AN ABSTRACT OF THE THESIS OF

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Title AERIAL PHOTOGRAPHS AS AN AID IN PREPARING A MANAGEMENT PLAN FOR THE BLODGETT TRACT

Abstract approved

There are approximately 4,000,000 acres of cut-over and burned-over land in western Washington and Oregon which are either non-stocked or unsatisfactorily stocked with young forest growth. This brings about a great need for a quick and efficient method of land examination from which to plan reforestation measures and make up management plans. This thesis is an explanation of one method, that of using aerial photographs in conjunction with limited ground observation. An example is given which illustrates that each $1.00 saved in the planning stage of forest regeneration means $19.23 more profit at the end of 100 years using an interest rate of 3% compounded annually.

More and more forest industries are beginning to use aerial photos for management plans, reforestation programs, and even cutting plans and preliminary road location.

The first part of this thesis deals with the using of the aerial photographs and the recognition of the information found on them as substantiated by ground examination.

The Blodgett tract is 2400 acres of logged and burned-over land in northwestern Oregon which was deeded to the Oregon State College School of Forestry for the purpose of establishing a reforestation study area.

The photographs used were standard 9 x 9 inch contact prints of negative photographed with a f-12" Aerial Mapping Camera by Delano Aerial Surveys of Portland, Oregon. The average scale of photography was 1:12,000.

The photographs were taken to the Blodgett tract and used as a guide in examining certain areas of the tract. Next a base map was made of the area using a slotted template laydown for horizontal control. The planimetry was transferred to the base map from the aerial photos by means of a multiscope. Fuel types were also determined from the photos. Other maps, including the proposed road and water development map, the hour control map and the seen area map, were also prepared. They were not particularly dependent upon the photographs for their information, except that the roads were located along old railroad grades and the water holes were beaver ponds, both of which could be observed on the photographs.

A second land examination was made to correlate the types of vegetation on representative areas with the vegetational types given those areas from aerial photograph interpretation. Certain changes were made where the land examination showed the stocking or the species composition to differ from the photo interpretation. Well defined areas of each type were examined by the stocked quadrat method of reproduction examination and final classifications were based on the results.

In conclusion to the first part of the thesis the author states that the field work in preparing a reforestation plan can be reduced to one-fifth of the time required by land examination alone. Forest boundaries and type boundaries may be easily recognized on the photographs and transferred to the base map. Fuel type and hour control maps may be made from the photos. Seen area maps may not be made from photographs without first constructing a topographic map.

Tree species can be recognized to a certain degree from the photographs. Pure fir stands can be differentiated from pure hemlock stands, but they are not easily separated when in a mixture. Alder stands can be separated from the willow-vine maple stands, but again not in mixtures. However it is easy to distinguish coniferous stands from the hardwoods.

The degree of stocking on reforestated areas can be determined from aerial photo examination, but only when the young trees average better than five feet in height and two feet in crown diameter.

Part Two of the thesis is a brief management plan for the Blodgett tract. It includes the history, physiographic features, and condition of the forest on the tract. Silvicultural recommendations are made and also the fire protection maps previously mentioned.

The area has high site quality, ample moisture, deep soil, and is ideally suited to the growing of Douglas-fir veneer stock on a rotation of between 100 and 150 years. It is located close to the Columbia River, which facilitates the transportation of the timber products. There is an adequate supply of local labor. The author recommends the planting of non-stocked and understocked areas, the pruning of selected crop trees, and periodic thinnings. Also recommended is the construction of access and fire roads, and a program of rodent and game control to assist in the re-establishment of the forest.

AERIAL PHOTOGRAPHS AS AN AID IN PREPARING A MANAGEMENT PLAN FOR THE BLODGETT TRACT

by

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AERIAL PHOTOGRAPHS AS AN AID IN PREPARING A MANAGEMENT PLAN FOR THE BLODGETT TRACT

INTRODUCTION

There are roughly 4,000,000 acres of cutover and burned-over forest land in Western Oregon and Western Washington which are either nonstocked or are unsatisfactorily stocked with young forest growth (9 p.1). At least one million acres of this land have been nonstocked since before 1920.

It is often stated that the forest is our only renewable natural resource, yet the above figures are mute evidence that the lumbering industries are not doing their utmost towards restoring these lands to productivity.

There are two principal reasons why these lands have been abandoned. First, there seemed to be an unending supply of virgin old-growth timber, and second, the high cost of carrying charges on the long term investments involved in reforestation and taxation.

The first reason is fading with time. Industry now clearly foresees the end of these vast forests of the West and realizes that in order to continue in existence it must grow trees as a crop.

The second reason stated above is as strong as ever. Private industry, unlike the federal government,

must show profit to remain as a going concern. Money cannot be invested unless it will repay itself with interest, this is fundamental.

It is generally accepted that Douglas-fir can be grown on the average sites on a rotation of 100 years (13 p. 10). Using 100 years as an example, interest tables show that $1.00 invested for 100 years must return to the investor $19.23 to have earned 3 percent compound interest.

This example helps to explain why the factor of cost in combination with a plentiful supply of timber has been successful in preventing reforestation in the past. With the end of the virgin old-growth stands of timber in sight, any saving which would reduce the initial cost of reforestation may well place it in the category of a sound investment.

