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COOPERATIVE LEVELS-OF-GROWING STOCK STUDY IN DOUGLAS-FIR

REPORT NO. 1

DESCRIPTION OF STUDY AND EXISTING STUDY AREAS

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
PORTLAND, OREGON

Levels-of-growing-stock study treatment schedule, showing percent of gross basal area increment of control plot to be retained in growing stock

Thinning	Treatment							
	1	2	3	4	5	6	7	8
	Percent							
First	10	10	30	30	50	50	70	70
Second	10	20	30	40	50	40	70	60
Third	10	30	30	50	50	30	70	50
Fourth	10	40	30	60	50	20	70	40
Fifth	10	50	30	70	50	10	70	30

Public and private agencies are cooperating in a study of eight thinning regimes in young Douglas-fir stands. Regimes differ in the amount of basal area allowed to accrue in growing stock at each successive thinning. All regimes start with a common level-of-growing-stock which is established by a conditioning thinning.

Thinning interval is controlled by height growth of crop trees, and a single type of thinning is prescribed.

Eight study areas, each involving three completely random replications of each thinning regime and an unthinned control, have been established in western Oregon and Washington, U.S.A., and Vancouver Island, Canada. Site quality of these areas varies from I through IV.

Climatic and soil characteristics for each area and data for the stand after the conditioning thinning are described briefly.

Keywords: Thinnings, stand growth, Douglas-fir.

LEVELS-OF-GROWING-STOCK

COOPERATIVE STUDY

ON DOUGLAS-FIR

Report No. 1--Description of Study and Existing Study Areas

by

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Cooperator

INTRODUCTION

In 1962, representatives of State, Federal, and industrial forestry organizations met to organize a cooperative effort aimed at providing the biological information necessary to develop reliable yield tables for managed stands. The participants adopted a study plan[1] designed to examine (1) cumulative wood production, (2) tree size development, and (3) growth-growing stock ratios as affected by eight different thinning regimes. This study plan had been developed earlier at Weyerhaeuser Company, and procedural details to insure comparable data from all cooperators were developed by the Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service.

Each organization present at the 1962 meeting designated a representative to the Levels-of-Growing-Stock Studies Committee operating under Station auspices. This committee has met annually to develop additional procedures to further assure validity of study results and to disseminate new information pertinent to the study. A current list of committee members is appended.

A brief description of the study design, together with a description of study areas established through 1964, was published in 1965.[2]

[1] George R. Staebler and Richard L. Williamson. Plan for a level-of-growing-stock study in Douglas-fir. Available through the Director, Pacific Northwest Forest and Range Experiment Station, P.O. Box 3141, Portland, Oregon 97208.

[2] Richard L. Williamson and George R. Staebler. A cooperative level-of-growing-stock study in Douglas-fir. USDA Forest Serv. Pac. Northwest Forest & Range Exp. Sta. 12 p., illus., 1965.

The committee decided in 1969 to publish results from all study areas in the Station's Research Paper series. All papers pertaining to this study will have a similar format and be consecutively numbered. The Canadian Forestry Service will publish its reports, using the common format and report-number series. Since treatments at different study areas are staggered in time, the committee members will present information as soon as possible through reports on individual study areas. Whenever possible, results from two or more study areas will be presented together to facilitate area comparisons. This report is intended to bring readers up-to-date on all study areas and to clarify study procedures.

DESCRIPTION OF EXPERIMENT

The experiment is designed to test a number of thinning regimes beginning in young stands made alike at the start through a "calibration" thinning. Thereafter, through the time required for 60 feet of height growth, growing stock is controlled by allowing a specified addition to the growing stock between successive thinnings. Any extra growth is cut and is one of the measured effects of the thinning regime.

Study Area Selection

Criteria for study area selection are:

(1) Dominant portion of the stand 20 to 40 feet tall.
(2) Tree growth not seriously diminished by competition.
(3) Species other than Douglas-fir constitute no more than 20 percent of residual stand basal area.
(4) Trees distributed uniformly over the area.
(5) Site quality uniform through area.

Presumably, stands in the specified height range are sufficiently adaptable to recover rapidly from any minor competition effects existing before conditioning thinning.

These criteria could not be met in all cases. The stand which best met these criteria in southwestern Oregon was 55 feet tall, but all other criteria were satisfied. Alternative stands had either severe competition and/or patchy stocking.

Experimental Design

A single experiment consists of eight thinning regimes plus unthinned plots whose growth is the basis for treatment in these regimes. There are three plots per treatment arranged in a completely randomized design for a total of twenty-seven 1/5-acre plots. Experience indicates that a gross area of approximately 9 acres is required for a study area.

Interaction of site quality and treatment can be evaluated by replicating installations on each site quality class. Cooperative effort has made this replication possible.

