nous ont permis de constater que ces propriétés subissent des changements réguliers.

L'absorption de l'énergie de rayonnement par les feuilles dans les forêts cultivées augmente proportionnellement à l'accroissement de la rigueur du climat, au fur et à mesure que l'on s'éloigne des régions méridionales en direction des régions plus septentrionales. Le même accroissement de l'absorption de l'énergie lumineuse par les feuilles a été constaté en faisant pousser des plantes dans des conditions où le sol et l'air étaient refroidis artificiellement.

Une fertilisation abondante du sol augmente l'absorption de l'énergie de rayonnement par les feuilles de ces plantes. Cet accroissement est particulièrement remarquable chez les plantes qui ont reçu des quantités abondantes de phosphore.

Une humidité insuffisante aussi bien qu'une humidité excessive du sol, entraînent une réduction de l'absorption de la lumière, par rapport aux plantes qui bénéficient d'une humidité optimum du sol.

Par conséquent, en plus des coupes d'éclaircissage, il est possible d'employer d'autres moyens pour favoriser une absorption maximum de la lumière. La façon la plus facile de tirer profit de ces moyens sera d'employer des engrais et de régulariser le taux d'humidité du sol.

La Utilización de la Luz en la Silvicultura, de Acuerdo con las Condiciones Imperantes en el Medio Ambiente

Una de las tareas más importantes de la silvicultura y de la agricultura modernas es la adopción de medidas que aseguren la mayor intensidad del proceso de fotosíntesis por unidad de superficie fotosintetizante. En gran medida este proceso se rige por la absorción de energía radiante.

Desde hace mucho tiempo se han estado aplicando en la silvicultura diversas clases de operaciones de entresaca, siendo su objetivo principal asegurar que los árboles en crecimiento tengan acceso a la mejor luz posible.

Es sabido que solamente una parte de los rayos del sol que llegan a la tierra es absorbida por las porciones verdes de las plantas. Hasta ahora, en los diversos trabajos sobre la materia no ha habido una unidad de criterio con respecto al grado de asimilación de la radiación solar por parte de las hojas verdes. En lo que respecta a la luz reflejada, encontramos magnitudes que oscilan entre el 10 y el 25 por ciento de toda la radiación solar; en cuanto a la luz penetrante, el porcentaje también varía del 10 al 25 por ciento, mientras que para la luz absorbida hallamos que es del 30 al 85 por ciento.

Cierta información sobre la fisiología de las plantas, sobre la agrometeorología, la información recogida por medio de fotografías aéreas, así como los datos reunidos por medio de la astrobotánica, una nueva rama de la ciencia, permiten comprender la causa de estas fluctuaciones que se producen en el grado de absorción de la energía radiante.

Oportunamente se ha establecido que la inestabilidad de las propiedades ópticas de las hojas depende de las condiciones de crecimiento y de la latitud geográfica del lugar.

Esta conclusión provoca el deseo de hallar métodos que permitan estimular la absorción de luz. La absorción máxima de luz es económicamente ventajosa ya que a ella se asocia la activación del proceso de fotosíntesis, mejora el crecimiento y se refleja en la calidad de la planta en crecimiento, elevando su caloricidad.

En años recientes hemos llevado a cabo trabajos de investigación sobre los cambios que se producen en las propiedades ópticas, que dependen de la latitud geográfica en que se halla el bosque en crecimiento, de la temperatura del suelo y del aire, así como de las características y cantidades de los abonos minerales aplicados al suelo y del grado de humedad contenido en el suelo. Se ha determinado que tales factores producen cambios regulares en estas propiedades.

La absorción de energía radiante por parte de las hojas en cultivos forestales incrementa en proporción con el aumento del rigor del clima a medida que se va de las regiones meridionales a las más septentrionales. Igual aumento en la absorción de energía luminosa por parte de las hojas, ha podido observarse en plantas cultivadas bajo condiciones de enfriamiento artificial del suelo y del aire.

La aplicación al suelo de cantidades abundantes de abonos aumenta la absorción de la energía radiante por parte de las hojas de estas plantas. Este aumento es particularmente notable en plantas que han recibido aplicaciones abundantes de fósforo.

Tanto la insuficiencia como el exceso de humedad en el suelo, producen una reducción en la absorción de luz, en comparación con plantas que se cultivan en suelos que cuentan con óptimas condiciones de humedad.

Por lo tanto, además de las operaciones de entresaca, es posible hallar otros métodos que estimulan la máxima absorción de luz. Entre aquellos de más fácil aplicación se halla el empleo de abonos y la regulación del contenido de humedad del suelo.

The Problem of Conversion of Coppices Into High Seed Forests

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The area occupied by coppices in Bulgaria is 1,800,000 hectares, or 55.1 per cent of the woodland of the country.

They consist mainly of various species of oak (*Quercus sessiliflora* Salisb., *Q. conferta* Kit., *Q. pubescens* Willd., *Q. pedunculata* Ehrh.); cerris oak (*Q. cerris* L.); and hornbeam (*Carpinus betulus* L. and *C. orientalis* Lipsky). Our coppices are characterized by their one-storied growth and by the usual absence of underwood. They lie chiefly in the lower forest zones at an altitude under 700 metres above sea level. The temperature and rainfall in this zone are typical of the general climatic conditions of our country—moderately Continental—with a mean annual rainfall of 670 mm. and a mean annual temperature of 12° C., with extremes ranging between —38° C. and +45° C. The average age of the coppices is about 15 years, since, in the past, they were exploited at short rotations.

Coppice forestry is evidently unprofitable. This has always been realized by our forestry specialists, and there have been proposals for converting the coppices into high seed forests. In the past, however, these proposals never materialized because the necessary economic conditions were lacking. The woodlands were, in the past, owned by private persons or the local urban and village councils and were exploited to supply the population with firewood, with leaf fodder and as grazing land. The nationalization of all forests and the development of the coal mining and electric power industries have limited the use of the forests as a source of fuel. Since the co-operation of farming, the use of the woodlands as grazing grounds has considerably decreased. All this has created the necessary prerequisites for limiting coppices and the conversion of large coppice areas into high seed forests.

For the time being, some 630,000 hectares of coppices have been earmarked for conversion into high seed forests. This represents a full third of the total area of such forests, which are no longer treated as coppices. Furthermore, the clearcut in the remaining coppices is being gradually restricted, and measures are being taken to improve them and transform them into seed stands.

The practical transformation of these coppices into seed forests follows methods that have been found most appropriate to our particular economy. One of these methods is the conversion of the coppice-land, while ensuring in the process the highest possible yield of average-sized timber. The method of conversion by medium forest husbandry is applied as an intermediary stage. We shall mention this method briefly.

Method of Conversion of Coppices into High Seed Forests, While Ensuring the Highest Possible Yield of Average-Sized Timber

This method aims to achieve the best balance between the desired conversion of the coppices into seed forest and the highest possible yield of average-sized timber. According to the standards of this country, average-sized timber is obtained from logs with an 8 to 17 cm. diameter at the thin end. Such timber is in greatest demand in our country. It is obtained by a rotation of 40 to 60 years, when the volume increment per unit area is near its peak. At this age the percentage of the yield is highest, as at a later age the coppice trees, and especially the cerris oak, begin to suffer from decay, dry top and other injuries. On these considerations, we have decided that the conversion of the coppices into seed forests should be carried out at a comparatively early age—between 40 and 60 years.

The underlying idea of this method is that during the period of conversion, the thinnings and regeneration cuts should be carried out in a manner allowing the greatest possible number of straight-growing shoots to reach average size. The suckers yield the largest quantity of average-sized timber when reaching a breast diameter of 16 to 22 centimetres.

With this in view, during the earlier period of 10 to 25 years—when the first suckers reach the required diameter at breast height, the canopy of the coppices is maintained at a density of not less than 0.8, in order to stimulate the growth in height. During this period all crooked, branching and injured young trees are removed. When the first suckers reach the required diameter, thinnings are carried out in a different manner, and the cutting includes mainly trees which have reached a breast diameter of 16 to 22 centimetres. These trees are usually in their first and second class of growth (first, second and third class—according to Kraft). This enables the remaining, more slender trees (of the third, and even fourth class, after Kraft) to grow faster to the required size. In this way the increment covers the maximum number of straight-stemmed trees reaching the average-sized timber.

The third period begins by the regeneration cut operations at the moment when so many trees reach a diameter of 16 to 22 cm. that their removal decreases the canopy to under 0.7.

The regeneration cut operations involve mainly trees that have reached a diameter of 16 to 22 centimetres. To avoid frequent and unnecessary intrusions, it is preferable to wait until a larger number of trees have reached the required size. In the interim, usually a period of 10 to 15 years, seed regeneration should be assured. This can often be attained by natural regeneration, as at this age the woods yield sufficient quantities of oak and beech seeds. In the absence of seeds during sterile years, or whenever current species are to be replaced by more valuable ones, reforestation work can be speeded up by sowing or planting of seedlings. Whenever thinning appears necessary, the suckers are cut close to the ground.

The method under discussion is at present applied in our country for the conversion of 430,000 hectares of coppices, which involves annual thinnings of over 40,000 hectares of young stands.

A comparison between the above method and other methods applied in silviculture shows its proximity to that proposed by Professor V. G. Nesterov. There is also a certain analogy with Borgrave's method of selective thinning. The essence of the method under discussion is the fact that it is applicable to natural woodland for the purpose of its conversion into seed stand, while at the same time it affords opportunities of obtaining from the stand volume the largest possible amount of average-sized timber.

Reconstruction of Forests of Unsuitable Composition

The reconstruction of coppice and its conversion into seed forest is applied to woodlands of unsuitable composition. In such cases the stands are clearcut. The reforestation work is undertaken, according to site conditions, by the planting of valuable species of white and black pine, poplars, etc. Reforestation work with poplars and acacias usually necessitates prior clearcutting. In other cases, reforestation can be carried out under the canopy.

Utilization of Medium Forest in the Conversion of Coppices into High Seed Forest

The medium forest form can be applied in two ways. The first aims at obtaining the largest possible amount of timber.

Accordingly, during the first coppice cutting cycle 350 trees per hectare are left standing. During the second cycle an additional similar lot per hectare is left standing. The same process is continued in all subsequent cycles until the formation of a close canopy, which would hamper the development of sucker growth occurs. At this stage the stand is ready for regeneration cutting.

When the composition of the coppice stand is highly unsuitable and a sufficient number of valuable species cannot be selected for the desired canopy, such would have to be introduced by the planting of suitable species of seedlings.

As mentioned above, the coppices in Bulgaria occupy more than half of the woodland of the country. For that reason, the task of their conversion into seed forests and the problem of a general improvement of their productivity are of great importance to our national economy. Accordingly, they have become a matter of prime concern both in the praxis of forestry, and in the field of scientific research.

