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Trends in REFORESTATION and its COST in the Pacific Northwest

by BRIAN R. PAYNE

PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
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SUMMARY

Serious commercial efforts at artificial reforestation in the Pacific Northwest began in 1915 with the planting of 2,500 acres. In 1962, nearly 205,000 acres were reforested, 102,000 by direct seeding and 103,000 by planting. The total cost of reforestation in 1962 was \$7½ million, an average of \$37 per acre.

In contrast to the expenditure for seeding and planting, one-third of a million dollars was spent for reforestation research in 1961.

Approximately 255,000 acres of commercial forest land are denuded each year by clear cutting and by fire in immature timber. In addition, there is a backlog of about 2 million unstocked acres. It is probably not economical to reforest all of these acres artificially, but a reasonable annual reforestation goal probably should be at least 250,000 acres.

Existing nursery and seed extraction capacity may impose a limit on expansion of the reforestation effort. In addition, there are several large areas which present unusually difficult reforestation problems and which are not likely to be reforested until more successful and economical methods of seeding or planting are developed.

Judging from past trends, the reforestation effort probably will be increased. However, it should be concentrated on those acres which provide an acceptable return on their reforestation cost. Additional information is required to make an economic evaluation of Pacific Northwest reforestation efforts.

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INTRODUCTION

Approximately 43 percent of the total land area of 104,384,000 acres in the Pacific Northwest (Oregon and Washington) is commercial forest land (U.S. Forest Service, 1958).¹ Of these 45 million acres of commercial forest land, about 2 million are not stocked with forest tree species, and more are denuded each year by fires and clear cutting. Natural regeneration has not been sufficient to maintain the commercial forest area in full production. Since 1915, artificial reforestation has been used in significant amounts to supplement natural seeding and is currently contributing greatly to maintaining the productivity of Pacific Northwest forests.

This study describes the current status and the development since 1915 of artificial reforestation activities in the region. It describes the total annual investment in reforestation and reforestation research for the last several years. It discusses the area found to be in need of reforestation, the regional capacity to meet this need, and some problems which remain to be solved.

Expenditures for reforestation are considered as an investment. To be practical, reforestation must be economical; that is, it must result in sufficient returns to justify its cost. This study deals with reforestation cost and effort and, to a limited extent, with results. Returns on reforestation investments are not examined.

HISTORY OF REFORESTATION EFFORTS

While some forest plantings were apparently made as early as 1893, the earliest available records of artificial reforestation in significant amounts in the Pacific Northwest were in 1915,² when the U.S. Forest Service recorded the planting of Douglas-fir seedlings on 2,500 acres (fig. 1). For the next 10 years, the Forest Service planted about 2,000 acres per year. The first private and State planting efforts were begun in 1926 and increased total planting to 6,000 acres per year by 1930. Beginning in 1937, the planting effort grew rapidly before slackening off to a wartime low of 8,000 acres in 1942. During this period, the Bureau of Land Management began a reforestation program as a result of the passage of the O&C Sustained Yield Act in 1937.

By 1947, planting had increased to the prewar level of 14,000 acres per year, and in 1948 reforestation efforts began to increase much faster than ever before. By 1950, planting per year had increased to 46,000 acres. This increase was due primarily to greater planting by private landowners coupled with the first large-scale planting efforts by the State of Oregon.

During the 1950's, planting continued to increase to a high of 118,000 acres in 1959. The rising trend in acres planted leveled off at about 110,000 in 1960 and 1961. Acres planted decreased to less than 105,000 acres in 1962.

Large-scale direct seeding in the Pacific Northwest was begun during the period 1948-51, primarily on private land. Following the exceptional seed year and severe fires of 1951 and aided

¹Names and dates in parentheses refer to Literature Cited, p. 11.

²Historically, credit for the first Pacific Northwest commercial forest planting goes to Willamette Pulp & Paper and Crown Paper Companies (predecessors of Crown Zellerbach Corp.) who first planted cottonwoods on an island in the Willamette River in 1893. In 1896, they planted 300 acres at the mouth of the Pudding River along the Willamette River in Oregon.