The purpose of this paper is to show how aerial photographs may be used as an aid in reforestation planning, land examination, and management planning. Incidental problems which arose during the study are: (1) The correlation between the degree of stocking, based on a mill acre plot study, and the number of trees per acre which are large enough to resolve on the aerial photographs; (2) recognition of the various species of Western conifers and hardwoods as they appear on the photographs.

Before entering into any discussion on the use of aerial photographs, it should be understood that there are certain characteristics which limit their use.

The photographic image on a negative is made up of finely divided particles of precipitated silver. When the image of the object on the ground becomes as small as these particles it loses its identity, or may not appear on the negative at all. This is termed "resolution." An object on the ground must be at least two feet in diameter before it will resolve on the picture when the photo scale is 1:12,000 with panchromatic film. Consequently small seedlings, and the tips of trees do not show on the photographs. For this reason, in making a reproduction survey, it is necessary to find some previously determined correlation between some features of the area, visible on the photographs, and the actual stocking in young seedlings.

Ground cover such as bracken fern and salal brush cannot be recognized by shape, but may have distinguishing tonal or textural qualities.

This thesis is in two parts. The first, to illustrate the manner in which aerial photographs may be used as an aid in the formulating of a management plan for cutover land, and the second, a management plan for the 2,400 acre Blodgett Tract in Northwestern Oregon.

HISTORICAL AND REVIEW OF THE LITERATURE

Historical

Early day man, with his more or less natural tree climbing ability, was quick to learn that he might spot game easier from a high place.

Photographs were taken from a kite, and a captive balloon as early as 1858 by Laussedat, and from an airplane in 1909 by Wilbur Wright (1 pp. 109-125). The Germans took aerial photographs from zeppelins during the First World War. With the gradual improvement in equipment and methods, aerial photographs became an important factor in the preparation of military maps (17 p. 74). The Air Corps is charged with performing the aerial photographic work for the military mapping operations in accordance with specifications prepared by the Corps of Engineers.

Lage Wernstedt, in 1917, made a topographic map of one of the western national forests, largely from aerial photographs (6 pp. 104-106).

By 1920, Canadian foresters were making forest type maps from photographs, and by 1929, were making rough volume estimations (6 pp. 104-106).

In the middle 1930's the California Forest and Range Experiment Station used aerial photographs in

surveys of vegetation and forest types. Consulting foresters used them as a supplement to ground cruising in the California redwoods (6 pp. 104-106).

Federal agencies have photographed more than three-quarters of the land area of the United States. Much of the photography was contracted for by the Department of Agriculture (14 pp. 65-67). The U. S. Geological Survey, the U. S. Forest Service and other government agencies make most of their topographic maps from 1:20,000 scale aerial photographs. They have found that aerial photo mapping is less expensive, faster, and is of a high degree of accuracy.

Ten years ago the idea of using aerial photographic methods to assist forest planning and timber management was considered impractical and was scarcely used (18 p. 53). Aerial mosaics were used before World War II to a limited extent. Kinzua Pine Mills and Weyerhaeuser Timber Company used them primarily for the purpose of giving management a general picture of their logging operations and timber land holdings.

During World War II, instruments and techniques were perfected which made photogrammetric mapping practical for the logging industries.

The Canadian Government, in 1946, awarded the largest commercial contract ever made in the British Empire

to Photographic Survey Co. Ltd. of Toronto, Canada. The contract called for photographs and detailed planimetric maps of 125,000 square miles of forest land (12 pp. 3-4).

In 1947, Mr. Norman Jacobson of St. Paul and Tacoma Lumber Company, completed, in ten days, an aerial cruise of 20 square miles of timber. This ten days' time included the flying and processing of the pictures, and the computation of volumes. This would have been impossible by any other method due to the presence of six feet of snow on the area at the time. The cost of the cruise was $.10 per acre as compared to an estimated $1.00 per acre by conventional methods. The volume estimation was from 2 percent to 7 percent high by sections, indicating that better results might be obtained by using the aerial photographs in conjunction with ground checking of type volumes (7 pp. 56-58).

Review of Literature

There is much similarity in the way aerial photographs are used in all forestry work. The first requisite is a base map showing the land grid or control. On this map is drawn the various features of the area obtained by the examination of the photographs through one of the plotting devices. The base map control is established by the slotted template method (14 p. 98), of

radial line triangulation (14 pp. 89-92).

Forest types are delineated on the photographs, and these boundaries transferred to the base map. Timber type areas are then measured on the map. When the volume per acre of each type is determined, it may be applied to the area of that type to arrive at a total volume figure.

Using the photos thus, as an aid to ground cruising, costs may be reduced as much as 75 percent, because of the lessened amount of field sampling (16 p. 324).

The U. S. Forest Service in the North Central Region (2 p. 961) uses the marked photographs in the location of their sample plots by random selection.

In the Pacific Northwest the Forest Service (8 pp. 317-320) makes many of their management plan maps from photographs. They determine site, type, and total volumes as well as mapping in topography and transportation routes. Cutting plans and methods also are determined from the information taken from the photographs.

The Pacific Northwest Forest and Range Experiment Station (11 p. 326) is doing research in perfecting aerial volume tables. These are not yet ready for publication, but they predict that these tables will greatly reduce the amount of leg work necessary in timber cruising.

The Oregon State Tax Commission (5 p. 156) is using aerial photographs for the determination of the value of

privately owned forest lands for taxation purposes. From the photographs and ground control, they map in ownership boundaries, timber types, and timber volumes.

