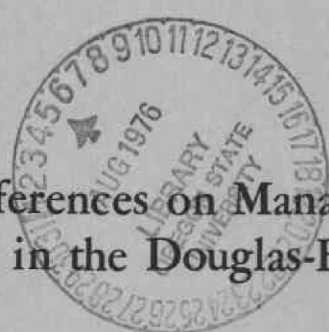


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Annotated References on Managing Young Forests in the Douglas-Fir Region

Alan B. Berg

Research Paper 29
May 1976

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ANNOTATED REFERENCES ON MANAGING YOUNG FORESTS IN THE DOUGLAS-FIR REGION

INTRODUCTION

This bibliography lists selected references useful to the forester in managing young forests in the Douglas-fir region. The references pertain to those management activities that are carried on in the forest from stand regeneration until final harvest. Emphasis is on silvicultural, operational, and economic aspects of management, but social and ecological aspects are also included. The publications are those that a practicing forester in the Pacific Northwest should have in his library or should at least be aware of. Most publications listed can be obtained by writing to the author or the issuing agency.

The general publications and proceedings cover a variety of subjects on forest management. For example, subjects such as economics, ecology, and operations, although not listed by subject, are covered in the proceedings.

Spacing tests begun in 1925 at the Wind River Douglas-fir plantation by the Pacific Northwest Forest and Range Experiment Station with 1-1 seedlings are the oldest tests in the Pacific Northwest. They show trends in stand growth and development for spacings of 4 x 4, 5 x 5, 6 x 6, 8 x 8, 10 x 10, and 12 x 12 feet. Table 1 is a summary of that information periodically for the first 43 years.

The levels-of-growing-stock cooperative study in Douglas-fir is in its early years. The publications describe the thinning regimes, the study areas, and the cooperators. During the next year, publications on several of the study areas will cover early response.

The bibliography is not exhaustive, and the selection of publications is the sole responsibility of the author.

Table 1. Wind River Douglas-fir Spacing Tests.

Author	Year	Stand age	Wide spacing results in: ¹	
			An INCREASE in:	A DECREASE in:
		Years		
Isaac	1929	7	--	Average height
Isaac	1937	12	Average height	--
Munger	1946	21	Average dbh Average height	Cubic-foot volume --
Eversole	1955	28	Average dbh Average height Board-foot volume	Cubic-foot volume (little effect) --
Reukema	1959	34	(Same as age 28 years)	
Reukema	1970	43	Average dbh Average height Cubic-foot volume Board-foot volume	-- -- -- --

¹As reported by investigators in column 1.

GENERAL PUBLICATIONS AND PROCEEDINGS

BAUMGARTNER, David M., Ed. *Precommercial Thinning of Coastal and Intermountain Forests in the Pacific Northwest*. Cooperative Extension Service and Dept. of Forest and Range Mgmt., Washington State University, Pullman. 109 p. February 1971.

Articles include: thoughts and questions about precommercial thinning; growth and stand management of ponderosa pine; evaluating options for management of Douglas-fir and western hemlock stands with theoretical stand models; growth response in lodgepole pine after precommercial thinning; use of chemical thinning in dwarf mistletoe control; thinning ponderosa pine to prevent outbreaks of mountain pine beetles; Oregon pine *Ips* infestation from red slash to green trees—a misconception; progress report on studies of the safety of organic arsenical herbicides as precommercial thinning agents; summary of the application of economic analysis to precommercial thinning in the Washington Department of Natural Resources; application of economic and biological yield data in precommercial thinning; precommercial thinning objectives of the Washington Department of Natural Resources; the future of precommercial thinning in the U.S. Forest Service; precommercial thinning Weyerhaeuser style; and the future of precommercial thinning.

BERG, Alan B., Ed. *Management of Young-growth Douglas-fir and Western Hemlock*. School of For., Oregon State University, Corvallis. Symposium Proc., Vol. 1, \$3.00. 145 p. December 1970.

Thirty-one articles by 23 authors on silvicultural, operational, economic, social, and ecological aspects of young-growth management. Subjects include: history and philosophy of thinning; precommercial thinning in Douglas-fir and western hemlock; chemical silviculture; sociological and ecological aspects; soils and tree-growth requirements; disease, insects, and wildlife in young stands; genetics; water yield; recreation; forest inventory; the telescopic Spiegel-Relaskop; the optical dendrometer; marking trees; growth and yield; roads and skidroads; felling and bucking; skidding and loading; economics; markets and marketing; and commercial thinning.

The following field trips are described: levels-of-growing stock study in Douglas-fir, precommercial thinning in mixed Douglas-fir and western hemlock, precommercial thinning on BLM lands, commercial thinning on Starker Forests, and commercial thinning on the Black Rock Unit, George T. Gerlinger State Experimental Forest.

BERG, Alan B., Ed. *Managing Young Douglas-fir and Western Hemlock. Economics, Yield Control, and Thinning*. School of For., Oregon State University, Corvallis. Symposium Proc., Vol. 2, \$5.00. 175 p. September 1971.

Articles include: yield control of young Douglas-fir; economics of young-growth management; managing young timber; and marking trees for thinning.

Field trips on chemical thinning, commercial thinning on Boise Cascade Corporation lands, and precommercial and commercial thinning on Crown Zellerbach Corporation lands are described.

BERG, Alan B., Ed. *Managing Young Forests in the Douglas-fir Region*. School of For., Oregon State University, Corvallis. Symposium Proc., Vol. 3, \$5.00. 224 p. September 1972.