Crop Tree Selection

Well formed, uniformly spaced, dominant trees at the rate of 80 per acre, or 16 per plot, are designated as crop trees prior to initial thinning. Each quarter of a plot must have no fewer than three suitable crop trees nor more than five--another criterion for stand uniformity.

Initial or "Calibration" Thinning

All 24 treated plots are thinned initially to the same density to minimize the effect of variations in original density on stand growth. Density of residual trees is controlled by quadratic mean diameter of the *residual* stand according to the formula:

Average spacing in feet = 0.6167 (quadratic mean d.b.h.) + 8.

Some basic stand characteristics resulting from sample solutions of this equation are:

Quadratic mean diameter *(Inches)*	Spacing *(Feet)*	Trees per acre *(Number)*	Basal area per acre *(Square feet)*
3	9.8	449	22.0
4	10.5	398	34.8
5	11.1	355	48.2
6	11.7	318	62.4

If one concentrates on leaving a certain amount of basal area corresponding to an estimated overall quadratic mean d.b.h. ($\overline{\overline{Dq}}$), then the residual number of trees may vary freely and the actual $\overline{Dq}$'s may vary between plots up to ± 10 percent. Alternatively, if emphasis is on leaving a certain number of trees corresponding to an estimated overall $\overline{\overline{Dq}}$, then the basal area may vary and the actual $\overline{Dq}$'s may vary up to ± 15 percent between plots.

The choice of emphasis is optional, but the basal area guide is recommended for better control of growing stock.

In addition to achieving a common density, the objective of the calibration thinning is to leave a stand as uniform and as evenly spaced as possible. The effect of different thinning regimes in stands as nearly alike as possible at the start is being measured. The interval following conditioning thinning permits the trees to adjust to the common density of the plots before treatment thinnings are started.

Treatments

The eight thinning regimes tested differ in the amount of basal area allowed to accumulate in the growing stock. The amount of growth retained at any thinning is a predetermined percentage of the gross increase found in the unthinned plots since the last thinning (table 1). The average residual basal area for all thinned plots after the calibration thinning is the foundation upon which all future growing stock accumulation is based. As used in the study, control plots may be thought of as providing a "local gross yield table" for the study area.

Thinning *regimes* are being tested, rather than single thinnings. Several treatments (1, 3, 5, 7) are of approximately constant cutting intensities, differing among themselves in level only; two treatments (2, 4) vary intensities from heavier to lighter; and two treatments (6, 8) vary intensities from lighter to heavier.

Clearly, this range of treatments will explore the ability of Douglas-fir to respond to varying degrees of release as the stands pass through critical developmental stages. After several treatment thinnings, densities should range from very high basal area levels to very low levels in which all trees grow as open-grown trees do. The range in yield, tree size, and growth-growing stock ratios should permit foresters to choose regimes that will satisfy any particular objective of management.

Four factors may be expected to strongly influence the results of a thinning regime: (1) volume of growing stock retained; (2) interval, or years between thinnings; (3) kind of thinning practiced--low, high, selection, etc.; and (4) site quality. A complete experiment would probably test three levels of each of the four factors in combination resulting in an experiment with 81 different treatments. In this study, only growing stock will be purposely varied, however, and the other factors will be held as constant as possible as explained in the paragraphs that follow.

Control of Thinning Interval

Thinnings will be made whenever average height growth of crop trees following the year of the calibration thinning comes closest to each multiple of 10 feet.

Table 1.--*Levels-of-growing-stock study treatment schedule, showing percent of gross basal area increment of control plot to be retained in growing stock*

Thinning	Treatment							
	1	2	3	4	5	6	7	8
	Percent							
First	10	10	30	30	50	50	70	70
Second	10	20	30	40	50	40	70	60
Third	10	30	30	50	50	30	70	50
Fourth	10	40	30	60	50	20	70	40
Fifth	10	50	30	70	50	10	70	30

Control of Type of Thinning

As far as possible, type of thinning is eliminated as a variable in the treatment thinnings through several specifications:

1. No crop tree may be cut until all noncrop trees have been cut (another tree may be substituted for a crop tree damaged by logging or killed by natural agents).
2. The quadratic mean diameter of cut trees should approximate that of trees that are available for cutting.
3. The diameters of cut trees should be distributed across the full diameter range of trees available for cutting.

DATA COMPILATION

Stand data for all studies in this cooperative effort are calculated and compiled by the same set of computer programs. Basic data for each tree are d.b.h., basal area, total cubic volume, and condition class (damage or mortality). Diameter at breast height, basal area, and cubic volume are summed by condition class within each plot. These sums are averaged for the three plots within each treatment. Plot and treatment values of basal area and cubic volume are expressed on a per-acre basis.

Tree volumes are currently based on a standard volume table for Douglas-fir,[3] as expressed mathematically.[4] Volumes from this table are usually poor estimates of volume from trees less than about 12 inches d.b.h., and the Station's mensuration project is investigating alternate volume bases.