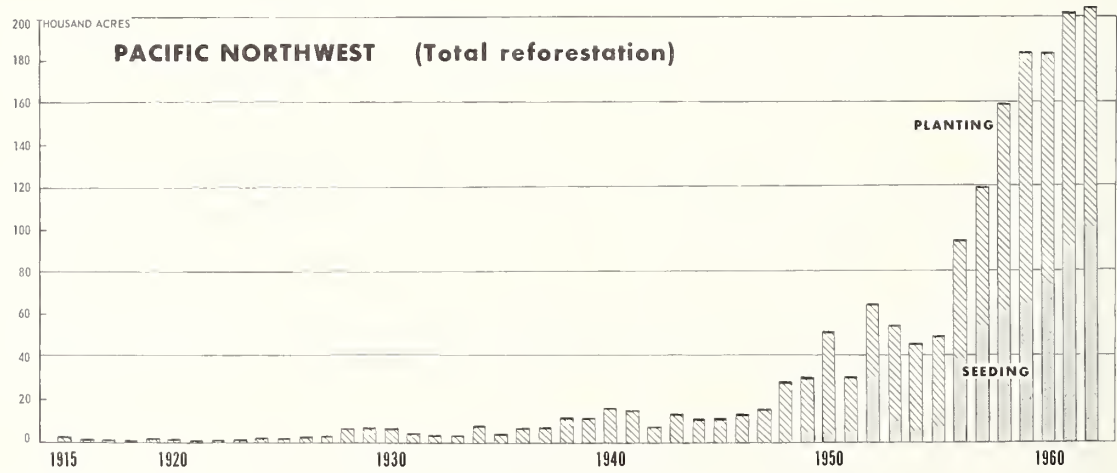
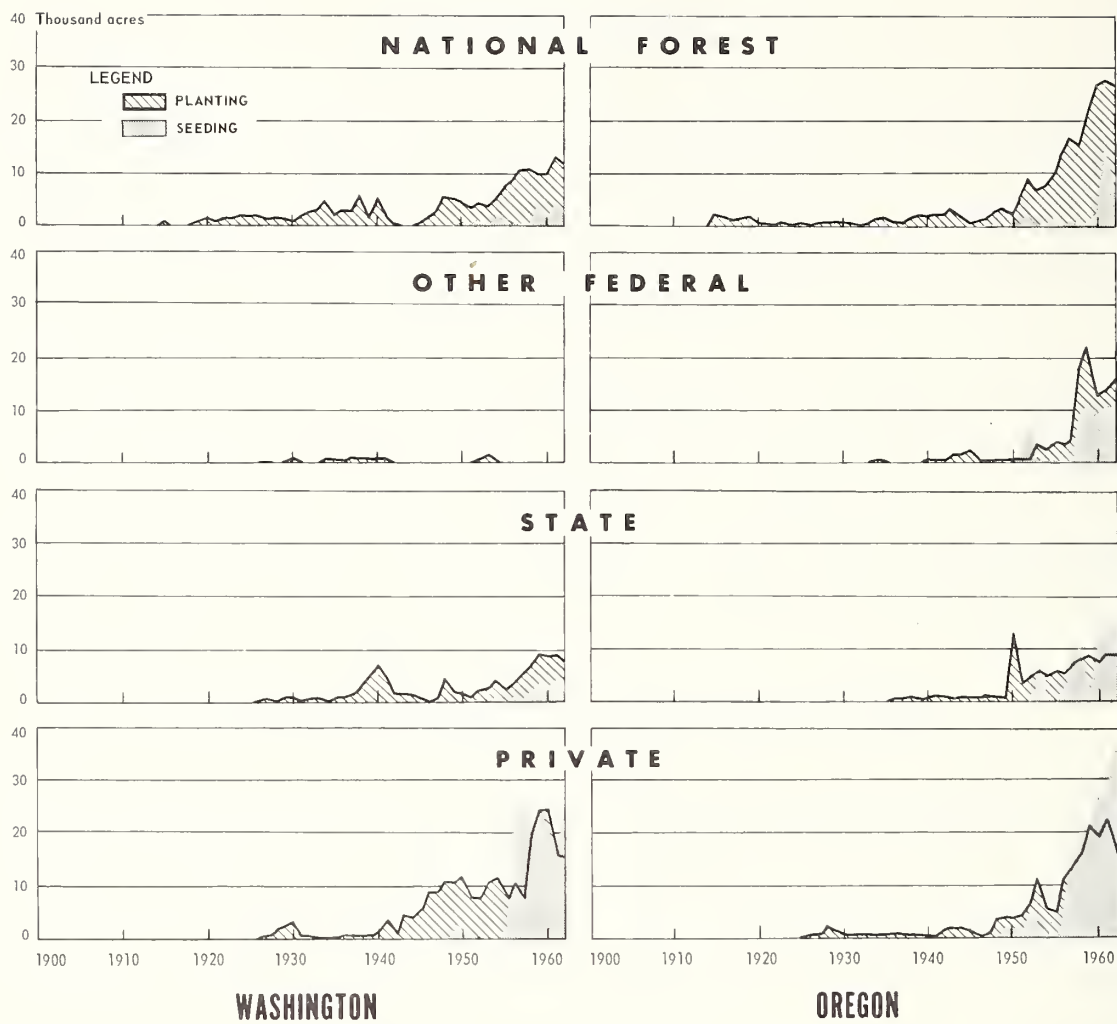