RESUMES

Le problème créé par la conversion des taillis en futaies

En République populaire de Bulgarie, les taillis occupent 55,1 pour cent des terrains boisés et tous les moyens sont mis en oeuvre pour arriver à convertir ces taillis en futaies dans un proche avenir. Diverses méthodes sont employées pour parvenir à ce résultat et elles sont appliquées conformément aux conditions économiques et biologiques des emplacements respectifs.

Lorsque les taillis sont composés d'essences de qualité telles que chêne, bouleau etc., la conversion s'effectue lorsque les arbres ont atteint l'âge de 40 à 60 ans. La méthode appliquée dans ce cas est basée sur le principe qui consiste à activer la croissance des arbres retardés. Au cours de cette période de conversion, les éclaircissages et les coupes de régénération sont pratiqués de façon à permettre au plus grand nombre possible des rejets existants d'atteindre un diamètre de 16 à 22 centimètres à hauteur de poitrine. Cette dimension permet d'obtenir un rendement maximum en bois d'oeuvre, bois de charpente, et autres catégories de bois qui sont nécessaires à notre économie nationale.

Au premier stade, l'éclaircissage tend à maintenir une densité de couvert qui ne soit pas inférieure à 0,8 afin d'activer la croissance en hauteur. Le deuxième stade commence lorsqu'un certain nombre de troncs ont atteint le diamètre de 16 à 22 cm. Au cours de cette opération, on coupe non seulement les arbres contournés ou endommagés mais aussi quelques arbres élancés dont les troncs ont un diamètre de 16 à 22 cm. La densité du couvert ne doit pas aller au-dessous de 0,7.

La coupe de régénération s'effectue en trois opérations au cours d'une période de 15 ans. Tout d'abord, les arbres dont les troncs ont atteint un diamètre de 16 à 22 cm. à hauteur de poitrine sont abattus, tandis que les arbres plus minces sont laissés sur pied jusqu'à ce qu'ils aient atteint le même diamètre. La régénération par ensemencement s'effectue au cours de cette période.

Les taillis composés d'essences inférieures font l'objet d'une coupe claire, suivie d'un reboisement en conifères, chênes ou autres espèces de qualité. Les taillis où le pourcentage des espèces de qualité est plus élevé sont convertis en futaies par l'application d'un aménagement spécial de transition.

El Problema de la Conversión de Tallares en Bosques de Producción Elevada de Semillas

En la República Popular de Bulgaria los tallares ocupan el 55,1 por ciento de las tierras forestales del país. Se están llevando a cabo medidas minuciosas a los efectos de convertir a estos tallares en un futuro cercano en bosques de elevada producción de semillas. Con tal propósito, se aplican diversos métodos adaptados a las condiciones económicas y biológicas que imperan en cada sitio forestal.

En tallares integrados por especies valiosas tales como robles, hayas, etc., la conversión se lleva a cabo cuando las existencias tienen un edad que oscila entre los 40 y 60 años. El método aplicado en este caso se basa en el principio de estimular el crecimiento de los árboles retrasados. Durante el período de conversión, las entrecortas y las cortas de regeneración se llevan a cabo en una forma tal que permite que el mayor número posible de los vástagos existentes alcance un diámetro de 16 a 22 centímetros a la altura del pecho. Este diámetro permite obtener la mayor cantidad posible de maderas, tirantes y otras selecciones de necesidad para nuestra economía nacional.

La primera fase de la operación de entresaca tiende a mantener una cubierta densa de no menos de 0,8, que estimula el crecimiento en altura. La segunda fase comienza cuando varios tallos alcanzan un diámetro de 16 a 22 centímetros a la altura del pecho. Durante esta fase no solamente se cortan los árboles deformes y dañados , sino también algunos de los que tienen un diámetro de 16 a 22 centímetros, a la altura del pecho. La cubierta se mantiene a no menos de 0,7.

Las cortas de regeneración se efectúan en tres etapas durante un período de 15 años; en primer término se cortan los árboles que han alcanzado un diámetro de 16 a 22 centímetros a la altura del pecho, dejándose a aquéllos que son más delgados hasta tanto

alcancen el diámetro señalado. Durante este período se produce la regeneración por semilla.

Los tallares compuestos de especies inferiores se someten a una corta total y se procede al plantío de coníferas, robles y otras especies valiosas. Los tallares que contienen un porcentaje más elevado de especies valiosas se convierten en bosques de producción elevada de semillas mediante la aplicación de métodos de administración especial para bosques de transición.

A Brief Account of Forestry in Portugal

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The object of this study is to present the principal aspects of Portuguese Forestry to those members of the Congress who have no direct knowledge of the reports regularly submitted by Portugal to the FAO Forestry and Forest Products Division, and also to remind the others of the great importance—geographic, ethnical, economic and social—that forest resources have in this country.

It is, therefore, only a summary of forestry history in Portugal and not an exposition of the many interesting details in the exploitation of forests, whether in its evolution over the centuries or in its present-day feature. Nevertheless, some references are made to the long history of forestry initiatives taken by the government.

It will here be of interest first to recall what the Portuguese territories are, their situation, area, population and populational density. This country was established more than eight centuries ago as a distinct nation and, having been subject to many influences—of the kind that often bring about radical changes in the biological characteristics of a country—could hardly help, therefore, being directly and strongly affected by the upsets that the more or less intemperate interference of man over the centuries has wrought on the soil and vegetation.

In this small European country, man's interference has been exercised for so long and to such an extent that it has long been recognised how necessary it is to control the use of these natural resources. Hence, the passing of laws and regulations by state and local authorities. These measures have been so regularly repeated that each one may be considered as derived from the one before. But it must be noted that it was on this tradition of regulations built up over the centuries—in spite of upsets due to wars, political changes and to the diversion of national activity into the great nautical enterprise of the discoveries, begun at the start of the 15th century—that present-day silvicultural practice has been based, with benefits that are obvious throughout the whole country.

The line of development has shown, in all forestry work undertaken up to now, that tradition has always been the main reason for taking in hand any task, however difficult or up to the modern standards it may be.

In truth, forests are protected nowadays just as it was recognised as advantageous to do so in the 12th century. Sand dunes are planted, because it was shown in the 13th century how necessary it was to improve the soil in this way. The vegetation of the Overseas Provinces is studied, just as it was at the beginning of the 15th century by the sailors working on Henry the Navigator's instructions, who collected and kept samples of each plant species, together with a note of where it had been found and the name it may have had.

In Portugal, we find that the principal aims of the Forest Services, as regards the development and administration of forest resources, as well as the management of inland waters, are as follows:

1. The preservation, protection and regeneration of forest areas, which are considered to be one of the fundamental geographical elements of the country, and therefore, an integral part of the physical substratum of the national and ethnical grouping.
2. The profitable use of these resources, by which is understood the full and lasting enjoyment of all the direct and indirect advantages that they bring on, which may eventually raise the standard of living and welfare of the population.

Consequently, in Portugal, forest resources, which nowadays occupy about a third of the total area of the Portuguese mainland, are not just thought of as a simple economic factor, since several other aims, even purely moral considerations, have always been reckoned with.

Since to analyse the history of the utilisation of forest resources is equivalent, in a way, to following the long evolution of the primitive forests after their having reached a stable biological balance, a brief sketch is made illustrating the principal features of the arboreal covering of the country, with some account of the influences it has undergone over the centuries, and of the regulations and legal dispositions that have dealt with it and protected it.

In point of fact, to visualise the ecological conditions under which the present-day types of autochthonous vegetation originated, developed and eventually reached their climax, we must go back to a period several centuries prior to proto-historical times—perhaps even to such early ages as those when the xerothermic period set in, on the retreat of the ice, and, of course, the following grasslands stage, which must have been rather short, on account of the southerly location of the Iberian Peninsula.

On the other hand, the influence of man on the makeup of the landscape, although of long duration and profound, has not been such as to prevent us, on examining the present flora, from concluding that the climactic forest was the predominant feature of the first native vegetation of the country and that *Quercus* forests were the most common climactic formations. Even today, much degraded as they are, they show, as in a true reflection, a period of relatively stable ecological conditions, which most surely lasted for many thousands of years.

In fact, the historical evidence that it has been possible to collect, as regards the ancient vegetation of the country, leads us to assume that forest formations were predominant in post-xerothermic plant life, and that oak forests were the most common.

If only a few, there still exist living vestiges of these formations, in spite of their having been much modified by human influence. The associations are represented by a few and small, but nonetheless valuable, extant woods, specially in the North. But as for single exemplars of the botanical genera, descended from those great dense forest formations of former times, they are still abundant and are to be found everywhere. Thus, the genus *Quercus* is represented in the flora of Continental Portugal by some ten species. Most of these species are subjected to an orderly, methodical exploitation, or at least their utilisation, going back to a remote origin, has the features of a permanent undertaking of long standing.

Although their one-time distribution throughout the country has suffered certain changes, these broad-leaved species still dominate the modern landscape together with the cluster pine, *Pinus pinaster* Sol. ex Ait. In the same way, these species have for a long time supplied their large share of forest products.

As for the two adjacent archipelagoes—the Azores and Madeira—we know that at the time of their discovery at the beginning of the 15th century, they were covered with rich forest formations, containing many species that were only to be found in the mainland flora of the Tertiary period. This vegetation belongs to the Atlantic floral division known as the "Macaronesia." From an examination of its makeup, the most important features would seem to be a predominance of Lauraceae, an absence of Castaneaceae and a small showing of Coniferae. Of the *Pinus* species, not even the Canary pine (*Pinus canariensis*) must have existed at that time in the Azores and in Madeira.

In truth, everything leads us to believe that the only softwoods in the ancient flora of the two archipelagoes were the two known junipers and the yew, which are still to be found there.

Of the primitive insular formations, so rich in their general compositions as well as in their endemism, there are still a few relics. These, especially on the northern slopes of Madeira, in spite of their having been greatly interfered with, may even today give us an idea of the marvellous forests which Prince Henry's mariners were fortunate enough to discover, study and admire.

Coming back to the Continent, although it may be said that it is not easy to estimate with any exactness the degree of intensity with which, over the millenia, man's influence has made itself felt in the constitution of the vegetational covering, nevertheless, the results are unmistakable and profound. And given ample evidence of man's activities here in the Neolithic age, this influence must indeed be very old.

To estimate the duration of this influence, however, it is not necessary to go so far back. It is sufficient to observe the repeated evolutions of civilisation before the founding of the nation in 1139, and thereafter, during its consolidation, to be able to form some judgment of the long-drawn-out changes that the first vegetational formations were already exposed to. All movements of population, connected more or less intimately with fires and the pressing need to clear land for cultivation, are the principal causes of the great modern transformation of the original biological character of the country.