STUDY AREAS

Lands of site quality I through IV are represented by eight study areas to date. Basic data for each study area are summarized in tables 2 and 3. Data in table 2 apply to the stands at times of calibration thinnings. Data in table 3 are mostly long-term averages[5] for weather stations nearest their respective study areas.

Skykomish Tree Farm

The Skykomish study on the Skykomish Tree Farm of Weyerhaeuser Company was the first installed in this cooperative effort. Many of the details of the standardized work plan were developed at this study area.

This natural stand (fig. 1) was approximately 20 years old when the study was established in 1961. At this time, there was no specification limiting the percentage of other species in residual stands. Even though proportionately more hemlock than Douglas-fir was cut in the calibration thinning, the stand still contained about 50 percent hemlock after this thinning.

This study area occupies a north-facing slope along Youngs River near Sultan, Wash., at about 500-foot elevation. The slope averages about 35 percent. Soils[6] are in the Oso series and are derived from basaltic parent material weathered in place. The area has been mildly glaciated, but surface disturbance was minor and there was little deposition of glacial till.

[3] Richard D. McArdle, Walter H. Meyer, and Donald Bruce. The yield of Douglas fir in the Pacific Northwest. U.S. Dep. Agr. Tech. Bull. No. 201, 74 p., illus., rev. 1961.

[4] Robert O. Curtis. A formula for the Douglas-fir total cubic-foot volume table from bulletin 201. Pac. Northwest Forest & Range Exp. Sta. USDA Forest Serv. Res. Note PNW-41, 8 p., 1966.

[5] Meteorology Committee, Pacific Northwest River Basins Commission. Climatological handbook Columbia Basin States. Six vols., Vancouver, Wash., 1969.

[6] Personal communication from Eugene Steinbrenner, Weyerhaeuser Company, Centralia, Wash.

Table 2.--*Statistics of the study areas at time of conditioning thinning*

Study area and year established	Estimated site index[1] (index age: 50 years)	Age	Average height of crop trees	Quadratic mean d.b.h.		Trees per acre, all species		Basal area per acre	
				Control	Thinned	Control	Thinned	Control	Thinned
	Feet	*Years*	*Feet*	*----Inches----*		*----Number----*		*--Square feet--*	
Skykomish, 1961	119	[2]16	44	4.7	5.1	1,197	358	144.2	50.8
Hoskins, 1963	133	[2]13	36	3.7	5.2	1,727	345	133.8	49.8
Rocky Brook, 1963	90	21	28	3.3	4.0	1,300	400	85.0	35.7
Clemons, 1964	148	19	31	4.0	4.1	687	395	59.9	35.8
Francis, 1963	148	18	25	3.3	3.8	887	405	51.5	31.0
Iron Creek, 1966	127	17	36	3.7	5.0	1,125	355	82.0	47.4
Stampede Creek, 1968	95	[2]29	55	4.7	6.6	995	290	118.5	68.1
Campbell River, 1969	119	21	38	3.8	5.0	1,083	355	87.6	47.9

[1] James E. King. Site index curves for Douglas-fir in the Pacific Northwest. Weyerhaeuser Forest. Pap. No. 8. Weyerhaeuser Co. Forest. Res. Center, Centralia, Wash., 49 p., 1966.

[2] At breast height.

Table 3.--*Climatic data*[1] *for study areas*

Study area	Weather station	Average precipitation		Length of growing season	Average growing season temperature
		Annual	May-August		
		------Inches------		*Days*	*Degrees F.*
Skykomish	Snoqualmie Falls	60.3	11.4	151	59.2
Rocky Brook	--	[2]80.0	--	--	--
Clemons	Oakville	54.5	9.2	156	59.9
Francis	Willapa Harbor	87.5	13.8	197	59.4
Iron Creek	Rainier-Longmire	82.4	14.8	133	59.9
Hoskins	--	[2]80.0	--	--	--
Stampede Creek	Prospect	41.7	6.4	92	60.9
Campbell River	Campbell River	58.5	10.0	149	58.4

[1] Meteorology Committee, Pacific Northwest River Basins Commission. Climatological handbook Columbia Basin States. Six vols., Vancouver, Wash., 1969.

[2] Estimated from isohyetal map; see footnote 1.