The Oregon State Board of Forestry (10 pp. 334-335) is currently using aerial photographs in planning reforestation in the rehabilitation of the over 300,000 acre Tillamook burn in Northwest Oregon.

THE USE OF THE PHOTOGRAPHS OF THE BLODGETT TRACT

Following is a brief description of the Blodgett Tract, and the step by step procedure followed in using the aerial photographs as an aid in the examination and mapping of the area.

The Blodgett Tract

The Blodgett Tract consists of 2,400 acres of cut-over land in Columbia County, Oregon. It was logged over during the years between 1923 and 1928. The land is site I, and high site II for Douglas-fir. The volume removed, at the 1927 standard of utilization, was over 80,000 board feet per acre.

No allowance for seed trees was made, however a few unmerchantable trees were left. These potential seed trees were killed in the fires which followed the logging, and are now, along with the spar trees, snags which increase the fire hazard.

Some salvage logging has been completed on the Southwestern part of the tract but only merchantable snags and logs were taken, leaving many snags still standing. Another contract has been let covering green hemlock and damaged Douglas-fir trees in the southern part of the tract. This contract has not expired at the date of this writing.

Reproduction has advanced remarkably far despite the apparent lack of seed source. There is a two-storied effect to this reproduction which indicates that seeds came in from a distant seed source, germinated, and have grown to the size where they are in turn producing seed. These older trees are 20 to 25 years old, and almost without exception are Douglas-fir.

Seedlings 0 to 12 years old make up the balance of the reproduction. Sparcely restocked areas are predominantly Douglas-fir, while the more densely restocked areas have a higher percentage of hemlock, and Western red cedar.

The Aerial Photographs

The aerial photographs used in this study are standard 9 x 9 inch contact prints, printed on double weight semi-matte paper. The scale is 1:12,000. The photos were taken with a 12 inch camera using panchromatic film with a minus blue filter.

The photography was flown by Delano Aerial Surveys of Portland, Oregon. The cost of photo coverage was

$.02 per acre. Adjacent landowners joined with the State in having a large area flown, and thereby the cost per acre was less than had each tract of land been flown separately.

The Initial Land Reconnaissance

Before visiting the Blodgett Tract, the photographs were carefully studied under a stereoscope, to give the observer as much advance information about the area as possible. Forest types were marked on the photographs for field checking, and a proposed route of travel over the area was planned.

It rained on the day of the first visit to the tract, and little was accomplished except for locating, and pricking on the photograph a section center marker, and visiting certain areas.

The Base Map

The usual practice in the construction of a base map from aerial photographs is to first establish the ground control. Locate it in the field, prick it onto the photographs, and then transfer it to the base map by means of the slotted template assembly.

When the Blodgett Tract was logged over, survey markers were obliterated. Only where section lines crossed

nearby county or Forest Service roads are there any markers. On the second visit to the tract, two section corners were located. One of these corners was a mile North of the Western boundary of the tract, and the other was the Southwest corner. The photographs again made it possible to locate one of these corners by having a logger who knew the property locate the corner approximately on the photograph, then by carefully searching the area which he had indicated, the corner was found.

A slotted template assembly (14 p. 98) was made using the two section corners, the one center section point, principal points, conjugate principal points and wing points. This assembly was placed over a blank base sheet and adjusted to a scale of 5 inches to the mile, or slightly less than the scale of the photography.

All points were pricked through to the base sheet and marked. The map was then drawn in under a multiscope (14 p. 157). Roads, railroads, streams, and type lines were put onto the base sheet at this time.

The two section corners lay on the same range line so were connected with a straight line. The center section marker was used to establish the East-West line bearing, as it lay one half section to the Southwest corner of the tract. Thus the basis for plotting in the rest of the section lines from the original survey notes

was established.

The above method of plotting map control is admittedly not one of high accuracy, but when the map was completed the section lines were coincident with cutting lines which were visible on the photographs. Under the circumstances there was no other way to establish control, short of a complete resurvey of the tract.

The Forest Type Map

The boundaries for the forest type map were traced directly onto the base sheet at the same time that other planimetric detail was mapped. Types were not previously delineated on the photographs because the author believes that the type boundary markings obscure other detail and interfere with the stereoscopic image. The type boundaries are often arbitrarily located, and may be more easily located when viewing two pictures under a stereoscope. Thus, by locating them when making the map under the multiscope, their location is free of topographic displacement (14 p. 154).

The first type map, made from the photos alone, was later adjusted in parts where the land examination showed a different degree of stocking.

The Land Examination

The third visit to the Blodgett Tract was to gain

information as to the exact stocking of the area, and to try to correlate or verify the information taken from the photographs.

Two crews of two men each were used. The routes taken by the crews were previously marked on the photographs as to bearing and distance. The routes were so located as to put the observers into the various types. The type designations used are those developed by the Pacific Northwest Forest and Range Experiment Station, in cooperation with the Division of Timber Management, U. S. Forest Service, and described in the book "Log Scaling and Timber Cruising," by J. R. Dilworth (4 pp. 125-135). The examination was made on a line plot method, taking a sample plot each two chains along each strip through the type. A double plot arrangement was used, and the following observations were made:

1. The small plot was circular and of 1/250 acre in size. It was divided into four 1/1000 acre pie-shaped pieces, and the stocking in each part was examined. One established seedling, or tree in a 1/1000 acre plot made it fully stocked. Trees in these plots were also tallied as to species to determine the species composition of the stand.