Articles include: management of Douglas-fir in Europe; the role of alder in improving soil fertility and growth of associated trees; regulation of soil organisms by red alder: a potential biological system for control of *Poria weirii*; economics and marketing of alder; administration of thinning contracts; administration of partial-cut sales; some economic guides

for intensive forest management; and marking trees for thinning, a comparison of foresters.

Field trips to commercial thinning on Longview Fiber Company lands, partial cuttings and scenic view management on the Willamette National Forest, commercial thinning on BLM and Oregon State Forestry Department lands, and the Freres Lumber Company Mill are described.

BERG, Alan B., Ed. *Managing Young Forests in the Douglas-fir Region*. School of For., Oregon State University, Corvallis. Symposium Proc., Vol. 4, \$6.00. 234 p. July 1974.

Articles include: thinning and mechanization; forest fertilization; thinning steep ground; soil compaction; impact on forest streams; role of physiology: nutrition, fertilization, irrigation, growth regulators; using OSCUR to plan state forest operations; some economic aspects of thinning; an approach to economic evaluation of precommercial thinning; and how taxes influence young-growth management.

Field trips to precommercial and commercial thinning and a discussion of fertilizing forests on the Toledo Division, Georgia Pacific Corporation, commercial thinning on Starker Forests, and precommercial thinning in Douglas-fir and mixed hemlock and Douglas-fir, skyline partial cutting, shelterwood cutting, and partial cutting in mature Douglas-fir on the Siuslaw National Forest are described.

BERG, Alan B., Ed. *Managing Young Forests in the Douglas-fir Region*. School of For., Oregon State University, Corvallis. Symposium Proc., Vol. 5, \$5.00. 147 p. March 1976.

Articles include: a progress report on the Hoskins level-of-growing-stock study; bringing forestry to the small landowner; cable thinning in young-growth Douglas-fir; harvest cuttings and regeneration in young-growth western hemlock; programming and data management in forestry; the influence of intensive management on fire hazard; whether or not commercial thinning pays under sustainable harvest; and commercial thinning as an income opportunity for small woodland owners.

Field trips to rehabilitation of understocked stands on Georgia-Pacific corporation lands, release of conifers from brush, fertilization, precommercial and commercial thinning on Weyerhaeuser Company lands, and precommercial and commercial thinning and shelterwood cutting on the Blue Mountain Demonstration Forest are described.

FRANKLIN, J. F. and C. T. DYRNESS. *Natural Vegetation of Oregon and Washington*. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. General Technical Report PNW-8. 417 p. 1973.

Major vegetational units of Oregon and Washington and their environmental relations are described and illustrated. After an initial consideration of the vegetative components in the two states, major geographic areas and zones of vegetation are detailed. Descriptions of each zone include composition and succession, as well as discussion of variations associated with environmental gradients. Three chapters treat the forested zones found in the two States. Major emphasis is on the distinctive mesic temperate forest found in western Washington and northwestern Oregon. The interior valley forests, shrub lands, and prairies found between the Coast and Cascade Ranges in western Oregon are treated in a single chapter as are subalpine and alpine mosaics of tree-dominated and meadow communities. Unusual habitats, such as areas of recent vulcanism, serpentines, and ocean strand, are individually described. Soils, geology, and climate are considered in broad outline in an early chapter and in greater detail within discussions of individual geographic areas and vegetation zones. Appendixes are included for definition of the various soil types, scientific and common plant names, and a subject index. An extensive bibliography is included to direct the reader to other references.

LISLAND, Torstein. Cable Logging in Norway. Northwest Area Foundation Forestry Series. School of Forestry, Oregon State University, Corvallis. 52 p. 1975.

A description of cable logging equipment and methods presently used in Norway. Lisland, a mechanical engineer with the Division of Forest Engineering and Work Science, Norwegian Forest Research Institute, was a visiting lecturer in the development of skyline systems for logging small wood in steep terrain. The paper is appropriate for foresters managing young-forests in the Douglas-fir region.

OREGON WOODLAND PUBLICATIONS COUNCIL AND WASHINGTON WOODLAND COUNCIL. Woodland Handbook for the Pacific Northwest, Second Edition. Cooperative Extension Service, Oregon State University, Corvallis. \$5.00. 433 p. May 1969.

More than 40 persons, representing a wide range of forest interests, contributed chapters to the book. Subjects include: forestry as an investment enterprise; financing forest credit and insurance; records and accounting; social security; use of soil surveys in forest land management; reforestation; growth and yield of forests; determination of stocking and yield; a tree cropping system; woodland management plans; tree-farm program in the Pacific Northwest; herbicides and tending of forests; thinning in precommercial stands; commercial thinning of Douglas-fir; management practices of western hemlock and Sitka spruce; cutting practices in ponderosa pine; silvicultural characteristics and management practices in other species; vertical aerial photography; measuring timber; marketing timber products; mechanical aids to tree farming; federal laws and policies of aid to owners of small woodlands; protection from fire in Oregon and Washington; fire protection for tree farms; forest insects and disease; wildlife damage and control; wood preservation for woodland owners; forest fertilization; forest genetics and the small woodland owner; cone and seed collecting; growing and marketing Christmas trees; special forest products; forest recreation planning; laws and regulations, taxes, services available, and forest statistics for both Oregon and Washington; and forestry organizations and agencies.

SMITH, J. H. G., J. W. KER, and J. CSIZMAZIA. Economics and Reforestation of Douglas-fir, Western Hemlock and Western Red Cedar in the Vancouver Forest District. Faculty of Forestry, Univ. of British Columbia, Vancouver. Bulletin 3. 144 p. August 1961.