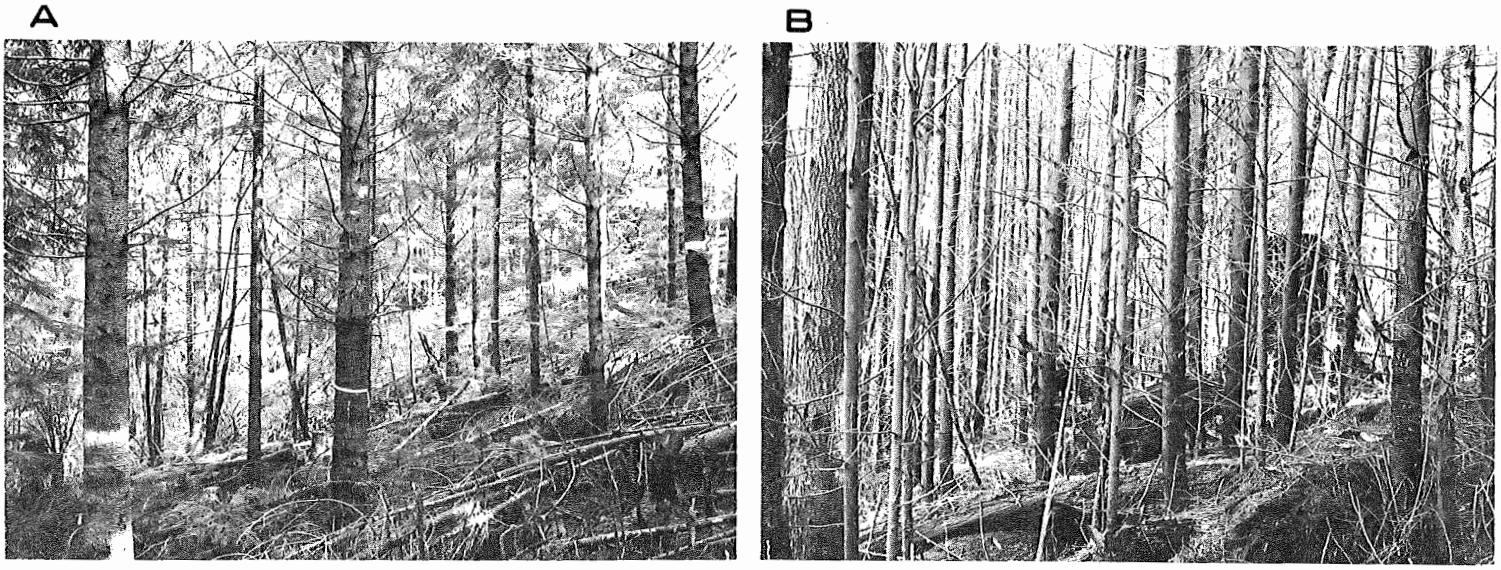

Figure 1.–The Skykomish area in 1969, just before the second treatment thinning. *A*, thinned area (treatment 6). Ribboned trees were removed in this thinning. *B*, unthinned area, with more than 4,000 stems per acre.