Figure 1.—Area of planting, seeding, and total reforestation per year in the Pacific Northwest, by State and ownership, 1915-62.

by war-developed chemicals for the control of seed-eating rodents, Federal, State, and private agencies seeded over 30,000 acres in 1952. Coupled with planting increases, direct seeding brought total artificial reforestation to nearly 65,000 acres in 1952.

Due to a cutback in 1953 in direct seeding in Oregon, total reforestation decreased to about 50,000 acres per year over the next 3 years. In 1956, direct seeding on a large scale was begun in Washington, primarily on private land. Large-scale seeding was resumed the same year in Oregon on State and private land and 2 years later by the Bureau of Land Management. Planting had been increasing steadily but began to increase even more rapidly in 1956. The result of these increases was the reforestation of over 180,000 acres in 1960.

As a result of increased direct seeding by private agencies in 1962 and by the U.S. Forest Service in 1961 in response to severe fires during the previous summer, artificial reforestation reached nearly 205,000 acres in 1962. For the first time, as many acres were seeded as were planted in 1 year.

In summary, the reforestation effort grew slowly from its inception in 1915 until the beginning of World War II. Following the war, planting increased rapidly before leveling off in 1950-56. The general acceptance of direct seeding as a satisfactory method of reforestation and a concurrent increase in planting resulted in a remarkable increase in growth of the reforestation effort between 1956 and 1962.

INVESTMENT IN ARTIFICIAL REFORESTATION

Annual Investment, 1949-62

The annual investment in reforestation in the Pacific Northwest has increased by tenfold over the last 13 years. As shown in table 1, expenditures for reforestation in terms of 1962 dollars have risen from less than \$800,000 in 1949 to more than \$7½ million in 1962.

The increase in reforestation investment is a result of greater expenditures by both public and private forestry agencies. During the last 14 years, the U.S. Forest Service and the West Coast Tree Farms have contributed an average of 35 and 26 percent, respectively, to the reforestation investment. The remaining 39 percent has been contributed primarily by the States of Oregon and Washington and by the Bureau of Land Management. These percentages have not remained constant but have varied widely from year to year. For example, the Bureau of Land Management increased its expenditure about fivefold in 1958 as a result of almost a million dollars being made available by the O&C counties.

Costs Per Acre

The average per-acre cost of artificial reforestation for all landownership classes in the Pacific Northwest has increased from \$26.07 to \$37.37 from 1949 to 1962, in terms of 1962 dollars (see table 1). Reforestation costs have thus increased by over 40 percent in 13 years. (If costs are not adjusted to 1962 constant dollars, this increase appears to be about 115 percent.) Looking at the situation from a somewhat different point of view, total annual expenditures for reforestation

Table 1. - Estimated total expenditure¹ and cost per acre² for artificial reforestation in the Pacific Northwest, 1949-62

Fiscal year	Estimated total expenditure ³		Cost per acre ³	
	Current	Adjusted to 1962	Current	Adjusted to 1962
	----- Dollars -----			
1962	7,647,000	7,647,000	37.37	37.37
1961	6,812,000	6,801,000	33.78	33.72
1960	5,269,000	5,315,000	28.98	29.23
1959	4,402,000	4,605,000	24.09	25.20
1958	3,874,000	4,214,000	24.87	27.05
1957	2,437,000	2,692,000	20.40	22.54
1956	1,751,000	1,934,000	18.62	20.56
1955	1,249,000	1,406,000	25.65	28.88
1954	1,131,000	1,302,000	25.16	28.96
1953	1,252,000	1,488,000	23.06	27.41
1952	1,404,000	1,710,000	21.88	26.64
1951	614,000	790,000	20.25	26.07
1950	893,000	1,280,000	17.74	25.43
1949	507,000	767,000	17.26	26.07

¹Including overhead.