2. The dominant tree nearest the center

of the plot was measured, and tallied as to species, diameter breast high, total height, age, and crown diameter.

3. A second plot with the same center was also established, and within it was counted the number of trees over five feet in height. The size of the second plot was based on the density of the type. For one-bar stocking (4 p. 129) density the plot was 1/10 acre, for the two-bar density, 1/50 acre, and for the three-bar stocking a plot of only 1/100 acre was used. This information was later converted to trees per acre over five feet in height.

4. The fourth tally made at each plot station was an ocular estimate of the percent of crown closure in the area immediately around, and including the 1/250 acre plot.

Two other types of plots were taken, one to determine the average size and age of the trees in a Douglas-fir small saw timber stand. The other was, at several places on the area, a prominent spar tree was to be picked as the center of a plot. The tree was to be pin-pricked on the photograph, and then each individual tree, log, and different type of brush or hardwood within a circle of 100 feet was to be mapped on paper. This is to

help in learning to recognize the different objects on the photographs.

As a result of the land examination a new type map was made. Some of the land previously classed as two-bar stocking was transferred to three-bar, and some to one-bar. One area classed as one bar stocking was changed to nonstocked. Another area formerly listed as a Douglas-fir type was changed to hemlock type as a result of the check on species composition.

The reforestation plan in part two of this thesis will be entirely based on the forest type map, and the information gained from the land examination.

The Fuel Type Map

Fuel type maps for fire analysis are based on two factors, namely, rate of spread, and resistance to control. There are four degrees of each: low, moderate, high, and extreme. The same color is assigned to the same degree of each of the factors, the border color of an area being the degree of rate of spread, and the body color the resistance to control.

Rate of spread is based on the character of the forest fuels, snags, and topography.

Low -- Old growth and second-growth fully stocked stands of timber, with

no snags.

Moderate -- Under-stocked old growth and second growth Douglas-fir stands with no snags, slopes up to 40 percent.

High -- Old burns and logged over areas with some snags, slopes up to 40 percent, little dead and down material.

Extreme -- Snag areas, burned over, dead and down pole or smaller size material. High-graded logging area with down and crossed up logs and slash. Slopes over 40 percent.

The colors assigned are: Low -- green, Moderate -- blue, High -- orange, and Extreme -- red.

Resistance to control is based on the amount of fire line that one man can construct and hold per hour. This is in turn based on the amount of chopping and sawing that is necessary in line construction, and the rockiness of the soil.

Sufficient information can be seen on the aerial photographs to make up the fuel type map. Topography is easily seen and snag counts and density of stocking determinations are quickly made. A large area may be fuel typed in a relatively short time, as compared to the old method of field observation.

Proposed Road and Water Supply Development Map

This map is designed to show the most advantageous location of road extensions for better fire protection, and the location of year around water sources for filling tankers.

Under the stereoscope, the preliminary road location can be planned. Since topography is exaggerated, it is easy to recognize steep slopes, bluffs, and canyons and to avoid them. Even without topographic lines on the photos, a good road grade can be made.

Permanent streams, and beaver ponds are readily recognized, and mapped in. Also, under stereoscopy, gullies or narrow creek beds, where earth dams can be most easily constructed, can be located.

Old railroad grades offer excellent routes for the construction of fire roads. Since the entire area was railroad logged, there is a good coverage of old grades. Most of these old grades have been well rocked and it is only a matter of clearing off the vegetation and smoothing up the roadbed, and the road is finished. Shooflies must be built around places where railroad trestles have rotted out.

Hour Control Map

The hour control map shows the length of time it

would take to get fire fighters to any part of the tract from the nearest fire station. It is based on a get-away time of 6 minutes, the rate of speed that a loaded pickup truck can safely travel the various classes of roads, and the hiking distance from the nearest road to the fire. The aerial photographs play only a small part in the making of this map in that they indicate the type of ground over which the men must hike from the trucks. It would of course greatly lengthen the hiking time if it were a long, steep slope up from the road to the fire, and by using the photos it may be seen that a somewhat further distance from a road which is above the fire would have less travel time away, and would place the fire fighters in the proper place to start action.

Seen Area Map

The seen area map shows those areas of the tract which can be seen from the fire lookout, and those areas which cannot be seen.

There was not sufficient time to construct a new topographic map of the Blodgett Tract for use in making the seen area map. However, a U. S. Army Corps of Engineers tactical map, made from aerial photographs, was used.

In construction of the seen area map, radial lines

were drawn out from the lookout position, covering the area being mapped. Then arcs were drawn in at 1/2, 1, 1½ and 2 mile intervals. Ground elevation was then plotted on graph paper over radial distance from the lookout, and a profile of the ground surface along each of the radial lines was drawn. A line was then drawn from the elevation of the lookout through the high points on the profile to determine the visible and non-visible areas. These radial lines were then transferred to the map of the area and the points of visibility connected with a solid line. Different colors were used to indicate visible and non-visible areas on the finished map.

This method is used extensively when examining an area for the best lookout tower location.

A less accurate seen area map may be constructed by taking the aerial photographs to the lookout location and then by observing the tract, and locating the areas seen on the photos, visible and non-visible areas may be sketched on the pictures and later transferred to a map.

CONCLUSIONS

Aerial photographs reduced the amount of field work to an estimated one-fifth that which would have been necessary to do the job by field examination alone. A consequent gain in the time required to do the job was

made.