The increase in population and the accompanying expansion of agriculture and craft industries, together with the ever-growing desire (innate in all human beings, but especially in the countryman) to explore and appropriate the wilderness, to clear it for cultivation, and to turn to profit anything wild and seemingly unproductive, have given rise to this huge geographical transformation that is still being carried on today, in spite of the many-sided work of the public administration directed to the preservation and protection of the ancient vegetation. This work has long been evident in regulations, some of which are still kept in historical archives, as if just to prove that the very rigour of the steps taken was a tacit recognition of the reality of the destruction of the original forest that had been left as a heritage of previous stages of civilisation.

Documentary evidence does not go back much further than the beginning of nationality. In truth, although Roman domination in our land was long, well organised, and relatively stable and pacific—nearly four centuries of effective occupation, which mark a high point in demographic development and civilization, without, however, any lasting ethnical effects—it is only from the Visigothic monarchy, and therefore from a much more recent and shorter period, less than a century, that we have documents of any worth for the study of the history of the safeguarding and rational exploitation of forests.

This documentation is to be found in the celebrated code issued in the 7th century, the last Visigothic code containing legislation on the cork-oak and softwood forests. However, the regulations here laid down must have been only an attempt made by the Visigoths to correct their own genius for transforming the countryside. In spite of their being a warlike people, their rule here coincided with one of the few peaceful periods in the early history of the country.

It has not been possible to unearth any evidence for the period between the Visigoths and the establishment of the Portuguese Kingdom, i.e., for the five centuries subsequent to the promulgation of the Visigothic code. We may only conjecture about the many changes that must necessarily have taken place under the long and convulsive process of the Moslem occupation of the territory.

Under the first dynasty of the Portuguese monarchy, the Alphonsine dynasty, 1139-1383, various dispositions were made which exist still in the chanceries. They are made up of various laws, by-laws, regulations and charters of privilege, passed for the protection of forest areas and, more particularly, of pine, oak and cork-oak forests. Some of these documents regulate the felling of timber. These, although they include wide concessions of hunting lands and grants to bodies, many of which were unable to ensure the efficient conservation of the ancient forests, also deal with the preservation of the larger game animals, such as the bear, the deer and the wild boar. Amongst the oldest dispositions for the protection of the forests is the law of 1310, in the reign of King Diniz, prescribing punishment

". . . for any man who should cut down trees in the area of Campo de Ourique. . . ."

From that period dates the creation of the Pine Forest of Leiria, which even today is the most important of the state forest properties. It was planted with the object of stabilising the sand dunes on which it stands. At the same time, it supplied the country's dockyards with suitable wood for shipbuilding, especially for fitting out our first large fleets which were then being built. A hundred years later, from the beginning of the 15th century onward, such fleets would sail all the seas in search of the shores that were still unknown to the old world.

The monasteries and other religious organisations must take part of the credit, not only for carrying on the laborious reclamation of the soil for cultivation, but also for their part in the protection and regeneration of the large tracts of forest lands. This is especially the case of the Cistercian monastery of Alcobaça. During this period, the Alcobaça monks exercised jurisdiction over great properties, many of which were in fertile regions, but even so, for the most part occupied by forests that they maintained and even planted on their own initiative.

But, while it is certain that various ways of protecting the forest then came into use, it is no less true that, after the frontiers of the new nation had been established, a task that was completed by the middle of this period (1250) at the cost of much warring against the retreating Arabs, there succeeded a period of large-scale forest clearance, linked to the intense movement of reconquest and subsequent settling after peace had been restored. Towards the end of the dynasty, the important law of the "Sesmarias" (a wastelands ordinance) was promulgated by King Ferdinand, which must have widened the scope for clearing the forest lands still extant over a large part of the country.

Under the second dynasty (Aviz, 1385-1580), which covers the period between the two great battles for independence against Spain (Aljubarrota, 1385 and Alcantara, 1580) and reaches its political apogee in the formidable maritime expansion, begun and attained in the 15th and 16th centuries, there are four salient facts in the history of the country's forests, two of which belong to the first reign, that of King John I.

The first was the publication of the Book of Hunting, "Livro da Montaria," a treatise in the King's own hand on the art of hunting. He wrote it shortly after he had defeated the invading Castilian armies at Aljubarrota. The second was the creation of the office of Lord Game Warden, "Monteiro-Mor," by royal charter of 26 August 1414. In 1435, in the reign of King Duarte, this office was given its first regiment. The officer was to direct the guarding and policing of the preserves and forests, which were at that time enormous and extremely rich, not only in timber, but also in game.

The third of the facts, cause and effect of the second, is the extraordinary increase, up to King Manuel's time, in the area covered by the royal preserves. This circumstance, if we are to judge from complaints made by the people, must have affected large tracts of the ancient forests, and resulted, as we see from the General Assembly of Evora (1481-82), in a palpable setback in the increase in agricultural production.

The last important fact in the history of forest policy under the Aviz dynasty is a setback for protection. This is seen in the almost general clearing of all the hunting preserves of the Kingdom, ordered in the Regiment of King Manuel, of 8 August 1498. This measure was aggravated by new successive dispositions which were extended even to private preserves, which were condemned to almost complete extinction in certain cases, sometimes just to correct the abuses that their owners were guilty of in relation to the needs of the surrounding villages.

At the same time, the powers of the game wardens were restricted. In some districts the office was suppressed altogether. There were also some attempts at re-afforestation and preservation, which probably did not, however, have much influence for the better in the silviculture of the time. It should be pointed out, nevertheless, that it was in 1534 that the first Regiment of the Pine Forest of Leiria was promulgated, setting up amongst other rules, a felling regulation.

The lack of an adequate method in the utilisation of the other forests in the country, coupled with the increase in consumption due to the great alluring naval enterprise that inspired all, the ruled and the rulers, gave to this period the features of a true decline in forest conservation. This also happened in the Azores and Madeira; in the latter case, in defiance of the great care and strictness of King Sebastian's 1562 Regiment on Forest Resources.

After the defeats of Alkacer-Kibir, in Morocco (1578) and Alcantara, near Lisbon (1580), there began the reign of the third dynasty—The Philippine, (1580-1640) —during which the country and almost all her overseas territories were governed by the monarchs of Spain, which was then the most powerful state in Europe.

However, it was during the 60 years of this foreign domination that several legislative dispositions were issued, which must be considered as some of the most constructive measures, relating to forestry, passed in the whole history of the country.

The Philippine forestry policy may be symbolised in the Regiment of the Lord Game Warden of 1605, which laid down the foundations of a true forestry code, since, apart from controlling the conservation and exploitation of crown forests, it also made the same measures applicable to private woodlands.

In addition to this regiment, many other new measures were passed. While some of these disengaged certain forest areas from the protection they had enjoyed, others, on the other hand, were decreed with the object not only of demarcating the hunting preserves and providing for the protection of flora and wildlife, but also of furthering the afforestation of the Leiria heathlands. These measures, and others regulating felling of timber, had the object of remedying the great lack of building timber, then experienced.

An example of beneficent monastic action in regard to forestry under the dynasty is that of the Carmelite Order (Discalced) settling in 1630 in the wilderness, on the Bussaco hill range, where one of the most valuable forests in the country was created, now the National Forest of Bussaco, containing a stand of marvellous centenary exemplars of *Cupressus glauca,* unique in Europe.

When independence was re-established by the revolution of 1640, and the fourth dynasty began (Bragança, 1640-1910,) a new period in the history of the nation's forestry set in. From then on down to the present time, i.e., nearly three centuries, political and economic vicissitudes have been such that only one conclusion can be drawn as regards the preservation of the original biological unit: transformation went on apace, and on a greater scale than before.

The consolidation of national independence, carried out at the cost of repeated battles, most of which were fought within the country; the wars overseas waged against intruding pirates, and their repercussions at home; the economic crises and reforms of the second half of the 18th century; the Napoleonic invasions and their profound general influence on the preservation and administration of public resources; the crisis of liberalism in the 19th century, subsequent changes in the management of the large properties, and economic fluctuations; the opening of the new highway and railway networks, which made the exploitation of the more distant forests easier and more profitable; the great developments in industry, especially after the last quarter of the century; and, finally, the two great world wars of the 20th century, with all their incalculable effects on the life and economies of the world, combined with the increase in population, which in these last three centuries has been fourfold, and its consequent increase in the individual needs which became of a magnitude previously unknown—these are facts which altogether constitute a long series of direct or indirect causes of the wearing down of the ancient forest formations. This is a situation that has only been partly counteracted by attempts—beset with difficulties—at forestry reforms, which have resulted in the creation of a new landscape, a substitute landscape, that has many of the characteristics of the artificial.

The principal steps in the progress of silviculture in the three hundred years which have gone by, from 1640 to the present, may be summed up as follows:

During the period from the restoration to the accession of John V, i.e., from 1640 to 1706, we must point out the ratification of the Regiment of the Lord Game Warden and other measures dealing with the preservation of forests and the planting of trees on waste lands unsuitable for agriculture.

In the long reign of King John V (1706-1750) special importance would be given to: the acquisition by the state of certain new forest holdings, such as the Mafra and the Necessidades estates; the planting and upkeep of roadside trees; the establishment of the Medos Pine Forest, started from seed on the sand dunes; and the general regulation of felling. This last regulation was motivated by the many abuses then committed all over the country in the exploitation of forest resources.

However, these measures did not on the whole adjust the balance, notably in consequence of the great expansion of corn and grape growing, which just then started and which reclaimed large tracts of land that had previously been taken up by forests. The trend was further stressed in the following reigns.

During the reign of King Joseph I (1750-1777) and reflecting the spirit of the times, generally considered as a period of great political and economic reforms, many new important measures were taken. Amongst them were: the creation of the Inventory of the Royal Forests; the Regiment of the Pine Forest of Leiria; and the accompanying creation of the Office of Chief Warden of the Royal Forests; the issuing of regulations concerning hunting preserves; and further dispositions concerning the encouragement given to tree planting, both on the Continent and in the Islands.

The reforming spirit abounding in this reign was carried over into the reign of Queen Maria I (1777-1816), embracing the Regency period of Prince John, later King John VI. Among the most important forestry measures are those dealing with the planting and upkeep of roadside trees (1765 and 1796); the study of the fixation of sand dunes in the Island of Porto Santo, Archipelago of Madeira (1769); the creation of the Office of Superintendent of Crown Forests (1783), which somewhat later came under the management of the Ministry of the Navy (1797); the control of forest fires; works of afforestation, especially the planting of the sand dunes south of the village of Vieira, lying between the Pine Forest of Leiria and the sea (1791); the first steps of detailed research into the technique to be used to bind these shifting sands of the sea shores, carried out at Aveiro (1799) and Lavos (1802); the distribution of great quantities of seeds and seedlings for use in afforestation work on the Continent and in the Islands; the creation of new forests to supply the mining and iron smelting industries; the creation of the Office of Superintendent of the Pine Forest of Leiria and the reorganization involved (1783); the publication of a new Regiment for these properties (1790); the establishment of a new felling plan, applicable also to the Leiria Forest (1796); the commencement in 1803 of valuable studies and plans in watershed reclamation in the Adjacent Islands, followed by the publication of the Royal Charter of 1804, establishing a minimum of gradient above which lands were to be classified exclusively for forest capability; the general protection of all forest resources, a provision which also included various Overseas Possessions, such as Brazil; and the first general project of the fixation of sand dunes in the Metropolis which was published in 1815, by Andrade e Silva, under the title of "Memorial on the Need for Planting New Woods in Portugal."