²Costs per acre were calculated by dividing total expenditure by total acres reforested and thus represent an average value for both planting and seeding.

³Adjusted total expenditure and cost per acre were calculated proportional to average hourly earnings in logging in the Douglas-fir subregion as reported by the West Coast Lumbermen's Association "Industrial Facts," 1949 to 1961.

Sources: U. S. Forest Service, Region 6, annual planting and stand improvement reports for the years 1917 to 1962; information supplied by Industrial Forestry Association, Portland, Oreg., for years 1949 to 1962.

have increased tenfold from 1949 to 1962 while acres reforested annually have increased only sevenfold.

Per-acre reforestation costs vary widely between planting and seeding and from one site to another. In 1962, planting costs ranged from less than \$15 to more than \$100 per acre and averaged \$56.85 per acre for the region as a whole. Seeding costs ranged from less than \$7 to more than \$80 per acre and averaged \$15.25 per acre.

One reason for the increase in per-acre reforestation costs is that with greater amounts of money available it has been possible to seed and plant more difficult acres. Also, more attention has been paid to success of reforestation efforts in recent years, and it is probable that some portion of the increase in cost represents greater success. A third factor is that more accurate accounting in recent years has resulted in the assignment of a greater portion of overhead costs to reforestation than previously. Per-acre reforestation costs are likely to increase still further in the future, especially as increasingly difficult acres are encountered.

INVESTMENT IN REFORESTATION RESEARCH

The investment in reforestation research in the Pacific Northwest has tripled in the last decade. As shown in table 2, one-third of a million dollars was spent for reforestation research in 1961, compared with just over \$100,000 in 1950.

Table 2. – Estimated expenditures for reforestation research in the Pacific Northwest in 1950, 1955, and 1961¹

Organization	1950	1955	1961
	----- Dollars -----		
Federal Government	30,000	40,000	110,400
State government and universities	31,900	51,600	144,900
Private industry	46,700	71,500	81,200
Total	108,600	163,100	336,500

¹Figures shown for 1961 expenditures in some cases are expenditures for fiscal year 1962.

Source: Information on file, Pacific Northwest Forest & Range Experiment Station, Portland, Oreg.

About one-third of the current investment in reforestation research is being made by Federal agencies, chiefly the Pacific Northwest Forest and Range Experiment Station and the Bureau of Land Management. Also making significant contributions are Oregon State University, the University of Washington, Washington State University, and several private firms and associations.

The amount spent for reforestation research in 1961 is equal to about 5 percent of the amount spent for seeding and planting for the same year. Thus, a sizable amount of the total reforestation effort is concerned with research to develop new and better methods of seeding and planting and to insure greater seedling survival. While the research expenditure is large and is increasing, it has decreased in relation to the seeding and planting expenditure. In 1950, research expenditures were equal to 12 percent of seeding and planting expenditures. In 1955, this figure was 13 percent.

Two major obstacles to greater reforestation accomplishments have been the relatively high cost and the considerable risk associated with reforestation investments. Research which reduces cost or risk will make artificial reforestation a more attractive alternative to natural regeneration. Such research includes that directed at increasing the survival of seedlings and developing faster and cheaper methods of seeding and planting.

THE CURRENT ANNUAL REFORESTATION JOB

The current annual reforestation job consists of about 255,000³ acres of burned or clear-cut land plus some portion of a 2-million-acre backlog of unstocked land. It is not known how much of this job is being accomplished by natural seeding.

Annual Burning and Clear Cutting

It was suggested in 1954 (Vaux) that the Pacific coast as a whole was accumulating additional unstocked land due to fires and logging, even though an extensive reforestation effort had been in progress for several years. Artificial reforestation was scarcely offsetting annual fire losses in young timber. An area equal to the acreage clear cut and the acreage of mature timber burned annually was being left to restock by natural seeding.