Area reconnaissance is greatly aided by taking the photographs and a stereoscope into the field. Special areas may be located and visited that might otherwise be missed by not having the photographs along.

Forest boundaries may be marked on the base map under the multiscope without prior delineation on the photographs. However field examination of each type is necessary to determine accurately the degree of stocking and the species composition.

The fuel type map may be made without field examination. Green timber areas, brush areas, snags, steep slopes and so forth, which are the bases upon which the fuel type map is made, may be recognized directly on the aerial photographs.

Road developments may be planned directly from examination of the photographs with a stereoscope. Abandoned railroads make excellent road locations, and approximate locations of branch roads may be made by picking the route out along the stereoscopic image. Locations may be sketched on the photographs and later transferred to the base map.

Water sources such as beaver ponds, streams, and good places to build earth dams are easily located on the photographs.

Hour control maps may be made from the planimetric maps alone, but are better when such information as steepness of slopes and brushiness as interpreted from the photographs is used to determine the rate of travel from various places along the roads.

Seem area maps are best made from accurate topographic maps such as the U. S. Army tactical maps. These topographic maps are made from aerial photographs.

There seems to be a correlation between the number of visible trees per acre on the tract and the actual percent of stocking as determined by the line plot method. Also, the estimated percent of crown closure is similar.

The following is the unweighted average of the results of the land examination. The three factors are, first, the percent of stocking by line plots, based on 1,000 trees per acre. The second factor is the number of trees per acre over 5 feet tall, (these are the trees which are visible on the photographs, and were used to determine the type class). The third factor is the estimated percent of crown closure as estimated in the field.

TABLE 1. Trees per acre and crown closure verified by aerial photograph interpretation

Density Class	Percent Stocking by Line Plots	Trees per Acre Over 5' Tall	Percent Crown Closure
Three-bar (DF)	71	743	63
Two-bar (H)	57.5	707	20
Two-bar (DF)	37.5	600	30
One-bar (DF)	15.2	57	11.5

This table indicates that it is possible to determine the degree of stocking by observing the number of visible (over 5 feet tall) trees per acre from the photographs.

Hemlock, with its tendency towards grouping into clumps, makes it impossible to see individual trees on the photos.

Willow and vine maple species of hardwoods in mixture with conifers can be recognized on aerial photographs by their nearly white tone, in contrast to the dark grey of Douglas-fir and hemlock.

Alder trees are not easily recognized when in mixture with conifers, but in pure alder stands, the tone is intermediate between that of the willow-vine maple, and the conifers. Dense stands of alder also show as a finely pebbled texture in contrast to the individual

crowns of Douglas-fir.

It is extremely difficult to distinguish hemlock trees from Douglas-fir in mixed stands. Pure stands of hemlock can be distinguished from pure stands of Douglas-fir, the hemlock having a smoother texture than the other.

A MANAGEMENT PLAN FOR THE BLODGETT TRACT

The Blodgett Tract is an excellent example of what this writer terms "accidental forestry". At the time of cutting, no provisions were made for leaving seed trees, and no source of seed, other than a few then unmerchantable trees which survived the high-lead logging, was left. These scattered trees were lost in the fires which subsequently followed the logging operations.

No special fire protection was afforded the area except for one road built across the northern edge of the property.

Despite the lack of attention this area has made great advances towards returning itself to productivity. The present age of the dominant trees on the area is less than twenty years. A large part of the area was burned over in 1934. Since that time many young trees have appeared and are now in turn producing seed which will soon have most of the area well stocked.

Because of the young age of the stand, this management plan will not go into details of allowable cuts and regulation, but will try to show the trend towards normality which the cutover and burned area is taking, and approximately how long it will take it to reach normality. Approximate cubic foot volumes will be

shown for a date fifteen years in the future when the average age of the stand will be thirty years.

Recommended silvicultural practices, suggested improvements, timber type maps and protection maps are included in the management plan that follows.

HISTORY OF THE BLODGETT TRACT

The Deed

The Blodgett Tract was deeded to the Board of Regents of the State Agricultural College of the State of Oregon and the School of Forestry on the twentieth day of May, 1929. The consideration was one dollar and other valuable considerations.

The transaction was in reality a gift to the School of Forestry for the purpose of establishing an experimental forest for the study of reforestation methods for logged over land.

Legal Description

The property consists of 2400 acres, more or less, lying in Township 7 North of Range 5 West, Willamette Meridian, all within Columbia County, Oregon, and including all or part of the following sections as indicated below:

		Acres
Section 17:	South half;	320
Section 19:	Entire section;	640
Section 20:	Northeast quarter of Northeast quarter (NE¼ of NE¼);	40
	West half of Northeast quarter (W½ of NE¼);	80
	Northwest quarter (NW¼);	160
	Southwest quarter (SW¼);	160
	West half of Southeast quarter (W½ of SE¼);	80
Section 28:	Northwest quarter of Northwest quarter (NW¼ of NW¼);	40
Section 29:	North half of Northeast quarter (N½ of NE¼);	80
	Northwest quarter (NW¼);	160
	Northwest quarter of Southwest quarter (NW¼ of SW¼);	40
Section 30:	Northeast quarter (NE¼);	160
	West half (W½);	320
	Northeast quarter of Southeast quarter (NE¼ of SE¼);	40
	West half of Southeast quarter (W½ of SE¼);	80
	Total acreage	2,400 acres

The right of way of the Columbia and Nehalem River Railroad Company that falls within the boundaries of the tract have been excluded from the grant. Ten-year cutting rights for the removal of the remaining timber and logs were reserved by the original owners.