Discusses growth and yield of individual trees and stands; quality requirements; cultural controls of tree quality; cultural controls of wood quality; improvement of tree and wood quality by selection and breeding; costs of growing trees; costs of harvesting trees; costs of manufacturing logs; premiums for quality; profit in growing trees and maximizing profit in reforestation. 114 tables and 9 figures.

WESTERN FORESTRY AND CONSERVATION ASSOCIATION. "Too Many Trees? Western Reforestation." Proceedings of the 1966 Annual Meeting of the Western Reforestation Coordinating Committee, Portland, Oregon. 54 p. 1966.

Aspects of stocking control are discussed: biological (how stand development is influenced by density); financial (early stocking control); yield (whether dense spacing really produces the most volume); operational (what production studies show); and stocking control as practiced in the Douglas-fir region (U.S. and Canada), the white pine region, the ponderosa pine region, and the redwood region.

DOUGLAS-FIR

Precommercial Thinning

REUKEMA, Donald L. Guidelines for Precommercial Thinning of Douglas-fir. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. General Technical Report PNW 30. 10 p. 1975.

"Production of merchantable wood in even-aged Douglas-fir stands can be increased substantially by precommercial thinning. Guidelines for, and gains from, precommercial thinning both strongly depend on the size of trees wanted at the first commercial cut; the larger this size, (1) the fewer trees should be left after precommercial thinning, (2) the greater is the maximum age or tree size at which precommercial thinning is practical, and (3) the greater is the gain in usable yield from precommercial thinning. Also, generally, the longer the time required for a stand to reach commercial size without thinning, the greater the gains from precommercial thinning. These and other considerations are discussed, and procedures are recommended."

WILEY, K. N. and M. D. MURRAY. Ten-year Growth and Yield of Douglas-fir Following Stocking Control. Forestry Research Center, Weyerhaeuser Company, Centralia, Washington. Forestry Paper 14. 88 p. 1974.

"Growth of young Douglas-fir after stocking control was computed and analyzed for 205 sample plots over measurement periods ranging from 1 to 10 years. A similar analysis was made for 106 samples in young unthinned stands. Results in the form of abbreviated yield tables for both thinned and unthinned stands were developed. Yield comparisons show that (1) stocking control at an early age greatly increases the rate of merchantable volume growth in the ten years immediately following treatment, and that (2) the younger the stand at the time of stocking control, the more merchantable volume there will be at future ages."

Wind River Douglas-fir Plantation Spacing Test

CURTIS, R. O. and D. L. REUKEMA. "Crown Development and Site Estimates in a Douglas-fir Plantation Spacing Test." *Forest Science* 16(3):287-301. September 1970.

Report on spacing tests at the Wind River Douglas-fir plantation. Relations among stem and crown dimensions of Douglas-fir were examined. Average dbh, height, and crown dimensions of largest trees and comparable crown classes all increased with wider spacings. Site index differences are attributed mainly to restriction of height growth by competition. High initial density in low-site stands can lead to serious underestimates of potential productivity.

EVERSOLE, Kenneth R. "Spacing Tests in a Douglas-fir Plantation." *Forest Science* 1(1):14-18. March 1955.

Report on spacing tests at Wind River Douglas-fir plantation at 27 years of age. With wider spacing, increases occur in average diameter, average height, and board-foot volume. Spacing has little effect on cubic foot volume.

ISAAC, Leo A. "Ten Year's Growth of Douglas-fir Spacing-Test Plantations." Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Forest Research Notes 23:6. 1937.

Heights were tallest for 4 x 4 and 5 x 5 feet plantations in 1929 (5th year after planting), but by 1934 (10th year after planting) the 10 x 10 and 12 x 12 feet plantations were tallest.

MUNGER, Thornton T. "The Spacing in Plantations." Pacific N.W. For. and Range Expt. Station., Forest Service, Dept. of Agric., Portland, Oregon. Forest Research Notes 34:3-4. 1946.

Report on spacing tests at the Wind River Douglas-fir plantation after 21 years. With wider spacing the average diameter and the average height increases, but the average volume in cubic feet decreases.

REUKEMA, Donald L. Some Recent Developments in the Wind River Douglas-fir Plantation Spacing Tests. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Note 167. 7 p. March 1959.

Little is lost and much gained by planting at spacings as wide as 10 x 10 and 12 x 12 feet. The closer spacings are carrying an excessive number of trees, which hinder stand development. Wider spacings produce taller trees of larger diameter. Cubic-foot volume tends to be more nearly equal on all spacings, but board-foot volume increases with wider spacing.

REUKEMA, Donald L. Forty-year Development of Douglas-fir Stands Planted at Various Spacings. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-100. 21 p. 1970.

Report on spacing tests at the Wind River Douglas-fir plantation at age 43 years. A 40-year record illustrates greater tree and stand growth and lesser impact of mortality and damage on wide spacings than on close spacings. Without fairly wide initial spacing, few trees reached a size where they could have been removed in commercial thinnings. Average diameter, total height, cubic-foot volume, and board-foot volumes increased with wider spacing.

Levels-of-Growing-Stock Cooperative Study in Douglas-fir

BELL, J. F. and A. B. BERG. Levels-of-growing-stock Cooperative Study on Douglas-fir. Report 2—The Hoskins Study, 1963-1970. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-130. 19 p. 1972.

A calibration thinning and the first treatment thinning in a 20-year-old Douglas-fir stand at Hoskins, Oregon, are described. Data tabulated for the first 7 years of management show that growth changes in the thinned stands were greater than anticipated.

CROWN, M. and C. P. BRETT. Fertilization and Thinning Effects on a Douglas-fir Ecosystem at Shawnigan Lake: An Establishment Report. Canadian Forestry Service, Pacific Forest Research Centre, Victoria, B.C. Report BC-X-110. 45 p. June 1975.

