Table 1. Total medical and compensation reimbursement for logging accidents by activity[1] (State Compensation Insurance Authority 1984–1988).

Activity	Median	Minimum	Maximum	Average
		($)		
Unloading logs	723.67	66.50	330,102.00	67,694.44
Chasing choker	683.95	0.00	36,505.39	6,584.33
Felling	279.71	0.00	129,325.00	3,676.92
Other	243.98	0.00	166,857.00	17,928.58
Equipment operation	207.12	0.00	29,215.00	1,639.63
Limbing	197.62	0.00	32,942.17	1,287.49
Bucking	183.13	0.00	96,093.85	9,649.47
Driving log truck	178.36	0.00	46,803.45	4,343.47
Splitting firewood	170.31	131.00	1,848.27	605.80
Setting chokers	154.75	20.00	21,449.68	2,237.61
Maintenance	120.00	0.00	8,234.84	746.40
Slash handling	110.00	0.00	3,138.78	1,082.93
Supervising	95.89	0.00	191.79	95.89
Loading logs	72.00	0.00	2,000.00	358.82

[1] Fatalities are not included.

Table 2. Total days lost for logging accidents by activity.[1] (State Compensation Insurance Authority 1984–1988).

Activity	Median	Minimum	Maximum	Average
Unloading logs	11.5	0.0	42.0	16.2
Chasing choker	21.0	0.0	798.0	163.7
Felling	3.0	0.0	987.0	31.5
Other	0.5	0.0	534.0	57.9
Equipment operation	0.0	0.0	629.0	29.8
Limbing	1.0	0.0	968.0	23.7
Bucking	5.0	0.0	1091.0	129.0
Driving log truck	0.0	0.0	436.0	36.1
Splitting firewood	3.0	0.0	49.0	19.0
Setting chokers	0.0	0.0	201.0	20.2
Maintenance	0.0	0.0	150.0	9.1
Slash handling	0.0	0.0	27.0	9.0
Supervising	1.6	0.0	3.0	1.5
Loading logs	0.0	0.0	35.0	4.8

[1] Fatalities are not included.

costs appear to vary widely by locality, and compensation costs are based on the employees previous earnings, not the severity of the injury. It should also be noted that the medical and compensation portion of an accident probably only covers one-fourth to one-half of the real cost. The costs of lost productivity of the injured and those giving aid, damaged equipment, rehiring and training of replacement personnel, accident reporting, and compensation paperwork, and the cost of personal pain and family suffering should also be considered (Asfahl 1984).

Regretfully, not much is known about the educational levels or social situations of Colorado loggers. More study in this area would assist in devising a more effective training program for these workers. □

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TECHNICAL COMMENTARY

Is Research Keeping Up with the Needs of Douglas-Fir Tree Improvement Programs?

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Forest tree improvement made its debut in the Pacific Northwest in the 1950s, with coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii* [Mirb.] Franco). Since then, efforts have burgeoned into a regional conglomerate encompassing most commercially important species and engaging virtually all land management organizations. A cumulative investment of approximately a quarter-billion dollars has been made to enhance productivity. More than 10 species are included in tree improvement programs in coastal Oregon, Washington, British Columbia, and northern California; but coastal Douglas-fir remains the main focus across the region (Silen and Wheat 1979, Quam 1988, Woods and Crown 1988). Douglas-fir accounts for nearly 60% of the sawtimber harvest in western Oregon and Washington and 25% of the total softwood harvest in the United States (USDA 1982).

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Tree improvement must play a vital role in maintaining the long-term productivity of Pacific Northwest forests if the economic viability of the wood products industry is to be sustained. The region's commercial timberland base has decreased markedly during the past 30 years and may continue to shrink through the end of the century and beyond, at a rate much higher than that for the United States as a whole (Wall 1981). Tree improvement can be used effectively with other silvicultural tools to offset this acreage loss by increasing productivity on the available lands.

Throughout the region, forestland management organizations are engaged in individual and cooperative programs to develop and deploy genetically improved planting stock on their best lands. As these programs approach advanced stages, there is mounting pressure to devise more clearly focused strategies and to improve overall program efficiency. However, the ability to improve efficiency and to meet present and future expectations depends on a continuing flow of accurate, timely information generated by supporting research. Tree improvement research is expensive, and it is generally beyond the means of any one organization to carry out a comprehensive research program that will satisfy all their information needs. Thus, the most important information needs on a regional basis need to be identified and coordination of the overall research effort improved.