Logging

The area was logged during the years 1922 to 1927, inclusive (3 p. 4). A volume of approximately 145 million board feet was removed from 2060 acres, or about 70 thousand board feet per acre. Approximately 330 acres were in stands too young to be harvested at the time and were left untouched.

Fires

Fires from slashings escaped and nearly the entire area was turned over in 1934. The above mentioned areas of young green timber escaped the fires. Virtually all areas supporting reproduction at the time of the fires were devastated, with the possible exception of the areas now typed as D2, about 170 acres in all.

These fires killed all of the larger trees which had been left as unmerchantable on the logged over portion of the area. This is the reason for the great number of snags, and the lack of residual seed trees. Had these trees remained living the area would undoubtedly have restocked more rapidly.

Earlier Studies

The policy advocated by the School of Forestry after taking possession of the tract in 1929 was to

direct its efforts toward the reestablishment of a forest stand on the area.

Tentative plans were made for the opening of a truck road along the bed of the railroad grade, and the damming of streams for water reservoirs for fighting forest fires. Neither of these plans materialized.

Some experimental seeding plots and interplanting plots were established by a Silviculture class from the School of Forestry under the direction of Dr. W. F. McCulloch. These studies were not followed up due to war-time restrictions on travel.

Lyle Cummings, a Senior Forest Management student at the School of Forestry completed a study (3 p. 13) of the Blodgett Tract in 1942 which included the historical records, a record of the planting studies, and a stocking survey of the tract. Since 1942 no other studies of the area have been made.

PHYSIOGRAPHIC FEATURES

Topography

The Blodgett Tract lies on both sides of the two branches of Fishhawk Creek, and smaller streams leading into this creek. The width of the valley floor ranges from about 400 feet at its narrowest to over 1000 feet. The rate of fall of the creek is very moderate. The

slopes up from the valley floor are comparatively steep, ranging from 40 to 60 percent. The Northeastern part of the tract is a series of ridges and valleys, while the central and southern parts are more plateau-like above the slopes rising from the creek. The range of elevation is from 700 feet above sea level in the lower valley to 1350 feet at the top of the highest point on the area. The greater part of the area of the tract lies at a mean elevation of approximately 1000 feet.

Soil

The soil is deep and rich appearing, ranging from three to five feet deep over the parent material. The "A" horizon is a silt loam, from one to two feet thick depending on the slope and elevation of the land. The "B" horizon is a shot clay mixture of rather uniform thickness of nearly two feet. The "C" horizon is of well rotted basalt rock grading in texture from pea size to the solid rock of the parent material. The soil is mainly Olympic, and Melbourne series. It is well drained, and does not pack easily. This soil is excellent for forest vegetation. The "A" horizon has been somewhat altered by forest fires and subsequent erosion.

Climate

The land overlooks the Columbia River to the north, and is near the crest of the coast range of mountains. Rainfall is rather high. State Forestry records at Jewell, Oregon, show an approximate yearly average of 115 inches. Snowfall is moderate, seldom lying on the area over a month or two in the winter. Little snow damage to the trees was observed. The tract is exposed to northeasterly winds coming directly out of the Columbia River Gorge.

Site Quality

The tract is typical of the high site quality lands of northwestern Oregon. The repeated fires between 1930 and 1934 may have lowered the productivity of the soil somewhat.

The entire area will be treated as high site II. The cutting records and samples of tree measurements taken indicate that this classification is justified.

THE FOREST

The stocked quadrat system was used to classify the vegetation into standard forest types as indicated below. The area of each type was determined by measurement on the aerial photographs.

TABLE 2. Forest types and type areas

Forest type	Area in Acres	Percent of Total Area
XD1-h 1934	388	15.0
XD1=h 1934	355	15.0
XD1≡h 1934	434	18.0
XD2=1927	171	7.0
XH1=d 1934	348	12.0
XH1≡d 1934	192	8.0
D3 =	106	4.5
D3 ≡	204	8.2
D4=h	220	.8
H	156	6.5
XO	115	5.0
O	10	.5
Totals	2400 (approx.)	100 percent

Condition of Reproduction Stands

The following table is a result of the land examination made by the author. The percent of stocking for each type is based on the percent of mil-acre plots per acre containing at least one established tree or seedling.

The figures for average age, diameter breast high and height are for the average dominant tree in the stands.

TABLE 3. Stand and stocking of reproduction areas

Type	Stocking Percent	No. Trees Per Acre	Average DBH in Dominants	Average Age Yrs. Dominants	Average Height Ft. Dominants
XD1-h	17.9	60	5.8	17	30
XD1=h	44.5	584	4.9	17	27
XH1=d	44.5	584	4.9	17	27
XD1≡h	70.4	760	4.4	17	27

The survey showed no difference between the two types XD1=h and XH=d except species composition.

It is interesting to compare a stocking survey made in 1941 (3 p. J - appendix) with this one made in 1951. As near as can be determined, three general areas were sampled each time. Both surveys were based on the percentage of stocked mil-acres. The following table compares the two surveys.