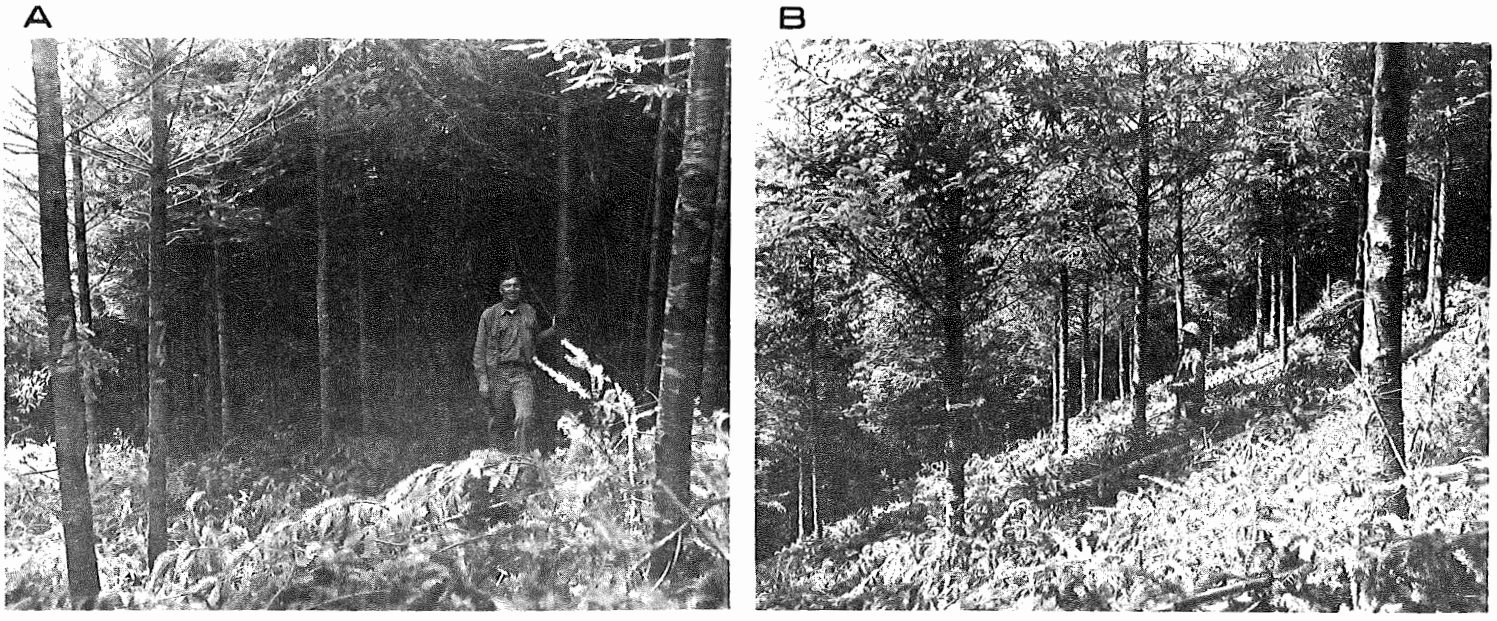

Figure 2.–Study area near Hoskins, Oreg. *A*, treated plot, with control plot in the background. *B*, treatment plots.

treatment thinning in the winter of 1969.

Hoskins

The Hoskins study was established by the School of Forestry, Oregon State University, and was made possible through the provision of land and timber by T. J. Starker and Bruce Starker, professional foresters and private landowners.

The stand was approximately 20 years old when the study was begun in 1963. This natural stand is outstandingly uniform in age and stocking (fig. 2); consequently, very little effort was required to mark all plots to the specified residual basal area and average diameter at the conditioning thinning.

The area is just west of the Coast Ranges' summit near Hoskins, Oreg., about 25 miles northwest of Corvallis. The aspect is southerly, with slopes from 15 to 55 percent. Elevation is about 1,000 feet. Soil information is currently not available.

Annual measurements at this study area have provided reliable determination of rate of response to thinning.

Rocky Brook

In 1963 the U.S. Forest Service (Region 6 and the Pacific Northwest Forest and Range Experiment Station) installed a study area on the Hoodsport Ranger District, Olympic National Forest, near Brinnon, Wash.

The Rocky Brook stand (fig. 3) was planted in 1942 and had plentiful natural fill-in. Installation was difficult because of several small foci of *Poria weirii* root rot throughout the stand. Ten spare plots were established in anticipation of undiscovered *Poria weirii* and future snow damage problems.

The stand occupies a glacier-formed, gently sloping (average 10 percent, short pitches up to 55 percent) terrace near the bottom of a deep, glaciated canyon. The gravelly, sandy loam soils are phases of the Hoodsport series.[7] Aspect is southerly. Cool temperatures, short growing season, and the stony, infertile soil probably contribute to the low site quality.

This study area, at 2,500-foot elevation in the Olympic Mountains, was hit by a record snowfall immediately after conditioning thinning in the fall of 1963. Spare plots were used at the first treatment thinning in the fall of 1969 to replace heavily damaged plots.

Clemons Tree Farm

This study area is in a stand planted in 1947. It occupies a very high quality site near Blue Mountain, about 10 miles west of Oakville, Wash., on the Clemons Tree Farm of Weyerhaeuser Company. Plots are grouped on top of a low ridge with gentle (0-15 percent) slopes at about 800-foot elevation. Aspect is northerly. Soils[8] are in the Astoria series derived from very deep marine sediments and are characteristically highly productive.

Because the plantation was badly browsed and suppressed by bracken in its early years, site index estimation is even more difficult than in most young stands

[7] Intensive soil survey report of the Rocky Brook Study Area, by Loren R. Herman, Soil Scientist, Region 6, U.S. Forest Service. On file in Portland, Oreg., and in Olympia, Wash.

[8] See footnote 6, page 4.