"A multidisciplinary research project, initiated in 1970, to study the effects of thinning and nitrogen fertilization on a 24-year-old Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) stand near Shawnigan Lake, B.C., is described. The site is characterized by edaphic factors, climate, vegetation, stand history, and growth at the time of treatment. Experimental design, plot layout and treatments are given in detail. Component studies of tree growth, tree physiological conditions, water relations, atmospheric conditions, understory vegetation, soil chemistry, soil fauna, and soil microflora are described. By studying these biological relationships, the project proposes to improve our capability in predicting effects of thinning and fertilization under different site and stand conditions. This publication provides a comprehensive background reference for future progress reports and publications."

DIGGLE, Paul K. Levels-of-growing-stock Cooperative Study in Douglas-fir in British Columbia. Report 3. Pacific Forest Research Centre, Canadian Forestry Service, Victoria, B.C. Information Report BC-X-66. 46 p. May 1972.

Describes the installations in two plantations, Sayward Forest (Campbell River), 20 years old, and Shawnigan Lake, 25 years old. Additions made to the basic levels-of-growing-stock study are discussed.

WILLIAMSON, R. L. and G. R. STAEBLER. A Cooperative Level-of-growing-stock Study in Douglas-fir. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. 12 p. 1965.

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.

WILLIAMSON, R. L. and G. R. STAEBLER. Levels-of-growing-stock Cooperative Study on Douglas-fir. Report 1—Description of Study and Existing Study Areas. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-111. 12 p. 1971.

Thinning regimes in young Douglas-fir stands are described. Some characteristics of eight individual study areas established by cooperating public and private agencies are discussed.

Commercial Thinning

BRUCE, David. Potential Production in Thinned Douglas-fir Plantations. Pacific N.W. For. and Range Expt. Station., Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-87. 22 p. 1969.

Nine foreign production tables for Douglas-fir (thinning guides) were converted to American units of measure. They suggest that potential yields of thinned stands in the Pacific Northwest are higher than has been estimated on the basis of natural unthinned stands, and the culmination of merchantable, mean annual production with heavy thinning may occur at 65 to 80 years. Stands were from Great Britain, France, Italy, Sweden, Netherlands, Germany, and New Zealand.

CURTIS, Robert O. A Method of Estimation of Gross Yield of Douglas-fir. Society of American For., Washington, D.C. Forest Science Monograph 13. 24 p. 1967.

Estimates were developed for growth rates in gross basal area and gross cubic volume for Douglas-fir based on a combination of existing permanent plot data and new data from temporary plots. Gross growth rates appeared to be related to stand density. Gross yield was estimated as the integral of the rate equation; the values obtained were somewhat higher than previous estimates for the species. The temporary plot procedures appeared to give results comparable to those obtained from permanent plots. Some possible modifications and extensions of the methods are discussed.

GROMAN, William A. Comparative Development of a Thinned and a Natural Douglas-fir Stand from 45 to 60 Years of Age. Oregon State University, Corvallis. Ph.D. thesis. 130 p. 1972.

An unthinned and a heavily thinned plot on the George T. Gerlinger State Experimental Forest are compared. Individual tree measurements and classification data collected in 1955

and in 1970 from all stems were used to compare growth and developmental changes occurring during the interval. Also, all trees were measured with a Barr and Stroud optical dendrometer to determine volumetric and morphological differences after 15 years. The thinned stand was superior in site index, stand restructuring for dominance, basal area growth, and relation of dbh to volume based on total cubic foot volume inside bark.

The dynamics of crown class movement is discussed. The upward movement of intermediate and codominant classes was greater than previously observed. Greatest actual growth in basal area occurred in the dominant trees, but larger codominants and smaller dominants gave greatest response. The volumes of dominant and codominant trees on the thinned area were significantly greater than dominants and codominants of corresponding dbh's on the unthinned plot.

GROMAN, W. A. and A. B. BERG. "Optical Dendrometer Measurement of Increment Characteristics on the Boles of Douglas-fir in Thinned and Unthinned Stands." *Northwest Science* 45(3):171-177. August 1971.

Discusses use of optical dendrometer to measure upper stem diameters at the same location on the stem without destructive sampling. Gives examples of three trees from a heavily thinned stand and comparable trees from an unthinned stand measured first in 1967 and remeasured in 1969. Trees in the thinned stand showed accelerated growth and a more consistent increment along the entire bole.

HARMON, Wendell H. "Timber Stand Improvement Thinning Guidelines for Douglas-fir." *J. Forestry* 67(1):36-39. January 1969.

Presents a Douglas-fir thinning guide giving leave-tree stocking by stand size class (dominants and codominants) for Sites II, III, IV, and V with instructions on use. Also presents a theoretical example of stand management of Douglas-fir on an acre basis. Intermediate cuts are at 15-year cutting cycles with shelterwood regeneration cut at 100 years. Gives basal area guides for intermediate cutting in previously unmanaged stands of Douglas-fir 12 inches dbh and larger and a guide for quick site determination from internodal growth for Douglas-fir.

HOYER, G. E. *Measuring and Interpreting Douglas-fir Management Practices*. (Explanation of a Simulation Technique, Its Results and Meaning). Dept. of Nat. Resources, State of Washington. DNR Report 26. 80 p. September 1975.

"Growth estimates are developed from both thinned and nonthinned Douglas-fir sample plots in Oregon and Washington. Thinned stands, in response to release, grow both more basal area and more cubic foot volume than nonthinned stands having the same amount of live basal area. Equations express growth in terms of site index, live basal area, and total age. Results of the analysis provide a consistent basis for thinned and nonthinned stand simulation of Douglas-fir.