Representatives of several public and private forestry organizations, sharing a common interest in furthering the advancement of tree improvement in the coastal Douglas-fir region, formed an ad hoc committee to address these pressing concerns. The goals of this committee were to: (1) determine the current scope of Douglas-fir tree improvement programs in the region, (2) identify regional information needs, and (3) assess the level of existing research. It was felt that this information would be useful to Northwest managers and researchers in assigning priorities to future research efforts and would be helpful in seeking funding for the most pressing needs. In this paper, we report the findings of two surveys conducted by this committee and advance the contention that the current regional effort in Douglas-fir tree improvement research falls short of meeting the needs of operational programs.

APPROACH

The committee's approach to meeting the above goals was to distribute questionnaires to public and private forestry organizations in western Oregon and Washington, northern California, and coastal British Columbia. In addition to questions on each organization's tree improvement effort in coastal Douglas-fir (numbers of breeding populations and progeny test sites, seed orchard acreage, permanent staffing, etc.) respondents were asked to assess their need for additional research on 55 objectives. These objectives covered most of the major questions in operational tree improvement programs which must be answered if breeding efficiency is to be increased and if genetically improved trees are to be more effectively incorporated into forest management systems. For each objective, respondents scored their level of need for additional information as 4 (high), 3 (moderate), 2 (low), or 1 (not needed). There was also the opportunity to give a "don't know" response The same list of 55 research objectives was sent to research organizations in the region in a second questionnaire, to determine which objectives are being addressed currently or have been addressed in recently completed projects where results have not been published. During 1988, 36 forestry organizations completed the questionnaire on information needs, while 11 research organizations responded to the second questionnaire. Details on the questionnaires, including a list of the 55 objectives and each objective's mean score over all respondents, can be obtained from W. T. Adams.

SCOPE OF EXISTING PROGRAMS

The overall regional effort in tree improvement in the Pacific Northwest with Douglas-fir is impressive (Table 1). The estimated number of acres under intensive Douglas-fir tree improvement programs exceeds 16.5 million (6.5 million ha). Due to the mountainous topography which results in extreme environmental heterogeneity over short distances (Silen and Wheat 1979), the region has been subdivided into approximately 200 Douglas-fir breeding zones. Several organizations may have breeding populations in one zone, so the number of separately managed breeding populations exceeds 250.

Progenies of 41,843 parent trees from wild stands are being tested in 1,387 plantations covering 10,843 A (4388 ha). This is nearly 17 square miles of test plantations! Data from these tests provide the means for roguing first-generation seed orchards and for making second-generation selections. These evaluation plantations also provide models for assessing the potential benefits and pitfalls of intensive plantation management.

Table 1. Summary statistics for coastal Douglas-fir tree improvement programs in the Pacific Northwest.[1]

Organization type	Tree[2] improvement ac (M)	Breeding[3] populations	First-generation progeny tests: parents	First-generation progeny tests: Test sites	First-generation progeny tests: acres	Seed orchards (ac)[4] Established: Less than 5 years old	Established: 5–10 years	Established: Greater than 10 years old	Established: Total	Planned next 5 years	Personnel[5]
United States											
Federal	6,943	164	25,509	669	6,275	454	114	206	774	909	141
State[6]	1,334	17	2,097	36	508	6	91	72	169	50	15
Private	5,515	80	13,737	583	3,330	289	185	392	866	47	33
Total U.S.	13,792	261	41,343	1,288	10,113	749	390	670	1,809	1,006	189
British Columbia	2,985	5	500	99	730	7	43	88	138	0	29
Overall Total	16,777	266	41,843	1,387	10,843	756	433	758	1,947	1,006	218

[1] Based on 1988 data (see text).
[2] Total Douglas-fir acres eventually to be reforested with seed orchard stock.
[3] Number of breeding populations. The total for U.S. programs incudes cases of counting the same breeding population more than once when it is managed by different organizations. There are approximately 200 different (i.e., geographically distinct) coastal Douglas-fir breeding zones in the United States.
[4] Mostly first-generation orchards; second-generation orchards make up less than 5% of the total established and planned acreage.
[5] Total person-years per year of permanent staff personnel devoted to Douglas-fir tree improvement programs.
[6] Includes state and county forestry organizations.