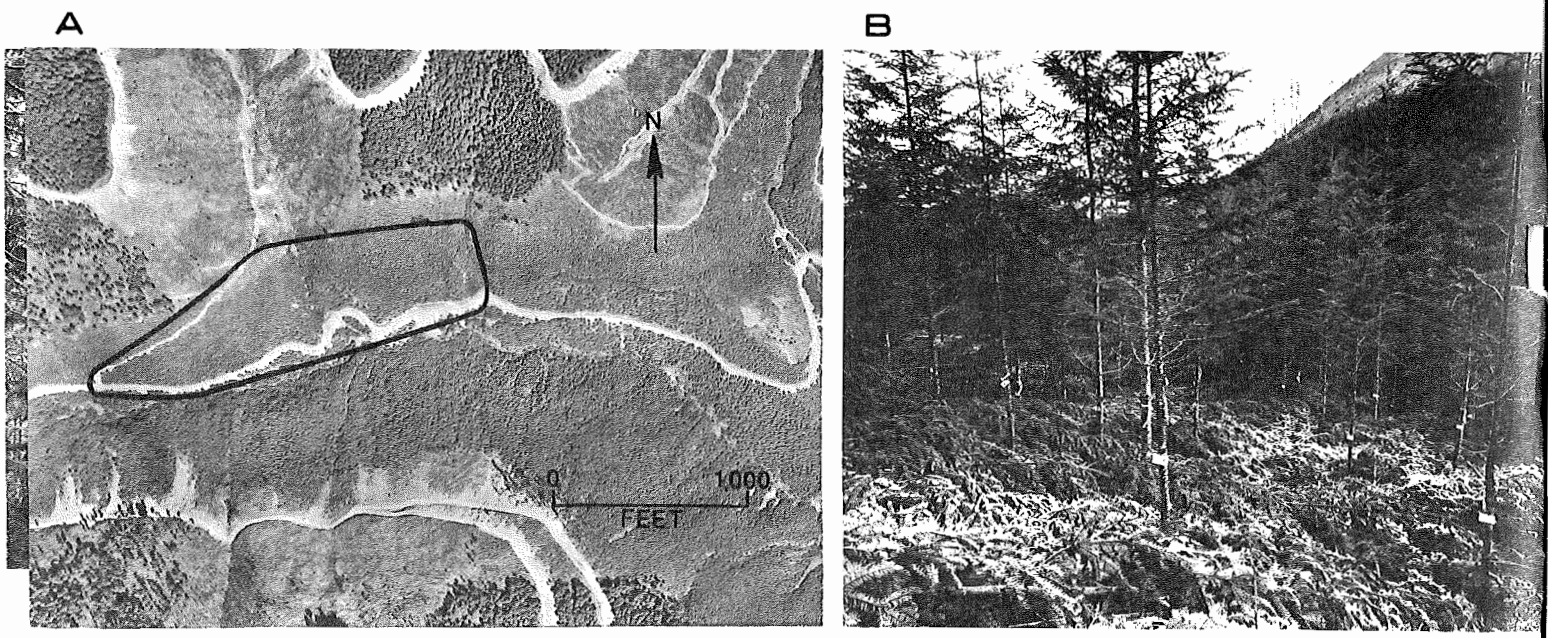

Figure 3.–The Rocky Brook study area, located on the Hoodsport Ranger District, Olympic National Forest, near Brinnon, Wash. *A*, aerial view. *B*, treatment plot.

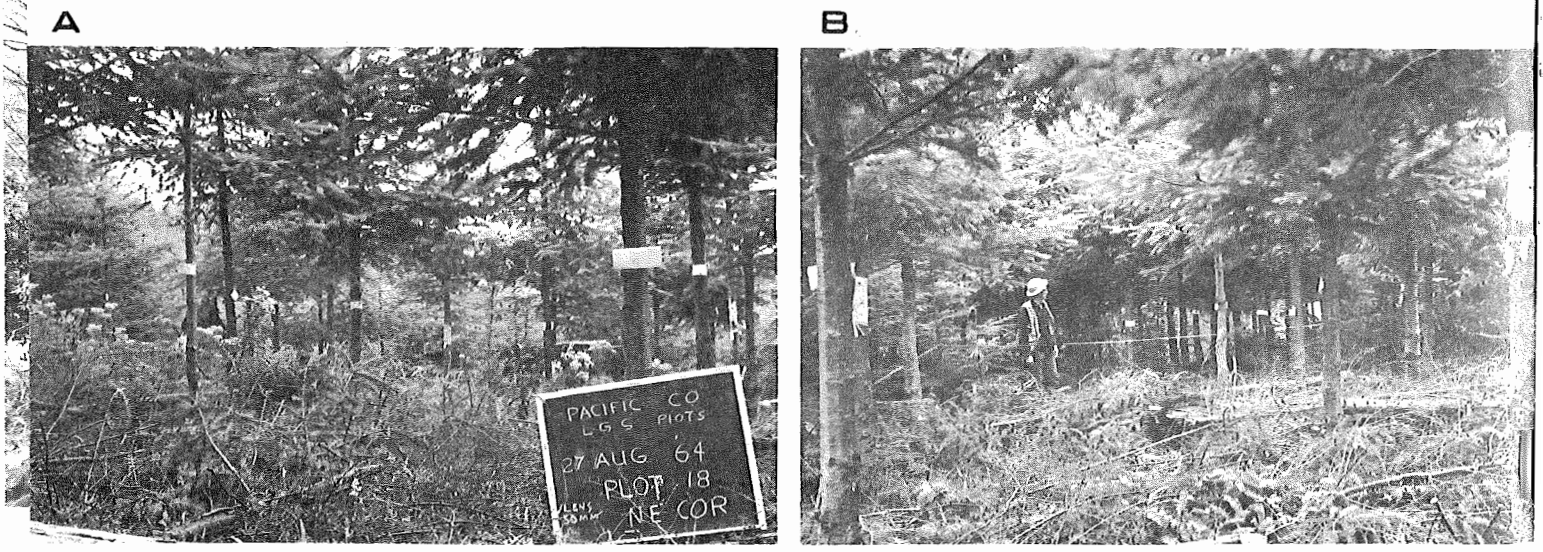

Figure 4.–Washington State Department of Natural Resources study area in the Willapa Hills near Raymond, Wash. *A*, treatment plot after thinning. *B*, treatment plot after thinning, with control plot in background.

and has been based primarily on current terminal growth.