Basal area growth together with a selected number of stems per acre, stand height, average stand diameter, and site index form the basis for simulation of Douglas-fir forest management practices. These factors, together with assumptions about mortality, future levels of utilization, timing and severity of treatment, fertilization response, rotation age, and other management assumptions, define practice regimes.

Economic assumptions appropriate to some public and private timber owners allow evaluation of the practices. Present net worth per acre of the discounted costs and benefits is the economic criterion used. From this, managers can judge merits of practices in terms of dollar values as well as cubic-foot and board-foot yield changes.

The growth estimates, simulated practice regimes, and economic assumptions together form an interrelated compatible basis, which allows evaluation of a wide range of current

forest management practices. The results are an initial estimate with more refinement expected as revised input information becomes available.

Results show that economic assumptions affect merits of a practice as significantly as do the management assumptions. Consequently, the decision maker must be aware of the often serious limitations of both sets of assumptions. The promise of increased yields and dollar-value benefits is high from many practices, but each landowner must carefully weigh costs and benefits of each practice before adopting it as a routine. Details provided make it possible for the reader to evaluate the yield results with economic assumptions and values different from those used in the study."

RANDALL, Robert M. An Operations Research Approach to Douglas-fir Thinning. Pacific N.W. For. and Range Expt. Station., Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-148. 23 p. 1972.

A zero-one integer programming procedure is used as the basis for a systematic framework for planning commercial thinning operations in young Douglas-fir. This new approach, termed "the unit approach", is demonstrated, tested, and compared to existing rule-of-thumb methods on a case study area in western Oregon.

REUKEMA, Donald L. Twenty-one-year Development of Douglas-fir Stands Repeatedly Thinned at Varying Intervals. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-141. 23 p. 1972.

A report on the Voight Creek Experimental Forest. First thinned at about age 38 years and observed for 21 years. Four treatments compared: no thinning, light thinning at 3-year intervals, moderate thinning at 6-year intervals, and heavy thinning at 9-year intervals. Eighteen years after initial thinnings (the first common end to all thinning cycles), all thinned stands had virtually the same total cubic volume as before thinning and about 65 percent of what they would have had without thinning. Early thinnings tended to be from above; later thinnings from below.

Thinning interval had no effect on total growth per acre, but gross growth in all thinned stands was about 20 percent less than that in comparable unthinned stands. Only about half as much mortality occurred in thinned as in unthinned stands, and enough was salvaged largely to offset the growth loss. Thinning had little effect on current relative tree-size distribution, because increased growth rate of residual trees was offset by removal of many larger-than-average trees. The primary benefit derived from these commercial thinnings was an earlier harvest of products, not a substantial increase in total usable production per acre.

REUKEMA, D. L. and L. V. PIENAAR. Yields With and Without Repeated Commercial Thinnings in a High-site-quality Douglas-fir Stand. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-155. 13 p. 1973.

A report on the McCleary Experimental Forest. Over a 15-year period beginning at age 57, light thinnings at 5-year intervals improved growth of individual trees but reduced gross growth per acre. This loss of growth was offset by forestalling and salvaging mortality. If the final harvest is made 10 years after the last thinning, at age 82 years, the thinnings will have increased the total usable production by an estimated 5 percent.

WILLIAMSON, R. L. Growth and Yield Records from Well-stocked Stands of Douglas-fir. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-4. 24 p. 1963.

In 1910, establishment of a series of permanent sample plots was started in young stands of Douglas-fir in western Oregon and Washington. Thirty-one of these plots have been remeasured periodically to determine growth, mortality, and yield. Stands sampled are

even-aged and well-stocked, with an age span of 38 to 119 years and a range in site quality from I through IV. Plots are located on the Willamette, Siuslaw, Olympic, Gifford Pinchot, Snoqualmie, and Mt. Hood National Forests and at Wind River.

WORTHINGTON, Norman P. Response to Thinning 60-year-old Douglas-fir. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Note PNW-35. 5 p. February 1966.

Thirty years of growth after first thinning on the Mt. Walker thinning plots (site IV) show that heavy thinning depressed gross increment substantially. Moderate thinning reduced gross increment slightly. Main advantages were salvage of mortality; reallocation of stand growth to fewer, larger, and higher quality trees; and realization of earlier returns.

WORTHINGTON, N. P. and G. R. STAEBLER. Commercial Thinning of Douglas-fir in the Pacific Northwest. Forest Service, U.S. Dept. of Agric., Washington, D.C. Technical Bulletin 1230. 124 p. January 1961.

Discusses theory, application, and financial aspects of commercial thinning of young Douglas-fir in the Pacific Northwest. Although somewhat out-dated, the bulletin contains much valuable information.

Mature Stands

WILLIAMSON, R. L. and F. E. PRICE. Initial Thinning Effects in 70- to 150-year-old Douglas-fir—Western Oregon and Washington. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-117. 15 p. 1971.

Data from nine study areas ranging from 70 to 150 years old at first thinning indicated that reserve basal area may be maintained between 60 and 85 percent of normal. Dramatic reductions in mortality were measured. Thinning should follow marking guidelines previously recommended but with more emphasis on crown release because spacing is important in vigorous, mature stands as well as in younger stands.

WILLIAMSON, Richard L. Results of Shelterwood Harvesting of Douglas-fir in the Cascades of Western Oregon. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-161. 13 p. 1973.

Shelterwood harvesting of coastal Douglas-fir at high elevations in the western Oregon Cascades resulted in satisfactory stocking of Douglas-fir seedlings. Shelterwood density of 100 to 180 square feet of basal area per acre is tentatively recommended. Stands with larger average dbh require greater shelterwood densities (basal area) to produce a given amount of shade than do stands with smaller average dbh. Shelterwood overstories experienced little mortality.