After the Napoleonic invasions, which caused a profound upheaval in the forest administration in Portugal, there followed another period of transformations during the struggles of Liberalism. The Cortes of 1821 immediately decreed measures which began by the suppression of all non-walled-in hunting preserves, together with the minor offices of game wardens. The upkeep of practically the whole of our forest resources was entrusted to the local authorities of the districts where the forests were situated.

Fortunately, the General Administrative Council of the Crown Forests was organised to remedy the decline in the fortunes of the royal forests. The order-in-council appointing this body under the Ministry of the Navy dates from 24 July 1824. Although it has been subjected to successive modifications in scope, it still maintains the main lines of its original setup. Amongst those are its taking over all the duties pertaining to the Office of Lord Game Warden, which was then suppressed; and, in 1835 and 1847, the extension of its authority to all the royal properties which in 1824 were not yet under its jurisdiction, together with other properties belonging to the religious orders, suppressed in 1834, and to the "Casa do Infantado" (a board for the management of a number of royal estates, the revenues of which contributed to the support of the younger Princes (Infantes) of the Royal House).

Amongst the documents with a forestry interest published at this time must be mentioned the 1839 decree, which deals with the planning of a forestry code; the new topographical map of the Leiria pine forest, drawn up in 1841; the 1842 directive containing precepts on the maintenance of forests; and also the 1843 circular, sent by the Ministry of the Interior to all Districts and Municipal Councils. This is a highly important document, ordering the execution of afforestation work on the seashores and on the wastelands of the interior, and specially on heathlands and mountain tracts under the afforestation projects, the object being to enhance the value of these lands that had been thought of as useless, and also to fix the sand dunes and improve the purity and use of water resources, and to increase the reserves of building timber.

This measure, supported by another circular, that of 1849, enhanced the results of the afforestation work, on the Continent as well as on the Islands, in consequence of large quantities of seeds of maritime and stone pines and seedlings of chestnut and various oaks having been granted free to whoever wanted to carry out such work.

In 1847, new regulations were published for the General Administrative Council which divided the country into small Forest Conservations and changed what had been laid down in 1824, when the Administration was set up.

In 1850, a new start was given to the fixation of a large area of sand dunes in a section of the Leiria pine forest, still unplanted, whereby the methods which were then considered the most advisable and that had been tested at Aveiro and Lavos at the turn of the century were employed on a larger scale than before.*

In 1852, the General Administrative Council was transferred from the Ministry of the Navy to the newly established Ministry of Public Works. By decree of 1864, it was officially recognised as necessary that professionals within the organisation should take over the management of the Forest Services. Detailed instructions to this effect were published the following year.

A decree on the elaboration of the Forestry Code was published in 1853, and in 1857 the Government proposed, amongst other improvements, the afforestation, over a period of 50 years, of 190,000 hectares of unproductive lands.

In 1865, preliminary studies were made for establishing a proper management plan for the royal forest of Machada (on the left bank of the Tagus, opposite Lisbon). The object was to turn it into an experimental forest, where the best methods to apply to the development and exploitation of lands under pine woods in the neighbouring plains on the Setubal peninsula (lying between the Tagus river and the Arrabida hills) should be tried out. As a starting point for the inquiry an estimation was made of soil fertility, defined by an examination of the humus soil covering and of the spontaneous vegetation in the various stands, and on the non-forested sites as well. These investigations are due to the initiative and great competence of the forester Bernardino Barros Gomes, to whom we are indebted for the execution of many other important projects, especially with regard to the improvement of production and rational exploitation of forests and to the knowledge of forest conditions in the whole country.

Three years later (1868), a reorganisation of the Forest Services was proposed. This included a draft plan for large-scale afforestation; measures for the preservation of existing stands; the reclaiming of waste lands; and the fixation of sand dunes. This preliminary project had been worked out by the Forest Services, but in the same year, the Geographical Institute completed the first General Survey of all the Bare or Unreclaimed Tracts of Land in Continental Portugal, begun the year before. Foremost, the work had in view to assess the possibility of re-afforestation of all the areas that would not be suitable for agriculture.

Of this painstaking task was born the Report on the General Afforestation of the Country, which accompanied the aforesaid cartographical representation of the uncultivated areas that were to be devoted to afforestation (and also to agriculture, as in the end it had become impracticable to make a definite distinction as to which areas were to be consigned to agriculture and which to afforestation). This report was the most comprehensive document ever issued up to that time in the history of Portuguese forestry.

The total of more than 4,000,000 hectares, in which were also included dunes, uncultivated and fallow lands, gives some idea of the size of the task which was contemplated—incidentally also of the state of deforestation that had by then been reached.

In 1872, following on the publication of the Reform of the General Administrative Council of Crown Forests, the Forest Services were enlarged and divided into two principal branches: the technical and the administrative. These improvements resulted in the elaboration—mainly by Barros Gomes—of valuable studies, which included a new plan for the regulation and exploitation of the most important Crown Forests; research on altitudinal variation in climate and vegetation on the Mondego river watershed area, from sea level to the crest of the Estrela mountain, the highest mountain range in Portugal (2,000 m.), and the centre from which the most important hill chains branch out; and also the drawing up of the hypsometric, regional and xylographic maps of the country. The last of these is still the best cartographical representation we have of the characteristics of the arboreal vegetation and of the way in which it is distributed.

In 1878, the promulgation of the Forest Code was again being prepared; in 1879, a bill was presented; and in 1881, the Administration Council was suppressed and the Services were reorganised as a branch of the Division of Agriculture. In the same year, on the initiative of the Geographical Society of Lisbon, a scientific expedition was sent to the Estrela mountain range to study various aspects of this orographical block in general and, in

*The fixation of these dunes, stretching from Vieira to Água de Madeiros, was completed in 1905/06 at the following rate:

Area fixed until 1867	262.10 ha.
Area fixed from 1868 to the end of 1896	896.90 ha.
Area fixed from 1897 to end of fiscal year 1905/06	722.00 ha.
Total	1,881.00 ha.

particular, its vegetation and climate, which were here again made the object of research by specialists.

As a result of these investigations, and by virtue of the new General Reform of the Forest Services, promulgated in 1886, it was possible to start on the re-afforestation work, decreed in 1888, in the Estrela mountain areas and also in the Gerez mountains.

It was in 1888, therefore, and on the two highest mountains of the country, that the Forest Services made a start with the methodical afforestation of slopes and highlands. Besides the creation and conservation of forest stands, this task had also the object of maintaining and improving pastures, and controlling soil erosion and floods in these two most important watershed groups in the country.

From the beginning of the project to the end of the century, the area planted and regenerated by the Forest Services in the two mountain ranges amounted to 450 ha. In the Estrela range, this work was preceded by various undertakings for soil consolidation and control of streams, such as the building of a special type of screens against landslides and building dams across the streams.

The severe financial crisis, experienced by the country about the year 1891, had greatly affected the progress of the work of the Forest Services, above all because it brought about a slackening off in the yearly rate of afforestation and soil fixation.

A few years later, however, new times of increasing prosperity had set in, and the budgets had become more normal. This new period was followed by various reforms and other legal provisions, of which the most outstanding were the following measures then adopted: the 1892 Reform of the Forest Services, which considerably enlarged the scope of this government body; then in 1897, the establishment of the Forest Services of the Archipelago of Madeira, the chief aims of which were to effect—by means of the adoption of the most efficient methods—the rationalisation of the work of afforestation and of forest conservation, activities which had already long been carried on there, especially under the reign of Queen Maria I (1777-1816); and, finally, the two decrees of 1898 which had the object of regulating the different branches of the Forest Services and forestry work in course throughout the country, such as the exploitation of forests and further land reclamation for forestry in the mountain tracts and on the coastal dunes.

Two years before the publication of these two last mentioned decrees, i.e., in the year 1896, the Forest Services presented to the government their General Plan for the Afforestation of Shifting Sands of the Coast in Portugal. This was a valuable and very thorough work, based on a long series of experiments that were carried out, ever since the end of the preceding century, conjointly with the soil and land fixation work which, at the end of 1896, already comprised nearly 2,900 hectares.*

The continuation with the work of fixation of the sand dunes was intended in this plan. The total area of bare sands in most urgent need of treatment along the coast, from the mouth of the Minho river to the Sado estuary, had been computed to about 37,000 hectares.

At the close of the century (1899) a new Reform of the Forest Services was put into force. The principal measures proposed included the re-establishment of the division of the country into administrative regions; the reorganisation of the afforestation work on the mountain areas; and the setting up of a study group, presided over by the Inspector of Forest Services, charged with the coordination of all research work.

In the 20th century, Portuguese forest legislation began with the bill, presented in 1900, dealing with the establishment of a new Forest Organisation and the afforestation of 1,500,000 hectares over a period of 100 years, inclusive of work then in progress on the mountains and sand dunes. This bill unfortunately was never passed into law.

In the following year (1901), however, a new organisation of the Forest Services was proposed and approved. It was brought into being by the decree of 1903. The two diplomas—the basis (1901) and the regulation (1903)—are considered a model of legislative unity; even today they still guide a great part of the forestry work in course in the whole country.

These diplomas established norms for the institution of the forest "regime," to be applied both on State properties and on those belonging to local authorities, to corporate bodies, to private individuals and to private enterprises. These norms are summarised in the very text in which the same law lays down the aims of the ordinance. They are given below.

> "The forest 'regime' comprises the whole of the measures taken to ensure, not only the establishment, exploitation and conservation of forest resources, from the view point of the national economy, but also the planting of woods on those lands where afforestation is to the public good, and advisable or necessary for a good water management and protection of the fertile valleys, for the improvement of dry plains and betterment of the climate, or for the fixation and conservation of the soil, in mountainous areas and on the sandy soils of the coast regions."

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*The development in fixation of shifting sands, carried out by the Forest Services from 1850 to the end of 1896, may be summarized as follows:

Coast region:	Beginning to end of 1867** (ha.)	From 1868 to end of 1896 (ha.)	Total (ha.)
Between the Minho and Douro rivers	—	48.36	48.36
Between the Douro and Mondego rivers	—	225.85	225.85
Between the Mondego and Tagus rivers	327.85	2,164.14	2,491.99
Between the Tagus and Guadiana rivers	—	114.12	114.12
Total	327.85	2,552.47	2,880.32

It should be noted that in the 19th century the fixation of sand dunes made the greatest progress between 1881 and 1891.