In the conditioning thinning, the majority of trees removed were deformed or of poor quality because of browsing or damage from a severe freeze in 1955.

Many trees felled in thinning had 4-foot leaders. The study includes two control plots installed 1 year previously for another experiment. Growth on these two plots in 1964 was 11 square feet of basal area per acre on 500 trees larger than 2.3-inch d.b.h. Average diameter increased a little more than 0.4 inch in the year between measurements. Obviously, the growth capacity of Douglas-fir on the site is exceptional.

The second thinning treatment was in the fall of 1970.

Francis

The Washington State Department of Natural Resources established a study in 1963 in a stand planted in 1945. The stand (fig. 4) is located on a gentle ridgetop at about 1,500-foot elevation in the central Willapa Hills near Raymond, Wash. Slope of ground varies mostly from 0 to 10 (maximum, 25) percent with aspects either level or confined to the NW and NE quadrants.

Stand growth on this area, like that on the Clemons area, will probably be very high since some trees have current terminal growth of about 4 feet. Soils in the area have not been classified but are described as a deep, well-drained silt loam developed in a mild, wet, coastal climate.[9/]

The stand received the second treatment thinning in the fall of 1969.

[9]Personal communication from H.W. Anderson, Soils Scientist, Washington State Department of Natural Resources.

Iron Creek

The second Forest Service study area is located on the Randle District of the Gifford Pinchot National Forest near Randle, Wash.

The stand (fig. 5) was planted in 1949, and little natural fill-in occurred. Before study establishment, black bears had girdled many trees in the general area. Approximately 20 percent of the trees left by the conditioning thinning had been partially girdled. A strong fence was built around the study area to prevent further damage.

The stand occupies a midslope position at about 2,500-foot elevation. Aspect is easterly, and slopes are gentle, averaging about 25 percent. The deep, well-drained soil is derived from volcanic ejecta overlying a residual soil developed on fractured volcanic rock. Surface soils range from sandy loam to loam with interbedded pumice.[10/]

First thinning treatment was in the fall of 1970.

Stampede Creek

The third Forest Service study is located on the Tiller District of the Umpqua National Forest near Tiller, Oreg. This stand (fig. 6) originated from natural seed fall about 10 years after a wildfire in 1929. This 10-year period allowed brush species to develop so that seedling density was not as heavy as in normal stands.

At age 29 years (1968), when this study area was established, the height of trees (about 55 feet) exceeded study plan specifications, but the initial relatively wide

[10]Preliminary estimate by Loren R. Herman, Soil Scientist, Region 6, U.S. Forest Service.