Yield Tables, Site, Growth

BARNES, George H. Yield Tables for Douglas-fir Under Intensive Thinning Regimes. Oregon State College, Forest Expt. Station, Corvallis. Research Note 1. 4 p. 1955.

British yield tables for Douglas-fir, site index 155 (I), 140 (II), 125 (III), and 110 (IV), to age 50 years, converted to standard American units of measure. A spacing table also is included.

BARNES, George H. "Intermediate Yields of Douglas-fir as Interpreted from British Yield Tables." *J. Forestry* 54(3):177-179. March 1956.

British yield table for Douglas-fir, site index 140 (III) to age 50 years converted to standard American units of measure. Compares yields, discusses spacing and density of stocking. A spacing table comparing Great Britain's and Briegleb's standards included.

CHAMBERS, C. J. and F. M. WILSON. *Empirical Yield Tables for the Douglas-fir Zone*. Dept. of Nat. Resources, State of Washington. DNR Report 20R. 16 p. April 1972.

Yield tables based on 356 permanent and 30 temporary plots located in the Douglas-fir zone of western Washington were developed, using breast-height age and 50-year site index curves. Density expressed as percentage of normal basal area (PNBA) was added to increase the accuracy of the tables and to allow prediction over a wide range of stocking. Stepwise multiple linear regression was the analysis procedure used to develop the tables.

FLORA, D. and J. FEDKIW. *Volume Growth Percent Tables for Douglas-fir Trees*. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. 145 p. 1964.

Presents tables of growth percentage based upon rings per inch for various site indexes, ages, and dbh's. Annual volume growth percentages shown for current and 5-year averages.

KING, James E. *Site Index Curves for Douglas-fir in the Pacific Northwest*. Forestry Research Center, Weyerhaeuser Company, Centralia, Washington. Forestry Paper 8. 49 p. 1966.

Site index curves for Douglas-fir. Site index based on breast-height age and total height, with index age at 50 years. Guides for application of the site curves include methods of selection and measurement of site trees. More reliable than site index based on 100 years in Bulletin 201.

McARDLE, R. E., W. H. MEYER, and D. BRUCE. *The Yield of Douglas-fir in the Pacific Northwest*. Forest Service, U.S. Dept. of Agric., Washington, D.C. Technical Bulletin 201. 74 p. 1961.

The classic work on yield of unmanaged Douglas-fir in the Pacific Northwest. Known as 'Bulletin 201' by all foresters who work with Douglas-fir.

WESTERN HEMLOCK

BARNES, George H. *Yield of Even-aged Stands of Western Hemlock*. Forest Service, U.S. Dept. of Agric., Washington, D.C. Technical Bulletin 1273. 52 p. 1962.

Yield tables for natural stands of western hemlock. Separate regional tables for Oregon-Washington, British Columbia, and Alaska when warranted by differences in yield variables. Author believes tables may be applied to hemlock stands on western slopes of Cascade Range as well.

CHAMBERS, C. J. and F. M. WILSON. *Empirical Yield Tables for the Western Hemlock Zone*. Dept. of Natural Resources, State of Washington, Olympia. DNR Report 22. 14 p. May 1972.

Yield tables based on 232 permanent plots located in the Western Hemlock Zone of western Washington were developed, using total-age and 100-year site-index curves. Density expressed as percentage of normal basal area (PNBA) was added to increase the accuracy of the tables and to allow prediction over a wide range of stocking. Stepwise multiple linear regression was the analysis procedure used to develop the tables.

KANGUR, Rudolf. Snow Damage to Young Mixed Forests of Western Hemlock and Douglas-fir. School of Forestry, Oregon State University, Corvallis. Research Paper 21.11 p. September 1973.

Trees growing openly at seedling and early sapling stages offered more resistance to snow injuries than trees in densely stocked stands. Sapling stands 21 years old, thinned 2 years before the snowfall, had more damage than an adjacent unthinned stand. Extremely heavy snowfall caused severe damage in a dense, unthinned stand, but damage in an adjacent stand thinned 6 years before snowfall was light. The percentage of damaged trees in sapling stands decreased with increase of tree diameter. In mixed stands of saplings, Douglas-fir trees were more susceptible to snow injuries than western hemlock. Early, heavy thinning is recommended to avoid damage from snow.

OSBORN, J. E. Influence of Stocking and Density upon Growth and Yield of Trees and Stands of Coastal Western Hemlock. University of British Columbia, Vancouver. Ph.D. thesis. 396 p. September 1968.

Discusses characteristics of coastal western hemlock, growth of juvenile trees, early stand formation, growth of trees in young and middle-aged stands, and growth of western hemlock stands. Presents a graphic synthesis of stand dynamics and management implications.

RUSSELL, K. W., J. H. THOMPSON, J. L. STEWART, and C. H. DRIVER. Evaluation of Chemicals to Control Infection of Stumps by *Fomes annosus* in Precommercially Thinned Western Hemlock Stands. Dept. of Natural Resources, State of Washington, Olympia. DNR Report 33. 16 p. 1973.

Young western hemlock stands in western Washington and Oregon are susceptible to invasion by *Fomes annosus* through freshly cut stumps. Aerial spore loads were high throughout the year except during cold months on high elevation thinnings. Dry borax effectively reduced infection of freshly cut hemlock stumps by *F. annosus*.

WALLIS, G. W. and D. J. MORRISON. "Root Rot and Stem Decay Following Commercial Thinning in Western Hemlock and Guidelines for Reducing Losses." *The Forestry Chronicle* 51(5):203-207. October 1975.