For the Pacific Northwest in the last few years, the reforestation situation is not so discouraging as suggested above. Acres clear cut and acres burned which added to reforestation needs are shown in table 3. The average annual cut and/or burned acreage decreased by 30 percent from the period 1950-53 to the period 1958-61. More significantly, the difference between acres cut or burned and acres reforested decreased by 75 percent from an average of 280,000 acres in 1950-53 to an average of 65,000 acres in 1958-61.

If the reforestation goal in the Pacific Northwest is defined as the restocking of every acre clear cut or burned annually, the job of meeting this goal has been getting smaller each year. And due to the increase in planting and direct seeding, more of this job is being accomplished each year. Thus, less and less area is being left to reseed naturally.

³Five-year average, 1956-60.

Table 3. – Acres clear cut and acres burned which added to reforestation needs in the Pacific Northwest, 1950-60

Calendar year	Clear cut				Burned ¹		Total ²
	Oregon	Washington	Pacific Northwest		Oregon	Washington	Pacific Northwest
			Western	Eastern			
-----Acres-----							
1960	141,000	89,000	210,000	20,000	22,400	12,200	265,000
1959	117,000	95,000	195,000	17,000	34,900	2,300	250,000
1958	112,000	73,000	172,000	13,000	9,400	7,500	200,000
1957	151,000	78,000	212,000	17,000	3,900	300	235,000
1956	183,000	99,000	263,000	19,000	7,800	900	290,000
1955	202,000	98,000	283,000	17,000	18,100	800	320,000
1954	213,000	85,000	280,000	18,000	1,300	500	300,000
1953	219,000	89,000	293,000	15,000	900	1,600	310,000
1952	236,000	90,000	315,000	11,000	14,000	21,100	360,000
1951	224,000	96,000	310,000	10,000	23,100	23,000	365,000
1950	178,000	80,000	253,000	5,000	10,600	1,800	270,000

¹Cut over acres burned and acres salvaged after fire are included as acres clear cut.

²To nearest 5,000 acres.

Sources for acres clear cut: U.S. Forest Service, Region 6, "Status of Timber Management Activities," for the years 1950 to 1960; Washington State Department of Natural Resources "Timber Harvest Report," from annual reports for the years 1950 to 1960; Oregon State Board of Forestry "Approximate Acres Logged and Thousand Board Feet Removed," from annual reports for the years 1950 to 1960.

Sources for acres burned: U.S. Forest Service "National Forest Fire Report," for calendar years 1950 to 1960; U.S. Forest Service Division of Cooperative Forest Fire Control "Forest Fire Statistics," for calendar years 1950 to 1960; Washington State Department of Natural Resources biennial reports for years 1950 to 1959.

Rehabilitation of Backlog Areas

It is generally thought that an appropriate reforestation goal should include not only the restocking of currently denuded areas but also the rehabilitation of backlog unstocked areas. When natural seeding fails to fill in the gap between currently denuded and artificially reforested acres, the size of the backlog area will increase, and vice versa.

The area of unstocked commercial forest land in the Pacific Northwest appears to have decreased somewhat during the past 30 years. Kummel et al. (1944) reported that in 1933 the unstocked area was about 3 million acres. They estimated in 1944 that "To bring the potentially productive forest area promptly into a fairly well stocked and productive condition would require the artificial planting of some 2½ or 3 million acres." In "Timber Resources for America's Future" (1958), it was estimated that in 1952 the plantable area of commercial forest land in the Pacific Northwest was just under 2½ million acres. The most recent Forest Survey reports indicate that approximately 2 million acres of commercial forest land in Oregon and Washington are less than 10 percent stocked with forest tree species.

To the extent that the above figures are accurate and comparable, the area of unstocked commercial forest land has decreased by 1 million acres in 30 years. However, it is the opinion of some foresters that much of the apparent decrease is the result of greater accuracy of recent estimates. While some reduction in acreage has undoubtedly occurred, the earlier surveys probably overestimated the extent of unstocked area. Of course, it must be recognized that in addition to the 2 million unstocked acres, there is much poorly stocked forest land which would require additional stocking to be made reasonably productive.

At least one agency has succeeded in reducing its backlog of unstocked land. In 1952, unstocked O&C lands amounted to 103,500 acres. By 1962, this area had been reduced to 25,700 acres, and the Bureau of Land Management has predicted complete elimination of the backlog of unstocked O&C lands by 1965.