TABLE 4. Stocking comparison between years 1941 and 1951

Area	Classification Type (1951)	Stocking percent (1941)	Stocking percent (1951)
A	XH1=d 1934	24	44.5
B	XD1≡h 1934	35	70.4
C	XD1-h 1934	9	17.9

This table shows that the stocking has nearly doubled in the last 10 years with the greatest increase towards normality occurring in the better stocked stands.

Future Condition of Reproduction Stands

In predicting the future condition of reproduction stands, estimates were based on data collected on 1/250-acre plots distributed throughout the area.

The average of the stand used in this computation is 15 years. While 17 years is the average age of the dominant trees, 15 years is more nearly the average age of the reproduction stands considering all crown classes.

The following table is based on a method of predicting the future stocking of reproduction stands, as described by Staebler in the Journal of Forestry (15 pp. 828-833).

TABLE 5. Prediction of future normality of stocking and cubic foot volumes for the reproduction stands

Timber Type (basis 1/1000 acre plots)	Percent of 1/250-acre plots stocked	Stand age years	Percent normality at 30 yrs.	Volume, cubic feet per acre at age 30 yrs.
XD1-h	54[1/]	15	74.8	3076
XD1=h	71	15	85.4	3500
XH1-d	71	15	85.4	3500
XD1=h	96	15	93.2[2/]	3828

These predictions of normality of stocking can be applied to estimations of volume or of basal area by applying them to the appropriate yield tables for normal stands.

The increase in normality shown in the above table indicates that it is possible for stands of one-bar density to reach full stocking in approximately 20 years. Two-bar and three-bar stands may require only 15 years or even less to reach normality.

1/ The stocking percent of 54 percent for a timber type listed as one-bar stocking is the result of the prediction study being based on the percent of stocked 1/250-acre plots, and the timber type being based on 1/1000-acre plots. The two sampling systems seldom, if ever, produce the same results, 1/1000-acre plots being used for young reproduction studies and 1/250-acre plots used in stocking surveys of somewhat older stands.

2/ The decrease of from 96 percent stocking to 93.2 percent indicates that at age thirty, 250 trees is too many for a fully stocked acre and the weaker and suppressed members have started to fall out of the stand.

Present Volumes of Merchantable Timber

The tree count and acreages included in the following table were taken from aerial photos of the area. The remainder of the data are from field measurements.

TABLE 6. Statistics and volumes of merchantable timber types

Type	Average DBH in.	Average Ht. ft.	Average age yrs.	Volume per tree Bd. ft.	Trees per acre	Volume per acre Bd. ft.	Acres	Total Volume Bd. ft.
XD2=	12	60	24	50	35	1,400	171	239 M
D3=	20	129	57	500	25	12,500	106	1,325 M
D3≡	18	129	57	410	55	24,600	204	4,600 M
D4	24	150	*	909	13	11,800	20	236 M
						Total - - -		6,400 M

* Age unknown.

ECONOMIC SITUATION

Communities, Industries and Markets

All parts of the Blodgett Tract are within 5 miles of Columbia River water. This is not the easiest route out to market at the present time, due to the steepness of the roads leading from the 1300 foot elevation at the ridge top, down to the river elevation of about 25 feet. The other outlet down Fishhawk Creek is an easy grade, but it is then about 25 miles additional distance to the Columbia River log dumps, or the town of Clatskanie.

Small sawmills are located within 20 miles of the tract which could handle small sawlogs but would not be in the market for pulpwood or larger sawlogs. It is important that prior to a large scale removal of forest products that a good road be constructed through the property from north to south so that the shortest route to the Columbia River can be utilized. From there logs and pulp sticks can be cheaply moved by water to the mills. Pulpwood can either be shipped on barges as cordwood or chipped in the woods and sent as chips.

The nearest pulpmill to the Blodgett tract is at Longview, Washington. The next closest mill is at St. Helens, Oregon, and then Astoria, Oregon.

The small farmer-logger towns of Mist, Birkenfeld,

and Jewel would be directly benefited by permanent forests in this area. They could furnish the labor necessary for both the forestry and logging practices.

MANAGEMENT

Objects of Management

The Blodgett tract is ideally suited to the growing of Douglas-fir peeler stock. This is evidenced by the type of timber that was removed from it in the past. The average size of the old-growth stumps on the area is approximately five feet in diameter.

The author has no intention of recommending that the future stand ever reach such diameters as five feet, however with the present closer standards of utilization Douglas-fir logs as small as 24 inches in diameter are peeled for veneer.

Certain crop trees should be selected early in the rotation, at about 20 years of age. These trees should be pruned to make the best possible grades of veneer. At the present time with the two storied effect in the stands, the crop trees can be easily selected, as they are the larger dominant trees. It is evident that they are in need of immediate pruning, as they have limbs nearly to the ground due to their open grown status.

SILVICULTURAL RECOMMENDATIONS

Planting

Certain unstocked areas of the Blodgett tract will have to be planted to establish a stand. The 125 acres of open, non-stocked land should be planted to root-pruned Douglas-fir seedlings which are at least two years old and are hardy. These non-stocked areas are heavily overgrown with ferns and grasses, and it will be necessary to scalp off an area in which to plant each seedling.

The XD1-h type should be the second choice for interplanting. These areas are largely the higher points and ridges. Understocking on these high places is undoubtedly due to such things as aspect, insolation, low soil moisture content during dry periods and game and rodent depredations. The planting stock for these exposed sites should be previously hardened to withstand heat and dry soil.