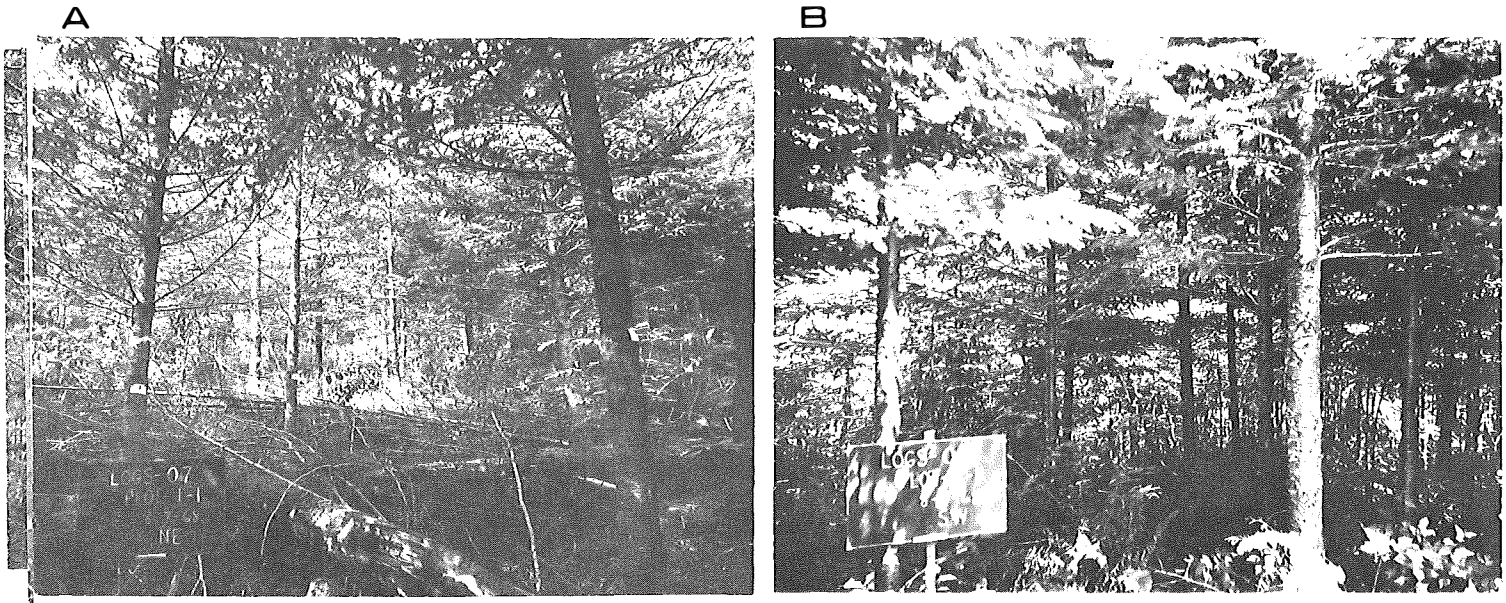

Figure 5.–Iron Creek area after conditioning thinning in 1966. *A*, thinned area. *B*, unthinned control plot.

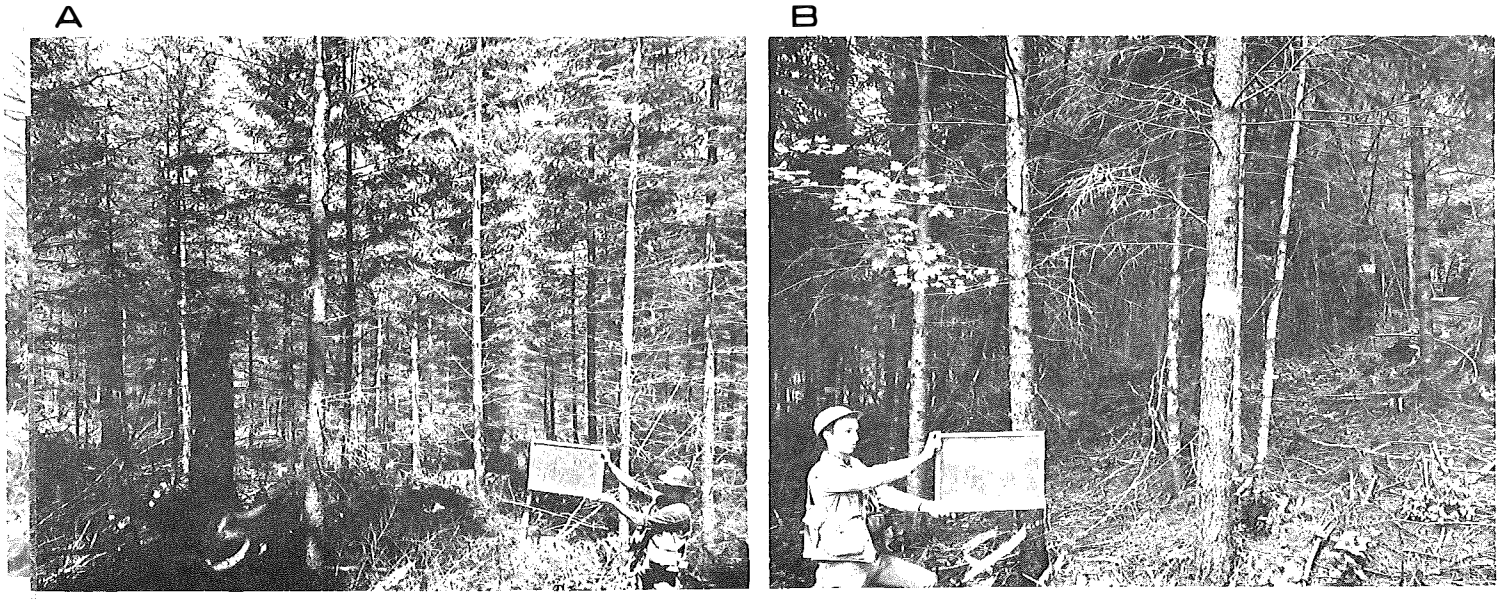

Figure 6.–Stampede Creek area after conditioning thinning in 1968. *A*, thinned area. *B*, unthinned control plot.

Figure 7.—Typical stand conditions at Campbell River. *A*, before conditioning thinning. *B*, after conditioning thinning.

Other LOGS (levels-of-growing-stock) reports:

WILLIAMSON, RICHARD L., and GEORGE R. STAEBLER.
1965. A cooperative level-of-growing-stock study in Douglas-fir. USDA Forest Serv. Pac. Northwest Forest and Range Exp. Sta., 12 p., illus. Portland, Oregon.

Describes purpose and scope of a cooperative study which is investigating the relative merits of eight different thinning regimes. Main features of six study areas installed since 1961 in young stands are also summarized.

The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
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