Reasonable Reforestation Goals

The artificial reforestation of every acre burned or clear cut annually and every acre of the 2-million-acre backlog area should not necessarily be the goal of Pacific Northwest forest-land managers. The cost of planting or seeding some areas is prohibitively high in view of expected returns. Artificial reforestation efforts should be concentrated on those acres yielding the highest rate of return on reforestation costs. Where planting or seeding costs exceed present value of expected returns, artificial reforestation should not be undertaken, except in cases where watershed protection or other nonrevenue-producing uses require reforestation and natural regeneration cannot be expected within a reasonable length of time.

CHANCES FOR ADEQUATE REFORESTATION

The success of Pacific Northwest forest-land managers in artificially reforesting probably in excess of 250,000 acres annually depends in part upon their ability and willingness to finance a greater reforestation effort, upon the nursery and seed extraction capacity of the region, and upon the success of reforestation efforts, particularly in what might be called special problem areas.

Availability of Financing

As previously discussed, the investment in reforestation has increased tremendously over the last decade. There is reason to believe that this investment will increase still more in the future. There is a growing opinion on the part of many forest-land managers that planting and seeding are economical methods of solving their reforestation problems. Federal appropriations for reforestation have been increasing and probably this will continue. The same is true for private firms. Financing to support a greater reforestation effort seems assured.

Nursery and Seed Extraction Capacity

Existing nursery capacity in the Pacific Northwest can currently provide 83 million 2-0 seedlings per year, enough to plant 165,000 acres (500 trees per acre). However, the trend is to use larger and older age classes with a consequent reduction in bed densities and a lengthening of rotations. This trend may reduce nursery capacity by as much as 50 percent unless expansion of nursery facilities continues.

Existing seed extraction capacity is 475,000 bushels of cones per year. At one-half pound per bushel, enough seed could be provided to seed 300,000 acres per year. In actuality, seed available falls far short of this potential. Good seed crops usually occur only once every 2 to 7 years (U.S. Forest Service, 1948), and seed suitable for use in certain locations may not be available even during generally abundant years. It is improbable, therefore, that full seed extraction capacity can be utilized in any one year. Additional seed extraction and storage facilities may be required to take advantage of good seed years and local needs if the direct seeding effort continues to grow.

Special Problem Areas

Certain unstocked or understocked areas of Pacific Northwest commercial forest land are so large as to offer unusual reforestation problems. These include the Tillamook Burn, the Yacolt Burn, and the brushfields of southwestern Oregon.

Tillamook Burn.—The Tillamook Burn area in northwestern Oregon was first burned in 1933. Parts of the area were reburned in 1939 and 1945, bringing the total area to 355,000 acres, 70 percent of which is owned by the State of Oregon.

Rehabilitation by planting and seeding began in 1950 on State-owned land. In the interest of fire protection, extensive salvage operations were performed to create snag-free corridors. According to Churchill (1961), a survey made prior to 1950 indicated that 143,000 acres of State-owned land could be restocked by aerial seeding. Seventy-five thousand acres would have to be hand planted, and the remainder would restock naturally.

As of June 1960, 74,000 acres had been seeded and 57,000 acres had been planted, a total of 131,000 acres (Oregon State Board of Forestry, 1960). Churchill estimated in 1961 that 30,000 acres had restocked naturally. If these figures are accurate, there remain almost 200,000 acres in need of reforestation. To the extent that replanting and reseeding are necessary, even more than 200,000 acres remain to be reforested.

One cause for considerable lack of success in reforesting the Tillamook Burn has been extensive animal damage to seedlings. In 1958, damage to seedlings by deer was so acute that the Board of Forestry considered discontinuing its reforestation program. The problem was partially solved through the cooperation of the Game Commission, which agreed to conduct special hunts each year for those areas of the Burn to be reforested the following year. Animal damage has since been about half as great as in 1958 (Schroeder, 1960).

Yacolt Burn.—In 1902, the 238,000-acre area of Clark and Skamania Counties known as the Yacolt Burn was first devastated by fire (State of Washington, 1963). Most of the trees killed in this blaze have remained on the area and have constituted a major fire hazard ever since. Fires in the years 1917, 1918, 1919, 1927, 1929, 1936, 1949, 1951, and 1952 have reburned various parts of the area several times, causing a tremendous loss of reproduction and young-growth timber. These fires killed practically all of the trees which would have provided seed for natural regeneration.