Significant losses can occur after thinning in western hemlock if stump protection is not practiced and attention is not given to limiting stem and root injuries. As many as 12 new *Fomes annosus* root rot centers per hectare were created by a low thinning that removed only about 250 trees, when stumps were not treated. An annual loss to decay of 0.75 percent of the gross volume was recorded in trees severely injured during logging. Procedures for reducing losses to decay are given.

WILEY, Kenneth N. Thinning of Western Hemlock: A Literature Review. Forestry Research Center, Weyerhaeuser Company, Centralia, Washington. Forestry Paper 12. 12 p. July 1968.

The few studies conducted on the effects of thinning western hemlock show that substantial increases in growth can be expected immediately. Increases have been obtained over a wide range of ages with the best results after heavier cuts. Damage during thinning can promote the entry of decay-causing organisms, especially *Fomes annosus*. Eleven references.

WRIGHT, E. and L. A. ISAAC. Decay Following Logging Injury to Western Hemlock, Sitka Spruce, and True Firs. U.S. Dept. of Agric., Washington, D.C. Technical Bulletin 1148. 34 p. 1956.

A total of 27 different fungi were identified with 20 of them causing rot in western hemlock, 11 in Sitka spruce, and 8 in true firs. *Fomes annosus* was the most common rot, with

Stereum rots next, on scarred western hemlock and true firs. *Fomes pinicola* was most common on Sitka spruce. Decay occurred more frequently east of the Coast Range than along the coast. Root injuries and scars close to the ground showed greater decay than injuries above breast height. Although decay per scar was greater after a light cut than after a heavy cut, windfall records showed that lighter cuts were safer with less windfall and therefore less scarring and sunscald. Infection occurred mostly during the first few years after logging. Penetration of decay was directly related to age of scar. Data are provided for estimating average volume of decay in injured trees when area and age of scar are known.

SITKA SPRUCE

HARRIS, A. S. and R. H. RUTH. Sitka Spruce—A Bibliography with Abstracts. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper PNW-105. 251 p. 1970.

Contains 1,741 references to world literature on Sitka spruce (*Picea sitchensis* [Bong.] Carr.) published through 1967. A subject matter index and a list of scientific and common names of plants mentioned are included. Abstracts are given for many references. Many abstracts were adapted or taken directly from "Forestry Abstracts." Special effort was made to include the large body of British literature resulting from extensive plantings of Sitka spruce in the British Isles.

RED ALDER

CHAMBERS, Charles J. Empirical Yield Tables for Predominantly Alder Stands in Western Washington. Dept. of Natural Resources, State of Washington, Olympia. DNR Report 31. 70 p. September 1974.

Yield tables based on 174 permanent plots in both the Douglas-fir and western hemlock zones of western Washington were developed. Stand and stock tables were also constructed for more detailed information.

DeBELL, Dean S. Potential Productivity of Dense, Young Thickets of Red Alder. Crown Zellerbach, Central Research, Camas, Washington. Forestry Research Note 72. 6 p. December 1972.

Total above-ground production was evaluated in 28 natural alder thickets, aged 1 to 14 years. On a per-acre basis, mean annual production ranged from 3 to more than 20 tons of green wood per acre.

TRAPPE, J. M., J. F. FRANKLIN, R. F. TARRANT, and G. M. HANSEN, Eds. Biology of Alder. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Symposium Proc. 292 p. 1968.

Proceedings of a symposium held at Northwest Scientific Association fortieth annual meeting, April 14-15, 1967, Pullman, Washington. Thirty-four authors discuss the taxonomy, distribution, ecology, soil and microbiological relations, physiology, growth, and yield of alder.

WORTHINGTON, N. P., F. A. JOHNSON, G. R. STAEBLER, and W. J. LLOYD. Normal Yield Tables for Red Alder. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric., Portland, Oregon. Research Paper 36. 29 p. August 1960.

Site curves developed from stem analyses of 43 felled sectioned trees from western Washington. Index age for curve is 50 years. Yield data were derived for the following stand characteristics: trees per acre; basal area per acre; diameter of average tree; cubic feet per acre; and board feet per acre, Scribner rule.

FERTILIZATION

BERG, A. and A. DOERKSEN. Natural Fertilization of a Heavily Thinned Douglas-fir Stand by Understory Red Alder. School of Forestry, Oregon State University, Corvallis. Research Note 56. 3 p. 1975.

A 62-year-old Douglas-fir stand reduced to 80 trees per acre in 1955 developed an understory of red alder some time after thinning. By 1972 the alder had added 200 pounds of total nitrogen per acre to the soil under light understory and 780 pounds under heavy understory.

GROMAN, William A. Forest Fertilization (A State-of-the-art Review and Description of Environmental Effects). Pacific N.W. Water Laboratory, National Environmental Research Center, U.S. Environmental Protection Agency, Corvallis, Oregon. EPA-R2-72-016. 57 p. 1972.

Information on concepts, scope, and methods of forest fertilization in various nations and regions of the world compiled from available sources. Factors influencing development to present status, possible trends, and impacts on water quality are discussed. Results of completed forest fertilization-water quality studies summarized and evaluated, and status of current water quality studies described. Recommendations for state-of-the-art review and essential research efforts presented.

LEE, Y. (Jim). A Review of Research Literature on Forest Fertilization. Forest Research Laboratory, Department of Forestry and Rural Development, Victoria, B.C. Information Report BC-X-18. 40 p. March 1968.

Discussion of nutrient requirements of forest trees, nitrogen cycle in forest stands, soil elements, foliar analysis, growth and survival of planting stock, combined effect of thinning and fertilizing, rate of fertilizer application, duration of response, time and methods of application, insect and disease, wood quality, and economic considerations. Sixty-seven references cited.