The fiscal years in which fixation work on the various dune areas was begun by the Forest Services up to the end of the century are as follows:

Leiria	1850/51	Vila Real St. Antonio	1886/87
Urso	1866/67	Lavos	1887/88
Pedrogão	1866/67	Leirosa	1887/88
Cabedelo	1867/68	S. Jacinto	1888/89
Camarido	1881/82	Gafanha	1888/89
Trafaria	1883/84	Peniche	1889/90
Caparica	1885/86		

**This was the year previous to the publication of the abovementioned Report on the General Afforestation of the Country, of 1868.

Besides many other dispositions related to the development of forest resources, the two diplomas, as has already been advised in the 1886 reorganisation, contained provisions for considering forestry work as of public weal in certain cases; and consequently compulsory for the landlord, although he might prefer to have the lands in question expropriated; the establishment of the Watersheds Conservation Service, which rationalised and widened the scope of work already begun with the correction of the mountain streams of the Estrela Mountain range; the reorganisation of the measures to be adopted for the encouragement to be given to the inland waters fisheries, that had been the object of special provisions in 1892 and 1893, and the results of which had been the establishment of the Fisheries Station on the Ave river, at Vila do Conde, in the North; and furthermore the establishment of a special budgeting system which conferred a certain degree of administrative autonomy to the Forest Services.

From then down to the present day, other measures have been taken to promote the conservation, amelioration, and increase of the country's forest growing stock.

Some of these measures break new ground for the Forest Services. But the doctrine contained in the decrees of 1901 and 1903 is so complete, detailed and foreseeing, that the majority of measures subsequently adopted must be considered simply as further steps taken on the same lines then laid down, rather than attempts to give a new direction to the work.

In a summarised account of the progress accomplished in Portuguese Forestry work in the 20th century, two periods may be distinguished: one from the beginning of the century up to 1926, and the other from 1926 to the present.

Apart from the two decrees already referred to, there were two important events in the first period: one was the Reform and Provision for the Expansion of the Forest Services (1918), and the other, the Services' being set up as a Direction General, that of the Forest and Inland Waters Services (1919). This new government body, the title of which is still in use at present, embraces the whole of the State Forestry activities.

But, although the decree was published in 1919, it was more particularly after 1926 that it became possible to make greater improvements, thanks to the devotion of all forestry personnel, the country's good-will and, above all, the effects of the General Reform of all Public Services. This began in 1926 and has been carried on ever since in all the Portuguese territories. It is continually reflected in a progress that is gradually and at all points affecting the different aspects of forestry.

The Direction General of the Forest Services is the present-day heir of the old General Administration of the Forests that King John VI set up in 1824, which was, in its turn, derived from the postmedieval Regiments, promulgated from our first days as a nation and also from the 15th century hunting practice. The Forest Services are the official body which nowadays deals with the development and care of our forest resources, both on public land and on private property; the afforestation of hills and mountains; the fixation of sand dunes and torrential control; as well as the development and upkeep of the hydrological systems (Law No. 26,091 of 23 November 1935); and the care of the flora and fauna of the inland waters.

During the second period (since 1926), the measures put into effect by the Direction General of the Forest Services have been most noteworthy. The following are the most important and have the largest budget voted to them:

Law No. 1,971 (15 June 1938) (Afforestation Plan), which deals with the afforestation, the improvement of pastures and renewal of plant and animal life on more than 420,000 hectares of land (State and local authorities), situated for the most part on the hills and mountains of the North of the country and in the Adjacent Islands.

Law No. 2,069 (24 April 1954) (Technical and Financial Aid for Planting and Improvement of Forest Resources on Private Land), a law motivated by the public utility of this work. In the more difficult cases of afforestation, soil conservation, watershed reclamation, etc., the technical and financial intervention of the State becomes indispensable.

Finally, Decree-Laws No. 40,721 (2 August 1956) and No. 41,582 (2 April 1958) (Reorganisation of the Forest Services) have brought about a renovation in their structure, not only for Continental Portugal, but also for the Islands.

These last four diplomas moulded all the technical and administrative services anew. With regard to research, its organisation comprises a Centre of Forest Investigation with the dependent Experiment Stations. This arrangement, however, is a provisional one, as is expressly stated in the decree itself, which foresees a reorganisation for the near future to meet the growing needs of the development in all branches of forestry.

It is also of interest to note that, apart from the monies which are ordinarily voted by the government to silviculture with regular increments, various legal dispositions have recently made it possible to widen greatly the scope of the work undertaken.

Thus, in addition to the extraordinary votes set aside by the 1938 Afforestation Plan, two fairly recent government measures have considerably assisted advances in the work in progress. They are the two Six-Year Plans for the Development of the Country's Resources (First Plan, 1953-58; Second Plan, 1959-64). These plans affect all branches of forest activities, not only in Continental Portugal, but also in the Overseas Provinces.

These two plans, with their declared object of helping develop the national economy in all sectors, have given such financial assistance to forestry schemes, that nowadays they are being carried out at a rate that has never before been known in the country's history.

This acceleration is due to the fact that, based on the investigation of the soil's capability, it has been found necessary to raise the present level of the rate of afforestation, from about 33% to over 50%.

The following tables give an idea, however brief, of the way in which the work of the Portuguese Forest Services, whether concerned with State or private lands, has progressed.

To avoid going into too much detail, only those areas that have actually been planted or put under the jurisdiction of our Direction General, i.e., under Forest "Regime," are indicated in the tables, although the Services have carried out other important tasks.

Amongst these are the improvement of grasslands; erosion, runoff and stream control; protection, improvement and exploitation of stands; pest and fire control; transport; construction of buildings and of forest roads; restocking of waterways with fish; technical aid to private properties not covered by Law No. 2,069, etc.

Table 1. Portuguese Territories: Situation, area, and population.

	Area (sq.km.)	Population (1950 census)	Density of population (per sq.km.)
EUROPE			
Portugal (incl. Azores and Madeira)	91,963[1]	8,441,312	92.1[2]
Overseas Provinces:			
AFRICA			
Islands of Cape Verde ..	4,033	148,331	36.5
Guinea	36,125	510,777	14.1
Islands of S. Tomé and Principe	964	60,159	62.4
Angola	1,246,700	4,145,266	3.3
Moçambique	783,030	5,738,911	7.3
ASIA			
Portuguese India (Goa, Daman, and Diu) ...	4,194	637,591	152.0
Macau	16	187,772	11,735.8
OCEANIA			
Timor (part of Timor Island)	14,925	442,378	29.6
Total	2,181,950	20,312,497	
Total average density			9.4

(1) Includes the areas of the Tagus and Sado estuaries and the Aveiro lagoon (261 sq.km., 115,4 sq.km., 64,2 sq.km., respectively).

(2) Does not include the areas in footnote (1).

Table 2. Lands submitted to the "Forest Regime," continental Portugal and islands, including total areas at the end of each year.

Years	Government lands (hectares)	Lands owned by the local authorities (hectares)	Lands in private ownership submitted to technical guidance by Forest Services (hectares)	Total (hectares)
To 1947	45,962	306,834	469,011	821,807
To 1948	45,962	306,834	469,011	821,807
To 1949	51,139	306,262	469,011	826,412
To 1950	51,181	333,720	469,011	853,912
To 1951	51,181	341,153	469,011	861,345
To 1952	51,084	341,153	469,011	861,248
To 1953	51,084	349,779	469,011	869,874
To 1954	51,084	384,374	469,011	904,469
To 1955	51,084	386,932	475,365	913,381
To 1956	51,135	417,392	505,965	974,492
To 1957	53,109	444,172	511,111	1,008,392
To 1958	53,109	450,109	651,492	1,154,710
To 1959	53,136	456,814	646,637	1,156,587

Table 3. Reclamation of sand dunes on the coast areas owned by the government and local authorities.

Coast zones	Work started	Names of properties	Areas afforested 1850/51-1867 (incl.) (hectares)	Areas afforested 1868-1896 (incl.) (hectares)	Areas afforested 1897-1925/26 (incl.) (hectares)	Areas afforested 1926/27-1946 (incl.) (hectares)	Total areas afforested (ha.)
Between the Minho and Douro rivers	1881-82	Camarido	—	48	—	96	144
Between the Douro and Mondego rivers	1888-89	S. Jacinto and Gafanha	—	226	1,531	21,991	23,748
Between the Mondego and Tagus rivers	1850-51	Leiria Forest	328	2,164	5,200	3,426	11,118
Between the Tagus and Guadiana rivers	1883-84	Trafaria	—	114	551	455	1,120
Total			328	2,552	7,282	25,968	36,130

Table 4. Areas afforested by the Forest Services on government lands and on lands belonging to local authorities—sand dunes of the coast, foothills, and ranges.
(Hectares)

1850/51-1938			68,043
In 1939	Beginning of the Afforestation Plan of 1938	5,481	
In 1940		4,612	
In 1941		3,538	
In 1942		5,674	
In 1943		4,127	
Total of the five-year period 1939-1943			23,432
In 1944		4,428	
In 1945		3,195	
In 1946		1,806	
In 1947		3,206	
In 1948		7,746	
Total of the five-year period 1944-1948			20,381
In 1949		6,425	
In 1950		7,429	
In 1951		8,193	
In 1952		8,077	
In 1953	Beginning of the 1st Plan for the Development of the Country's Resources	8,725	
Total of the five-year period 1949-1953			38,849
In 1954		9,107	
In 1955		9,095	
In 1956		13,461	
In 1957		17,081	
In 1958		20,724	
Total of the five-year period 1954-1958			69,468
In 1959	Beginning of the 2nd Plan for the Development of the Country's Resources	17,890	
Total area afforested by the Forest Services up to 1959			238,063

Table 5. Total forest production of continental Portugal and islands[1].