A total of 513 acres are in need of planting and interplanting, with preference to the 125 acres which are non-stocked. One planting crew of ten men should be able to complete the entire job in one winter.

Pruning

Pruning should be started immediately if possible.

Pruning the trees when they are at approximately the diameter of the cores from which veneer has been peeled will produce the greatest amount of clear wood in the subsequent growth.

About 110 trees per acre should be selected and pruned to a height of about nine feet above stump level. Later prunings to thirty-three feet should be made as the trees become taller and the crowns develop greater length. A fully stocked stand on high site II land should consist of 101 trees per acre and the average diameter would be approximately 23 inches. These 101 trees, in order to produce peeler stock, would have to be carried on to an age of at least 150 years. The rest of the trees in the stand would be removed in thinnings before reaching the 100 years of age.

Thinnings

Due to the under-stocked condition of the stands, thinnings will not be needed for at least another 25 years. Thinnings should pay for themselves by producing a salable product such as pulpwood, gang logs or poles.

Cuttings

The D3 stands which are fully stocked at the present time are mostly on steep ground which makes

thinnings unprofitable. These areas should be clearcut as needed to finance stand improvement on the rest of the tract. The D4 stand has already been cut and will be removed in the summer of 1951.

Cutting Practices

The author recommends that felling and bucking during summer and other dry periods be done with hand equipment to reduce fire danger. Power saw operations should be closely supervised to reduce breakage of the trees.

Logging Methods

On the steepest areas it will be necessary to log with a high lead cable system. On these slopes, no harvest thinnings can be made profitably, but the better formed trees could be pruned to produce clear wood.

On the gentler slopes, the logging could be accomplished with light crawler tractors or even horses. The maximum size of crawler tractors should be limited to Caterpiller D4 or comparable sizes in other makes.

For thinning operations the author recommends that the logs be bunched with horses and then skidded with tractors to landings.

Slash Disposal

Slash burning is one of the greatest of fire dangers, and is of somewhat questionable value. Slash concentrations around landings and along rights of way would reduce the chances of fires starting and making rapid headway if started. Slash fires should be avoided in areas where there is young reproduction.

Snag Felling

All snags on the tract should be felled as soon as possible to reduce the danger of spreading fires. A snag count from the aerial photos indicates that there is approximately 1,100 snags on the 2,400 acres. These snags range in size from three to six feet in diameter.

Rodent Control

The author recommends that the areas of one-bar stocking be given an aerial rodent poisoning prior to the time of seed fall. This may determine whether or not it is the rodent population which is keeping down reproduction.

Game and Recreation

The greatest enemies of the young seedlings are the deer and elk which winter on the area. They browse and trample the young seedlings and are especially fond of

cedar. Hunting should be allowed and even encouraged for the benefit of tree reproduction. Trapping and the hunting of predators should be discouraged. The predators live largely on the animals and rodents which destroy tree seeds and seedlings. Fishermen should be excluded from the area only during periods of extreme fire danger. Fishing in the area of the Blodgett tract is limited and it is doubtful if fishermen would constitute a problem.

BIBLIOGRAPHY

1. Birdseye, Claude H. Stereoscopic photographic mapping. Photogrammetric engineering 6:109-125. 1940.

2. Choate, Grover A. Aerial photographs - an efficient tool in management plan surveys. Journal of forestry 47:961-965. 1949.

3. Cummings, Lyle A. The Blodgett tract. Oregon State College, May 1942. 13p.

4. Dilworth, John Richard. Log scaling and timber cruising. Corvallis, Oregon State College cooperative association, 1949. 238p.

5. Eubanks, Wallace B. Photogrammetry and forest taxation. Photogrammetric engineering 16:156-165. 1950.

6. Garver, Raymond D. Aerial photographs in forest surveys. Journal of forestry 46:104-106. 1948.

7. Herold, George C. and Norman Jacobson. Cruising and mapping timber by aerial photography. West coast lumberman 74:56-58. 1947.

8. Hixon, Homer J. The use of aerial photographs in timber cruising on the national forests. Photogrammetric engineering 16:317-320. 1950.

9. Isaac, Leo A. Better Douglas-fir forests from better seed. Seattle, University of Washington press, 1949. 64p.

10. Kallender, R. M. Use of aerial photography in Oregon's rehabilitation program. Photogrammetric engineering 16:334-338. 1950.

11. Pope, Robert B. Aerial photo volume tables. Photogrammetric engineering 16:325-326. 1950.

12. Robinson, J. M. Air photography and its application to forest inventory. Timber topics 11:3-4. January-February, 1948.

13. Second-growth management committee. Management of second-growth forests in the Douglas-fir region. Portland, Ore., U. S. Department of agriculture, 1947. 151p. (Pacific northwest forest and range experiment station).

14. Spurr, Stephen H. Aerial photographs in forestry. New York, Ronald press company, 1948. 340p.

15. Staebler, George R. Predicting the volume and normality of reproduction stands of Douglas-fir. Journal of forestry 47:828-833. 1949.

16. Trobitz, H. K. Use of aerial photographs in the inventory phase of the forest management job. Photogrammetric engineering 16:321-324. 1950.

17. United States War Department. Topographic drafting. Washington, War department, November 12, 1940. 302p. (Technical manual 5-230).

18. Wood, Kendall B. Review of aerial mapping in the logging industry. Loggers handbook 10:55-64. 1950.

A P P E N D I X

p.47-52 are maps. They are located in
a pocket at the back of this thesis.