Rehabilitation of the Yacolt Burn has been very slow. Snag disposal and road construction have been undertaken in the interest of fire protection. Planting of the 26 percent of the burn in Federal ownership was begun in 1930. Reforestation of State-protected land followed legislation of 1953. Other public and private agencies have contributed to the reforestation effort. However, as of December 1962, only 21,275 acres have been planted or seeded. Much of the original area remains to be reforested. Natural regeneration will occur to only a limited extent due to the vast size of the denuded area and the lack of suitable seed trees.

Southwestern Oregon brushfields.—Brushfields occupy a large area of potentially productive forest land in southwestern Oregon. Gratkowski (1961) has estimated that the productivity of 26 percent or about 1,700,000 acres of commercial forest land in southwestern Oregon is drastically reduced by the presence of brush species. Approximately 300,000 acres are occupied exclusively by brush; 400,000 acres are poorly stocked with young-growth timber in serious competition with brush species; and 1 million acres support understocked sawtimber stands with a dense brush understory.

If these brushfields are to be brought into timber production, they will have to be reforested artificially. Natural regeneration has not been adequate to do the job. And so far, no generally successful and economical method of brush control and reforestation has been developed. While some seeding and planting trials have been successful, others have failed. Rehabilitation of the southwestern Oregon brushfields will not be accomplished until more economical reforestation methods are developed.

CONCLUSION

Artificial reforestation in the Pacific Northwest is likely to increase from its present high level in the next several years. It is probable that substantial reductions in backlog areas will occur as a result, especially if natural regeneration takes place to any great degree. Direct seeding probably will continue to increase faster than planting, mainly in response to its generally lower cost per acre. Future growth of reforestation efforts may be limited by nursery and seed extraction capacity, although construction of additional capacity is continuing and has so far kept pace with the reforestation effort. Funds to support a greater effort probably will be forthcoming. These funds will profit the region most if spent to reforest those acres which will provide an acceptable return on their reforestation cost.

In order to evaluate Pacific Northwest reforestation from an economic viewpoint, both costs and returns must be known. While costs are available for several methods of seeding and planting, they are tremendously variable. The factors responsible for this variation have not been quantified. Knowledge of returns to reforestation investments is inadequate. Information on survival of artificially established seedlings is lacking. Even less well known is the extent to which successful natural regeneration is taking place. Thus, an opportunity for research exists to discover the actual extent of natural regeneration and to discover and quantify the factors which contribute to costs and returns of investments in artificial reforestation. Knowledge gained from such research would form the basis for an examination of the future profitability of growing timber in the Pacific Northwest.

LITERATURE CITED

Churchill, Sam.

1961. Curing the Tillamook Burn. *Amer. Forests* 67(7): 36-37, 44-46, illus.

Gratkowski, H.

1961. Brush problems in southwestern Oregon. U.S. Forest Serv. Pac. NW. Forest & Range Expt. Sta., 53 pp., illus.

Kummel, Julius F., Rindt, Charles A., and Múnger, Thornton T.

1944. Forest planting in the Douglas-fir region. U.S. Forest Serv., 154 pp., illus.

Oregon State Board of Forestry.

[1960.] Forestry in Oregon. Biennial report of the State Forester for the period July 1, 1958 to June 30, 1960. 58 pp., illus.

Schroeder, Edward.

1960. Should State reforestation acts include provisions for protection? *In* West. Forestry & Conserv. Assoc. Annual Meeting of Western Reforestation Coordinating Committee proc., pp. 9-12.

State of Washington.

[1963.] The Yacolt Burn rehab story. Dept. Natural Resources leaflet, 6 pp.(Unnumbered.)

U. S. Forest Service.

1948. Woody-plant seed manual. U.S. Dept. Agr. Misc. Pub. 654, 415 pp., illus.

1958. Timber resources for America's future. U.S. Dept. Agr. Forest Resource Rpt. 14, 713 pp., illus.

Vaux, Henry J.

1954. An economic viewpoint on Pacific coast forest planting. Univ. Brit. Columbia lecture ser., H. R. MacMillan Lectureship in Forestry. 17 pp.

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