Species and products	Areas (1,000 ha.)	Output: Quantities (1,000)	Output: Unit	Output: Value[4] (1,000 Esc.)	Mean annual output per ha. in Esc.	Annual growth: (1,000)	Annual growth: Unit
Chestnut tree forests	60	—	—	*108,600*	1,810	—	—
Chestnuts	—	50	t.[2]	75,000	—	50	t.
Wood and firewood	—	120	c.m.[3]	33,600	—	80	c.m.
Oak forests	90	—	—	*39,600*	400	—	—
Wood and firewood	—	135	c.m.	32,400	—	90	c.m.
Acorns	—	7	t.	6,300	—	7	t.
Tanning bark	—	1.5	t.	900	—	2	t.
Green oak forests	600	—	—	*168,200*	280	—	—
Acorns	—	108	t.	129,600	—	108	t.
Wood and firewood	—	480	c.m.	38,400	—	330	c.m.
Tanning bark	—	0.5	t.	200	—	1	t.
Cork oak forests	750	—	—	*838,800*	1,118	—	—
Cork	—	180	t.	720,000	—	180	t.
Acorns	—	60	t.	54,000	—	60	t.
Wood and firewood	—	750	c.m.	60,000	—	500	c.m.
Tanning bark	—	4	t.	4,800	—	4	t.
Pine forests	1,270	—	—	*964,800*	760	—	—
Wood and firewood	—	5,080	c.m.	812,800	—	4,000	c.m.
Turpentine and rosin	—	60	t.	150,000	—	100	t.
Pine nuts	—	1	t.	2,000	—	1	t.
Eucalyptus groves	100	—	—	—	—	—	—
Wood and firewood	—	1,000	c.m.	*120,000*	1,200	900	c.m.
Other forests	80	—	—	*55,000*	687	—	—
Wood and firewood	—	120	c.m.	12,000	—	100	c.m.
Fruits	—	55	t.	43,000	—	55	t.
Total	2,950	—	—	2,295,000	778	—	—

[1] According to the last calculation made by Maximino Alvarez (1959). [2] Metric tons. [3] Cubic meters. [4] All values referred to the product in the forest.

Table 6. Export of forest products from continental Portugal and islands.

Products	1955 Quantities in metric tons	1955 Value in 1,000 Esc.	1956 Quantities in metric tons	1956 Value in 1,000 Esc.	1957 Quantities in metric tons	1957 Value in 1,000 Esc.	1958 Quantities in metric tons	1958 Value in 1,000 Esc.	1959 Quantities in metric tons	1959 Value in 1,000 Esc.
Timber	158,307	102,942	167,306	116,402	219,577	151,709	212,103	142,582	126,335	107,622
Lumber	179,410	428,712	194,359	486,609	173,675	419,880	175,965	435,212	161,055	418,418
Cork										
Raw	131,892	1,001,437	114,205	875,612	101,639	688,844	116,680	653,508	127,216	657,379
Manufactured ..	29,311	707,709	29,920	704,701	31,817	682,950	30,521	656,728	32,433	660,065
Naval stores ...	44,333	239,211	54,141	295,168	65,503	346,824	52,514	264,681	66,729	365,702
Tanning materials	29	172	20	148	20	136	17	101	27	189
Dying materials .	90	892	93	916	102	1,341	48	642	57	614
*Other products**.	29,317	102,717	20,625	104,064	25,110	103,941	30,193	122,316	32,930	126,807
Total	572,689	2,583,792	580,669	2,583,687	617,443	2,395,625	618,041	2,275,770	546,782	2,336,796
Grand total for continental Portugal and islands	2,453,462	8,165,170	2,774,882	8,620,526	2,543,611	8,289,030	2,644,905	8,298,744	2,653,721	8,351,451
Percentages in relation to grand total for continental Portugal and islands	23.3%	31.6%	20.9%	30.0%	24.3%	28.9%	23.4%	27.4%	20.6%	28.0%

*Export items: 162; 182; 183; 195; 196; 206-A; 209; 210; 213; 215; 216; 216-A; 217; 230; 402 to 405; 800; 801; 802; 825; 835; 859; 1,026; 1,028; 1,043; 1,044; 1,148 to 1,152 and 1,160.

RESUMES

Un bref exposé sur la sylviculture au Portugal

Le Portugal métropolitain, petit pays européen de 80.000 Km.[2] seulement de superficie, occupe une bande de terre sur la côte occidentale de la Péninsule ibérique. En tant que nation indépendante, bien délimitée, ayant sa propre individualité, elle existe depuis 800 ans à l'intérieur de frontières inchangées. Grâce à son expansion outre-mer, à la suite des prodigieuses découvertes du XV[e] siècle, le Portugal actuel, c'est-à-dire le territoire continental, les archipels portugais de Madère et des Açores et les huit provinces d'outre-mer, couvre une superficie totale de 2.200.000 Km.[2] et a une population globale d'environ 20.000.000 d'habitants (recensement de 1950).

Le présent exposé sur l'histoire de la sylviculture portugaise, préparé par les soins de la Direction générale des services forestiers, concerne seulement le Portugal métropolitain, c'est-à-dire le territoire continental et les îles portugaises, qui couvre une superficie totale de 92.000 Km.[2] environ et dont la population s'élève à environ 8.500.000 habitants (recensement de 1950). Dans les provinces d'outre-mer, toutes les questions concernant les forêts et leur administration relèvent des services forestiers de chacune des provinces, sous l'autorité du Ministère des territoires d'outre-mer.

Suit un rapide examen de l'évolution de la sylviculture au Portugal et des dispositions législatives les plus importantes en partant du code Wisigoth promulgué au VII[e] siècle (avant la fondation du Royaume du Portugal proprement dit qui remonte à l'année 1139). La plupart de ces lois concernent la conservation et l'accroissement des ressources forestières ainsi que l'entretien et la protection de la flore et de la faune, particulièrement du gibier à poil et à plume qui encore aujourd'hui est abondant et varié.

Cet encouragement donné à la sylviculture a été renforcé depuis le début du XIX[e] siècle, en dépit des vicissitudes politiques et économiques. De nos jours, on peut en mesurer les effets d'après le rythme auquel diverses entreprises sont réalisées, et qui n'avait jamais été atteint au cours de l'histoire du pays. Ce progrès a pu être réalisé grâce à la nouvelle structure de la législation forestière mise en pratique au début du XX[e] siècle et aussi, grâce aux programmes successifs qui ont été élaborés et à la réforme générale de l'administration publique du pays tout entier, décrétée en 1926.

Récemment, deux programmes pour le développement des ressources nationales, portant notamment sur l'encouragement à la sylviculture, dans les forêts appartenant à l'Etat aussi bien que privées, ont pour but principal d'élever la proportion des superficies boisées du taux actuel de 33% à plus de 50%. Ceci illustre le vif intérêt que le gouvernement attache à cette question.

Les raisons principales qui ont motivé ces mesures sont: la nécessité de boiser les terrains les plus pauvres et les plus exposés à l'érosion, et le fait que, depuis plus d'un siècle, les produits forestiers représentent un pourcentage élevé des exportations. En 1959, ce taux s'élevait à 28% du total des exportations du territoire continental et des îles portugaises.

Reseña sobre la Silvicultura en Portugal

Portugal metropolitano es un pequeño país europeo que ocupa una faja de tan sólo unos 80.000 km.[2] de superficie en la parte occidental de la Península Ibérica. Su historia como nación plenamente individualizada, independiente y bien definida, se remonta ocho siglos durante los cuales ha existido siempre dentro de los mismos límites geográficos. Debido a su expansión en ultramar, iniciada inmediatamente después de los prodigiosos descubrimientos en el siglo XV, la nación portuguesa contemporánea, esto es su territorio continental y los archipiélagos adyacentes de Madeira y Azores, comprende sus ocho Provincias de Ultramar y ocupa una superficie total de 2.200.000 km.[2] teniendo en conjunto una población de unos 20.000.000 de habitantes (censo de 1950).

El presente trabajo sobre la historia de la silvicultura portuguesa, preparado en representación de la Dirección General de Servicios Forestales, sólo abarca el territorio metropolitano del Portugal, es decir, la parte continental y las islas adyacentes cuya superficie total es de más o menos 92.000 km.[2], con una población aproximada de 8.500.000 habitantes (censo de 1950). En cuanto a las Provincias de Ultramar, todos los asuntos relacionados con los bosques y su administración son de incumbencia exclusiva de los Servicios Forestales de cada Provincia, que dependen del Ministerio de Ultramar.

Se hace aquí un breve examen de la evolución de la silvicultura en Portugal y, tomando como punto de partida el Código Visigótico, promulgado en el Siglo VII (es decir antes de la creación del Reino de Portugal que se produjo en el año 1139), se hace mención de las medidas legislativas más importantes. Tales medidas en su mayor parte se refieren a la conservación e incremento de los recursos forestales, así como al mantenimiento y a la protección de la flora y fauna salvajes, especialmente animales de caza y pájaros, que aún en la actualidad abundan en número y variedad.

Este estímulo de la silvicultura se ha intensificado desde principios del Siglo XIX, a pesar de las vicisitudes políticas y económicas, llegando a reflejarse en la actualidad en las diversas empresas que se cumplen a un ritmo jamás alcanzado en la historia del país. Este progreso ha sido posible gracias a la nueva estructura de las leyes forestales promulgadas a principios del Siglo XX, siendo asimismo resultado de los planes sucesivos que se han elaborado y de la Reforma General de la Administración Pública de todo el País, decretada en 1926.

Dos Planes recientes para el Desarrollo de los Recursos del País, que en gran parte se refieren al estímulo de la silvicultura tanto en tierras de propiedad del Estado, como en aquellas de propiedad particular, tienen por objetivo principal el incremento de la proporción de tierras forestales, para llevarlas del actual 33 por ciento a más del 50 por ciento. Ello es indicio del interés que el Gobierno tiene por este aspecto.

Estas medidas son motivadas principalmente por la necesidad de embosquecer los suelos más pobres y sujetos a fácil erosión, y por el porcentaje elevado que durante más de un siglo han representado los productos forestales en nuestro comercio de exportación. En la actualidad (1959), tales productos constituyen el 28 por ciento de las exportaciones totales del Portugal continental y sus islas adyacentes.

The Future of the Brazilian Pine Forests

(Findings of a Pilot Forest Survey in the State of Santa Catarina)

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Technicians are seriously apprehensive about the fact that the Brazilian Paraná pine forests are being overcut.

In forestry, a forest area is said to be overcut when the amount of timber cut annually exceeds the annual growth of the forest.

In certain cases overcutting may be planned and permissible insofar as it obeys the programme of an established forest policy. It may happen, for instance, that certain forest areas must disappear in order to make place for agriculture or even for the plantation of forests of a different composition. In extremely rare instances overcutting may be justified provided the forest policy established for that region deems that there is an excess of forestation.

Considering that there does not as yet exist a clearly defined forest policy for any part of Brazil, we approached the problem of the cutting of the pine reserves from an exclusively technical angle. Viewed from this angle, the situation and the prospects are most alarming, as is shown by our findings which we proceed to analyse.

In order to get an idea of the total amount of standing timber in the pilot area, for diameter classes of 20 cm. and up, under bark, as well as for diameter classes of 40 cm. and up, it is sufficient to consult Table 4, Chapter II. of the findings of the survey. These findings refer, of course, to the year 1957, when the aerial survey, the photographs and maps of which we used, was effected.