MILLER, R. E. and L. V. PIENAAR. Seven-year Response of 35-year-old Douglas-fir to Nitrogen Fertilizer. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric. Research Paper PNW-165. 24 p. 1973.

Applying ammonium nitrate fertilizer to a Wind River Experimental Forest, Site V, plantation resulted in significant increases in diameter, height and volume growth per acre during the 7 years after treatment. Dosages of 140, 280, and 420 pounds of nitrogen per acre increased gross growth by 55, 92, and 109 percent, respectively (515, 852, and 1,012 cubic feet per acre).

MILLER, R. E. and D. L. REUKEMA. Seventy-five-year-old Douglas-fir on High-quality Site Respond to Nitrogen Fertilizer. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric. Research Note PNW-237. 1974.

"Individually treated, 75-year-old, codominant, Douglas-fir trees growing on a highly productive site II soil responded well to nitrogenous fertilizers. Although the six treatments tested increased average 5-year basal-area growth by 17 to 53 percent over control growth, only ammonium nitrate at 300-N dosage increased growth significantly. The six fertilizer treatments did not differ significantly among themselves; response to 300 pounds of nitrogen per acre (336 kg/ha) as urea was as good as that to 600-N (672 kg/ha) or to other elements in combination with 300-N."

MILLER, R. E. and R. L. WILLIAMSON. Dominant Douglas-fir Respond to Fertilizing and Thinning in Southwest Oregon. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric. Research Note PNW-216. 8 p. 1974.

"In 30-year-old, Site IV Douglas-fir in southwest Oregon, fertilizing increased average 4-year basal-area growth of dominant trees by 57 and 28 percent on clay loam and sandy loam soils, respectively. Fertilizing with thinning increased growth by 94 and 132 percent over untreated growth. Thinning on clay loam soil increased growth by 53 percent. Treatment did not affect height growth on either soil."

VOLUME TABLES AND INVENTORY METHODS

ARNEY, James D. Tables for Quantifying Competitive Stress on Individual Trees. Canadian Research Centre, Victoria, B.C. Information Report BC-X-78. 45 p. February 1973.

"A competition index based on the maximum crown expansion of open-grown Douglas-fir in the Pacific Northwest." Attempts to "develop a uniform method of quantifying competitive stress on individual Douglas-fir trees, regardless of stand age, site index or geographic location" . . . and "to provide index values similar to a stand density index." Uses data from 132 observations in coastal British Columbia and 158 observations from western Oregon.

BRACKETT, Michael. Notes on Tarif Tree Volume Computation. Resource Management Report 24. Dept. of Natural Resources, State of Washington, Olympia. 26 p. September 1973.

Gives a schematic overview of the tarif system. Presents equations to determine tarif access number and tarif volumes, and a table of tarif access and volume constants.

BRUCE, D. and D. J. DEMARS. Volume Equations for Second-growth Douglas-fir. Pacific N.W. For. and Range Expt. Station, Forest Service, U.S. Dept. of Agric. Research Note PNW-239. 5 p. 1974.

Presents volume equations and tables for young-growth Douglas-fir. Table 2, estimated cubic-foot volume, Douglas-fir under 18 feet in height including stump and tip, gives volumes for trees from 6 to 18 feet in height by 1-foot height increments and dbh in inches from 0.4 to 3.5 inches by 0.7-inch classes. Table 3, estimated cubic-foot volume, Douglas-fir over 18 feet in height including stump and tip, gives volumes for trees from 20 to 180 feet in height by 10-foot height increments and dbh in inches from 1 to 33 inches by 1-inch classes.

DILWORTH, J. R. Log Scaling and Timber Cruising. Oregon State University Book Stores, Inc., Corvallis. 471 p. 1973.

The book is divided into three main parts: scaling, cruising, and the appendix. Scaling procedures and log-grade specifications of both the U.S. Forest Service and private bureaus are included. Cruising coverage includes the conventional fixed-radius plot or strip methods, variable-plot, and Three-P procedures. Five appendixes cover variable plot cruising tables, a glossary of variable plot cruising (point sampling) terms, details of how the Spiegel-Relaskop operates, computer code for entries on stand examination plot cards used by U.S. Forest Service, and standard log rule tables, volume tables, Douglas-fir yield tables from USDA Bulletin 201, and miscellaneous tables the author believes to be helpful. The book is revised each year.

JOHNSON, F. A. Volume Tables for Pacific Northwest Trees. Forest Service, U.S. Dept. of Agric. Agric. Handbook 92. 132 p. 1955.

A collection of volume tables (cubic, board-foot, and cord) for Douglas-fir, ponderosa pine, western hemlock, Sitka spruce, Pacific silver fir, lodgepole pine, red alder, western larch, white fir, Port-Orford-cedar, western white pine, sugar pine, western redcedar, incense-cedar, noble fir, Engelmann spruce, and black cottonwood.

TURNBULL, K. J. and G. E. HOYER. Construction and Analysis of Comprehensive Tree-Volume Tarif Tables. Resource Mgmt. Report 8, Dept. of Natural Resources, State of Washington, Olympia. 63 p. 1965.

TURNBULL, K. J., G. R. LITTLE, and G. E. HOYER. Comprehensive Tree Volume Tarif Tables. Dept. of Natural Resources, State of Washington, Olympia. Edition 2. 264 p. 1972.

Available from Department of Natural Resources: Tarif Tables, P.O. Box 168, Olympia, Washington 98504, price \$3.00. Make check payable to Commissioner of Public Lands.