While the establishment of first-generation progeny tests is nearly complete, seed orchard establishment is still in a rapid growth stage. Nearly 2000 acres of orchard are already in place, but the acreage is expected to increase by 50% in the next 5 years. Many of the established orchards are too young to produce commercial quantities of seed. Thus, the full impact of tree improvement on regeneration stock will not be fully realized in the region for 10 to 15 years to come.

INFORMATION NEEDS AND CURRENT RESEARCH EFFORT

The information needs survey identified many objectives which appear to be of strong interest throughout the region. More than 50% of the 55 objectives received mean scores (over all respondents) of 3 or greater, denoting moderate to high need. Among the wide variety of objectives included in this group were the following: develop efficient means of measuring traits in progeny tests; determine the extent to which geographic, climatic and edaphic factors influence the risk of seed movement; evaluate the potential for genetic improvement through wide crossing (i.e., crosses among breeding zones or provenances); assess the effects of different degrees of inbreeding on seed production and growth of progeny; and, determine patterns of effective pollen dispersal in seed orchards. The broad regional interest in many objectives may simply reflect the great range in stages of development that the different Douglas-fir programs are in. While some programs have nearly completed first-generation activities, other programs are just beginning.

Work by research organizations in the region is currently underway on many of the higher priority objectives. Approximately 26 person-years are spent each year on genetic studies of coastal Douglas-fir. Included in this number are 16 person-years for organizations devoted entirely to research.

Despite this effort, a number of the highest priority objectives are not currently being adequately addressed. A few of these are discussed below to illustrate the point. It is clear that better linkages are needed between tree breeders and specialists in stand management and wood technology. Although large acreages are planted each year with genetically improved stock, limited research has been directed at assessing gains obtained from these materials when grown under operational conditions or in determining how improved stock can best be incorporated into forest management regimes. What initial planting densities, thinning schedules, and rotation lengths take best advantage of genetically improved trees?

Breeders also need information which will help in deciding which traits to include in progeny test selections. Although no one argues with the importance of improving the rate of stem volume growth in coastal Douglas-fir, there is no general agreement on which, or if any, stem quality traits (e.g., stem straightness, branch diameter) or wood quality traits (e.g., density, longitudinal shrinkage, fibril angle) should be included in selection programs. Efficient means of measuring these traits on standing trees must be available, and the importance of these quality traits to product value (e.g., lumber strength and grade, pulp yield) must be determined. The latter can be determined only from conducting expensive product recovery studies which tie the traits measured in standing trees to product value. Breeders need information from specialists in stand management and wood science. On the other hand, stand management specialists and wood scientists must be encouraged to incorporate genetically improved stocks in their research, since these are the materials that will be used in intensive forest management in the future.

Another important area receiving limited research attention is methods of breeding and evaluation in the second generation and beyond. What mating designs or combination of designs are best for producing advanced-generation offspring and what methods are the most efficient in testing these offspring? Many programs have reached this stage where second-generation selections are made in first-generation progeny tests and a new cycle of breeding begun. Arguments for alternative mating designs have been made for other tree species, but their application to coastal Douglas-fir needs to be investigated.

The use of early evaluation (i.e., selection at young ages) is one advanced-generation selection strategy of great interest. If reliable early evaluation methods can be developed, the breeding cycle could be shortened. Even with effective early selection procedures, however, some long-term field testing will probably be required to ensure the adaptability of genetically improved stock Evaluations in nurseries or growth chambers might have value for identifying families with poor genetic potential. Culling of these families prior to outplanting would result in smaller and more efficient long-term field tests.

CONCLUSIONS

Given the magnitude of the tree improvement effort in coastal Douglas-fir and the shortage of information on many questions important to the continued success of this effort, the need to improve supporting research programs is clear. Increased efficiency through elimination of unnecessary duplication and redirection of research effort from low priority to high priority objectives is one step in the right direction. In addition, cooperative efforts among forestry organizations in tree improvement research is essential. One such cooperative program is the Pacific Northwest Tree Improvement Research Cooperative at Oregon State University. Communication and cooperation between tree breeders and silviculture, stand management, and wood science researchers also must improve if breeding efficiency and utilization of genetic improvements is to be maximized. Finally, the reduction or elimination of the information gap will require more than just better communication and cooperation. Additional support for tree improvement research by both public and private organizations is needed. Without such support, the supply of tree improvement information will not keep pace with increasing information needs generated as existing tree improvement programs mature and expand.□

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