In order to ascertain which is the amount of pine wood cut each year in the pilot area, we should have to find out how many sawmills there are and how many logs they consume. By means of the aerial photographs it was easy to count the number of sawmills. By means of intensive field work and by the information obtained from the local people, we were able to identify all sawmills as either working a bandsaw or a gangsaw. Thanks to the cooperation of Mr. Luis Meneguzzi, President of the Union of the Workers in the Sawmill Industry, of Curitibanos, we obtained an inventory of 51 sawmills situated in the pilot area or in its vicinity, which supplied the following data:

a. Type and location of sawmill.
b. Number of logs sawn per year by each of them.
c. Quantity of sawn timber produced, calculated in dozens (2.52 dozens equal to 1.00 cubic meter).
d. Year the sawmill was built.
e. Year the sawmill will have to close down for lack of raw material (according to estimate of the respective owner.)

In order to establish the tables of volume and yield per tree in the virgin Brazilian Paraná pine forests in the State of Santa Catarina, we measured 285 sawlogs felled for this purpose in the Curitibanos and Irani region (Data in *Boletim do Setor de Inventários Florestais* No. 1.) According to these data, the average volume of the sawlogs is 1,255 $m.^3$. Through an analysis of the information collected by Luís Meneguzzi, we came to the following conclusions:

1. The 24 surveyed sawmills working with a bandsaw consume annually 228,860 logs corresponding to 287,219 $m.^3$ of timber, which produce 389,906 dozen boards or 154,725 $m.^3$ of sawn timber, representing a yield of 53.9%. On an average, in this region, a bandsaw consumes annually 11,967 $m.^3$ of logs, or roughly 12,000 $m.^3$, or 40 $m.^3$ per work day, which cannot be considered as a large volume for this type of sawmill.

2. The 27 surveyed sawmills operating a gangsaw consume annually 123,445 logs, corresponding to 154,923 $m.^3$, which produce 207,589 dozen boards, or 82,377 $m.^3$ sawn timber, representing a yield of 53.2%. (On an average, in this region a gangsaw consumes annually 4,572 $m.^3$ logs, i.e., about 15 to 16 $m.^3$ of logs a work day, which cannot be considered much for this type of sawmill, either.)

By means of the aerial photographs taken in 1957, we found the following wood industries in the pilot area:

17 sawmills with a bandsaw;
34 sawmills with a gangsaw;
1 veneer factory; and
2 small mechanical papermills manufacturing pulp.

We estimated that the log supply consumption of the veneer factory visited by us is about the same as that of a sawmill with a bandsaw. The two small pulp factories use mostly small sized logs and some of the waste of the sawmills. Consequently, their influence on the consumption of timber in this region is negligible. According to our figures, the two correspond to about one sawmill with a gangsaw.

For the calculation of the annual requirements of log supplies necessary for the work of the sawmills located in the pilot area we assumed that by the end of 1957 there existed 18 sawmills with a bandsaw and 35 with a gangsaw. Taking the average figures culled from the survey of Luís Meneguzzi, we shall have a total log supply of $18 \times 11{,}967 + 35 \times 4{,}572$, i.e., 375,426 $m.^3$.

The average diameter of the trees exploited by the sawmills varying from 60 to 65 cm. over bark at breast height, and the average overall length being 25 meters, according to the formulae given in "Boletim" No. 1, a tree of diameter class 60 cm. over bark has 74.2% timber with a yield of 49.5% sawlogs. For trees 30 meters high, there will be 75.2% timber, with a yield of 50.3% sawlogs.

For diameter class 65 cm. over bark, there will be 74.2% timber with a yield of 49.2% sawlogs, for trees with an average overall height of 25 meters; and 74.9% timber, with a yield of 50.1% sawlogs, for trees 30 meters high.

Dividing the percentage of timber by the percentage of sawlogs, we obtain the following figures: 1.4989898—1.4950298—1.5081300—1.4950099.

In order to obtain the quantity of standing timber under bark that must be cut to produce 375,426 m.³ logs, we must multiply this figure by one of the given factors. Multiplying by the smallest, we shall have 561,266 m.³; multiplying by the largest, the result will be 566,191 m.³, with the difference of 4,925 m.³ corresponding to about 0.9%. In order to facilitate calculations, we considered this volume as being of 565,000 m.³.

Employing these elements, we shall reach a certain number of clearly defined previsions:

Hypothesis A. All the sawmills, existing in the pilot area as per aerial photographs of 1957, continue operating at the same rate, requiring, consequently a log supply of about 565,000 m.³ logs annually.

1. If only the economically rewarding types, as for instance "Type 2" and "Type 1" were exploited, both would be cut over within 6 to 7 years. They would, therefore, have disappeared by the years 1963 and 1964, respectively. (According to the volumes of Table 4, Chapter 2, we have: 3,360,670 and 3,864,136 divided by 565,-000 equal to 5.948 and 6.839 years, respectively.)

2. If besides the more profitable forest types 1 and 2, also the less profitable "Type 0" were cut over, the reserves would be exhausted within 8 to 9 years, i.e., in 1965 or 1966. (According to the volumes of Table 4, 4,296,553 and 5,108,931, divided by 565,000 equal to 7.605 and 9.042 years respectively.)

If the prices for pine timber maintain a satisfactory level, it is to be assumed that, wherever trees economically exploitable exist, they will be cut. Working conditions being favourable, not only specimens of the three types mentioned above will be used, but also those of "Type J" and those of the "capoeira" zone and the "non-forest area." Under these circumstances, the amount of standing timber under bark would be increased from 1,334,451 to 1,851,635.

Most of those trees that grow in isolated may only have been left out on previous occasions when their exploitation was considered uneconomic. Therefore, we think it prudent to estimate that the material yielded by that type corresponds only to half of that produced by other types.

By the exploitation of those trees it would be possible for the sawmills to keep on working for another two years. (1.334,451:2 × 565,000 = 1.81. On the other hand, 1,851,635:2 × 565,000 = 1.639).

If the sawmills work at this rate, there will be no more exploitable pine trees of diameter class 40 cm. and up in the pilot area by 1967 or 1968.

Hypothesis B. The sawmills reduce their rate of production and, as a consequence, the consumption of timber.

We elaborated figures for annual decreases of 5, 6, 7, 8, 9 and 10% from 1959 on, and presented the respective results in Table 1.

In this table there appear the dates on which the amounts of exploitable standing timber of diameter class 40 cm. and up, over bark, existing in the pilot area in 1957, separated according to forest type, as well as those existing in the "capoeira," zones and in the "non-forest area" would be cut, the first figures referring to a cut of 565,000 m.³ annually, and the following to cuts according to a continuous annual decrease of 5, 6, 7, 8, 9 and 10%.

Table 1.

Annual cut (cubic metres)	Year in which the exploitation Will come to an end		
	Types 2 and 1	Types 2, 1 and 0	Types and zones
565,000	1963-1964	1965-1966	1967-1968
565,000 with a decrease of 5% ..	1964-1965	1966-1969	1968-1972
565,000 with a decrease of 6% ..	1964-1966	1967-1970	1969-1974
565,000 with a decrease of 7% ..	1964-1966	1967-1971	1970-1976
565,000 with a decrease of 8% ..	1965-1967	1968-1973	1971-1981
565,000 with a decrease of 9% ..	1965-1968	1969-1976	1973-1992
565,000 with a decrease of 10% .	1966-1968	1970-1980	1977

From the survey undertaken by Luis Meneguzzi, we may draw the conclusion that of the 51 sawmills described, 27 will close down in 1964 or before; 17 will close during the period from 1965 to 1968; 1 will close in 1969; 3 in 1970; 1 in 1975; 1 in 1980; and finally the last in 1982.

The average date for the cessation of activities of the sawmills in that region will be 1966.

In fact, not all the sawmills surveyed by Mr. Meneguzzi are located inside the pilot area. Some are located in its vicinity, but their methods of work are similar so that the data supplied by them only serve to confirm our calculations.

From the above exposition, we draw the conclusion that the good pine trees of the pilot area, i.e., those of "Type 2" and "Type 1" and perhaps those of "Type O" and parts of those of "Type J" will not last beyond 1970.

Eventually, some of them will survive. That is, at least, what several owners of pine forests (some of them possessing substantial tracts) have assured us. In its overall effect, however, the general impression will be one of desolation, as is already the case in several regions formerly covered with magnificent and dense forests.

According to forestry, timber-producing trees should be exploited when mature. This means that specimens of the Brazilian pine tree should be cut when they present a diameter of 40 cm. and up. For economical reasons, it would not be advisable to let them go on growing, as they are liable to end up rotting and dying. The technical goal is to obtain from the forests a continuous production on a planned basis (sustained yield). According to this rule, pine trees should be cut when they attain the proper dimensions, but under observation of the indispensable sylvicultural techniques, in order to guarantee their natural regeneration.

It is not rational, economically speaking, to protect the patches of big Paraná pine trees indefinitely, unless in the case of areas chosen for the establishment of national parks or scientific reserves or else with a view to producing seeds for reforestation.

Unfortunately, the vast majority of forest owners in

Table 2.

Types or patches	Growth (per cent) Diam. class 20 cm. and more	Diam. class 40 cm. and more	Diam. class 20,25 30 & 35 cm.	Growth in volume (cubic metres) Diameter class 20 cm. and more		Diameter class 40 cm. and more	
Type 2	10.3	9.6	26.1	188,636	214,677	168,897	191,686
Type 1	14.1	10.9	66.6	239,197	279,861	174,545	203,548
Subtotal, types 2 & 1	—	—	—	427,833	494,538	343,442	395,234
Type 0—Low plateau	20.7	11.4	90.7	8,064	13,331	3,363	7,042
Type 0—High plateau	14.2	9.9	67.2	141,654	176,670	89,732	117,119
Subtotal Types 2, 1 & 0	—	—	—	577,551	684,539	436,537	519,395
Type J	43.6	42.6	45.3	77,016	92,698	43,179	56,243
"Capoeira"—Low plateau	43.2	21.8	99.8	1,122	2,486	—	—
"Capoeira"—High plateau—North	35.3	24.7	75.8	138,595	184,169	71,136	107,642
"Capoeira"—High plateau—South	26.0	19.8	64.2	220,215	274,213	144,795	179,276
"Non-forest" area—Low plateau	28.9	27.0	36.0	2,552	5,746	—	—
"Non-forest" area—High plateau—North	19.4	16.8	33.4	11,952	20,775	7,703	16,338
"Non-forest" area—High plateau—South	18.7	16.6	32.4	38,560	57,384	27,881	46,667
			—	1,067,663	1,322,010	731,231	925,561

the pilot area take no measures whatever with a view to furthering the regeneration of trees in tracts depleted of salable timber. On the contrary, we noticed that they, themselves, are first to contribute to the complete modification of the region, damaging the seeds and allowing their pigs, horses, oxen and mules to destroy the seedlings, which survive in comparative abundance in the soil.

Frequently, we also observed areas where the salable pine trees had been extracted and where the seedlings already out of danger of being destroyed by animals or choked by bamboo ("taquara") were being burnt without any control in order to provide land for planting or pasture.

Despite all the damage caused by man, young pine trees spring up in many parts, an exuberant manifestation of natural forest regeneration, as we had the opportunity to verify in areas occupied by "types" as well as in "capoeira" and "non-forest" tracts.

The "Type J" is one of those examples of natural regeneration: 49.1% of the pines are seedlings or present a diameter over bark of less than 20 cm.; 35.9% are more than 20 cm. but less than 40 cm. in diameter; only 15.0% have a diameter of more than 40 cm. The average number of trees is 50 per hectare, which is very little for a productive forest, as the average should be 400 trees (separated by about 5 meters).

There is a possibility that these forests of "Type J" may replenish naturally through continuous annual growth of the seedlings, but it is necessary that they be rigorously protected against all harmful interference from man, animal or bamboo.

The same possibility holds good for the regeneration of the other types. All of them present a certain quantity of young plants, which might develop and replace the mature trees if they were left to themselves or if the exploitation of the mature trees were operated gradually and carefully with a view to providing more light and space for the young trees, which should also be protected from spoilers. Besides all this, it would be necessary to clean the ground in order to stimulate the growth of the seedlings. The clearing away of bamboo would be the first step to be taken.

The great patches of "capoeira" offer specially favourable conditions for the restoration of depleted pine forest areas in a comparatively short space of time. In these tracts the average number of pine trees vary from 8 to 30 per hectare, and 70.2 to 81.4% of these are seedlings or have a diameter over bark of less than 20 cm.; 14,8 to 18.8% have a diameter of more than 20 but less than 40 cm.; and 3.5 to 14.2% present a diameter of more than 40 cm. One may assume that in the future these patches, if left to themselves, will close and produce forests similar to those of "Type 1."

We may ask: Which is the annual rate of growth of the standing pine timber in the pilot area, and to what extent will this growth contribute to sustaining a predetermined production?

We have already done our best to evaluate this growth. Let us suppose now that during the next ten years none of the pine trees surveyed in the pilot area were to die and that after ten years they presented the same annual growth according to diameter class. We might estimate the respective growth at its possible maximum, during a period of 10 years, as per Table 2, in which the forest types and the "capoeira" and "non-forest" zones figure separately.

In practice, the maximum volume of growth will never be reached, since we worked on the impossible assumption that none of the surveyed trees would die during the ten years following the survey. We adopted these data only by way of demonstration in order to show how discouraging the future of the forests of the pilot area really is, even when expressed in the optimistic figures above.

According to these data, the maximum annual growth for exploitable trees of diameter classes of 40 cm. up will be:

1. In the areas of "Type 2" and "Type 1"—about 34,000 to 40,000 m^3.

2. In the areas of "Type 2," "Type 1" and "Type 0" together—abount 44,000 to 52,000 m^3.

3. In the total area—73,000 to 93,000 m.³.

This means that "Type 1" and "Type 2" together might supply at the utmost two sawmills using "bandsaws" with their annual yield of sawlogs (1.5 x 12,000 m.³ of logs = 18,000 m.³ of standing timber), without overcuts. It also means that "Type 2," "Type 1," and "Type 0" together might supply the same two sawmills using bandsaws and another two using gangsaws. And finally, that the whole area, or all the surveyed pine trees, would furnish only a slightly better result, that is, the consumption of five sawmills using bandsaws.

If adequate measures are not put into practice forthwith, the present Pilot Survey would only have served to illustrate numerically the impending doom that awaits the pine forests of the region studied by us, and approximately that of the other pine forests where the pine timber industry is at present supplying itself. We hope that the authorities competent for the solution of this serious problem will not eschew their responsibilities.

In our opinion, the measures to be adopted with a view to saving the reserves of the Region of the Aracauria for the country are the following:

1. Make a complete inventory of the Brazilian pine trees in order to obtain an accurate overall picture of their location, extent and production capacity. On the basis of the experience gained in the course of this Pilot Survey, a complete survey could be executed within a reasonably short period of time.

2. Begin as soon as possible with reforestation on a large scale of depleted areas previously selected, as well as of areas of the "capoeira" zone.

There exists already in the country a reasonable volume of knowledge about this type of silviculture which might be put to profitable use. It is important to guarantee facilities for obtaining seeds on a large scale.

3. To protect, as rigorously as possible, patches of natural regeneration.

In view of the great expense involved, for instance, for the acquisition of wire, stakes, etc., for fences, it would not be justifiiable to execute this work in other than selected patches on private property and government land or on land which is to be reserved by Federal, State or municipal authorities.

RESUMES

L'avenir des forêts de pin brésilien

Les spécialistes s'inquiètent sérieusement du fait que les forêts de pins brésiliens font l'objet de coupes excessives.

Afin d'évaluer la situation, la Section des Inventaires du Service forestier fédéral du Brésil a procédé à une étude-pilote, sur une étendue d'environ 560.000 hectares, au coeur de la région où le pin brésilien est présent.

L'étude a été basée sur des photographies aériennes à l'échelle de 1: 25.000 et sur des échantillons recueillis sur place dans un total de 6.174 unités d'échantillonnage de 0,1 ha. chacune.

Sur cette superficie-pilote, le bois sur pied a été évalué à un volume de 5.631.004 à 6.960.566 mètres cubes. L'industrie du bois de la région utilise chaque année un approvisionnement en grumes de 375.426 mètres cubes, correspondant à 566.191 mètres cubes de bois sur pied. Etant donné que l'accroissement annuel du bois varie de 73.000 à un maximum de 93.000 mètres cubes, cette étude-pilote a démontré que notre inquiétude était justifiée en ce qui concerne les coupes excessives de pins brésiliens.

Dans le but de reconstituer les réserves de pins brésiliens, nous estimons que les mesures ci-après devraient être adoptées:

1. Procéder à une évaluation complète des forêts naturelles de pins brésiliens, afin d'obtenir un tableau d'ensemble exact sur leur site, leur superficie, et leur capacité de production.

2. Entreprendre le reboisement sur une grande échelle dans des secteurs épuisés choisis à l'avance.

3. Protéger le plus rigoureusement possible les secteurs de régénération naturelle.

El Futuro de los Bosques de Pinos Brasileños

Los técnicos están muy preocupados porque los bosques de pinos brasileños están siendo sometidos a cortas excesivas.

A los efectos de evaluar la situación, la Sección de Inventarios del Servicio Forestal Federal del Brasil realizó un estudio "piloto" en una zona de aproximadamente 560.000 hectáreas en el centro de la región en que se produce el pino brasileño.

El estudio se basó en fotografías aéreas en escala 1:25.000 y en muestras obtenidas en el lugar, con un total de 6.174 partes de selección de 0,1 hectáreas cada una.

Se comprobó que en la zona "piloto" el volumen de las existencias en pié oscila de 5.631.004 a 6.960.566 metros cúbicos. La industria maderera de la región utiliza anualmente 375.426 metros cúbicos detrozas, correspondientes a 566.191 metros cúbicos de árboles en pié. Teniendo en consideración que el incremento máximo anual de madera oscila entre los 73.000 y 93.000 metros cúbicos, pudo confirmarse en la "zona piloto" nuestra sospecha que los bosques de pinos brasileños son objeto de cortas excesivas.

En nuestra opinión, las medidas que deben adoptarse con miras de restaurar las reservas de pinos brasileños, son:

1. Efectuar un estudio completo de los bosques naturales de pinos brasileños, a los efectos de obtener un cuadro general sobre su ubicación, extensión y capacidad de producción.

2. Iniciar la reforestación en gran escala de zonas agotadas, previamente seleccionadas.

3. Proteger con el mayor rigor posible los montes de regeneración natural.

Comments

John Stanley Rowe (Canada):

I should like to make a general comment on Professor Wittich's interesting paper. In it there is implicit one extremely important idea that needs to be drawn out and carefully examined. It is this: that when we talk of forests or other vegetation, or soils, or local climates, we usually take for granted, and ignore, their physical basis, viz, the surface of the earth at particular geographic places. We skip over the geomorphologic substratum in our zeal to get at and classify the various interesting ephemera associated with it.

Any piece of the surface of the earth (including its organic cover) has form and structure, anatomy and composition, it has a precise position in space and a history that can be traced in time, it is the seat of present and past physiological and ecological activity, it has, in fact, all the requisites of natural objects amenable to scientific study. Unfortunately, the same cannot be said for natural populations of plants and animals, nor for soil profiles, nor for local climates. These find their meaning only in relation to the landscape of which they are characteristic.

In searching for a firm foundation on which to erect a science of forestry, foresters have repeatedly been distracted by two parallel fields of study, each claiming recognition as bona fide natural sciences: phytosociology (study of vegetation) and pedology (study of soils). Each misleads to the extent that it sets itself up as autonomous, failing to recognize its geographic-roots-in-earth place. Surely the basic consideration for any plant and animal community, any soil profile, is that it occupies and is the unique historical expression of a particular segment of the earth's skin.

A science of forestry must accept the same premise, identifying its units of study as biologically significant pieces of earth surface. In recognizing this, we provide ourselves with physical objects of study around which forestry knowledge can be accumulated with some precision.

In such a context, studies of vegetation, soil and climate are placed in correct perspective as contributors to an understanding of the greater whole. Thus, it is the terrain type or ecosystem type (i.e., land plus accompanying organisms) which forms the logical object of study and establishes a basis for the steady development of forest science.

G. Angus Hills (Canada):

Dr. Paul Zinke has asked about the degree to which my method of site classification is based on Jenny's equations of soil formation. Although I believe the answer to be implicit in what I shall say later this afternoon, and in what I have written, I wish to thank him for raising this question, since it suggests that I should deal with this matter explicitly as well as implicitly. This, I hope to do in detail elsewhere.

At this time, I merely wish to say that I have found Jenny's approach very stimulating, and doubtless his philosophy has influenced my thinking very much. However, I consider many of Jenny's assumptions misleading rather than helpful. Take, for example, the concept of independence of the factors of soil formation in which most factors remain constant, enabling the influence of one factor on soil formation to be determined. It is true that a given absolute level of a specific factor may remain constant within a number of soil systems. However, the significance of this specific level in the development of soil profiles does not remain constant but varies according to the total complex of features of which this particular feature is a part. Thus, any feature, in itself, determines its own effectiveness, only in part.

A more realistic approach is to assume the interdependence of each soil-forming (or forest productivity) factor and to establish the relative effectiveness of a combination of factors within "types." This is accomplished by dividing gradients of all the factors of production into classes and combining classes from a large number of gradients to form ecological types. By a comparison of these types in many dimensions, the ecological significance of the various classes which constitute them may thus be evaluated in relative terms. In other words, the gradient classes of the various features are identified by ranges in absolute values, but are grouped into gradient classes according to their relative ecological effectiveness expressed within types of ecosystems (not Jenny's soil ecosystems) which are combinations of classes from all the gradients of features which influence productivity.