THE TRUE FIR RESOURCE

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ABSTRACT

Abies *is an important coniferous genus over much of the northern hemisphere. It consists of approximately 40 species concentrated in four regions: Siberia and eastern Asia, the Mediterranean, and North and Central America. True firs are generally found in montane and subalpine or boreal environments. They play important ecological roles and represent a significant resource in each of these regions. In western North America true firs are widely distributed geographically and altitudinally in the form of subalpine fir, Pacific silver fir, grand fir, white fir, noble fir, and California red fir; bristlecone fir is a seventh, narrowly restricted species. These species are a major forest resource. True fir timber volumes on commercial forest lands total 81.9 billion cubic feet in western North America and 17.1 billion cubic feet in Oregon and Washington; this is approximately 15 percent of the available timber. True firs provide cover in high mountain watersheds critical to maintenance of water quality and to snowpack management. These mountain lands are prized recreation sites which aesthetically benefit from the spire-like true firs. True firs also have important specialty uses, such as for Christmas trees and greenery. As with all genera, true firs have a mix of desirable and undesirable attributes. Included are aspects of production (potential high stand volumes, but slow initial growth), wood (good pulpwood and abundant, but structurally weak), silviculture (shade-tolerant, allowing many silvicultural options, but disturbance sensitive), and pathogens (noble and California red fir relatively free of pests, but most species with significant insect and disease problems).* Abies *appears to be an important but underattended genus, partially due to a lack of knowledge. Management will probably involve more use of advance regeneration, longer rotations, higher stocking levels, and fewer intermediate entries than would be the case with Douglas-fir. It is a valuable genus with an ability to tolerate and often maximize production on severe environments.*

INTRODUCTION

True firs (*Abies*) conjure many images. We recall spire-like trees, as individuals and in groups, growing in subalpine park lands; symmetrical trees of dark or grayish green adorned with ornaments at Christmas time; columnar boles of gray and white within heavily shadowed forest stands; glistening barrel-shaped cones upright on the branches and crowded high in the crown; and memories of grouse, beargrass, and pungent resins.

Not all our images of true firs are positive, however. We also recollect woods of inferior strength and frequent, extensive development of rots, especially in stands east of the Cascade crest. Problems with defoliators and balsam woolly aphid (*Adelges piceae* Ratz.), and advance regeneration of questionable pedigree and potential are also a true fir heritage.

For better or worse, true firs are a major forest resource and destined to increase in importance in the future. True fir wood is abundant and we are long past the stage of dealing only with premium woods. Rather, we are looking to these "inferior" species to take us into the future. In drier climates, fire control programs are encouraging increases in true fir and other shade-tolerant species. Silviculture is becoming more sophisticated and use of species mixtures is increasing; true firs will be frequent candidates for associate status.

Although true firs increasingly concern us as we move to higher elevations in our search for wood supplies, relevant knowledge lags behind management needs. There are problems associated with regeneration of all types (e.g., pre- versus post-logging regeneration and successful methods of artificial regeneration), lack of growth and yield information, and controversies over slash treatments, just to name a few. The purpose of this symposium is to bring out existing relevant information.

This paper is an overview of the true fir resource. The western true firs will be emphasized: Pacific silver fir (*Abies amabilis* [Dougl.] Forbes), subalpine fir (*Abies lasiocarpa* [Hook.] Nutt.), grand fir (*Abies grandis* [Dougl.] Lindl.), white fir (*Abies concolor* [Gord. & Glend.] Lindl.), noble fir (*Abies procera* Rehd.), and California red fir (*Abies magnifica* Murr. var. *Shastensis* Lemmon). I will consider the resources and particular opportunities and problems associated with the true

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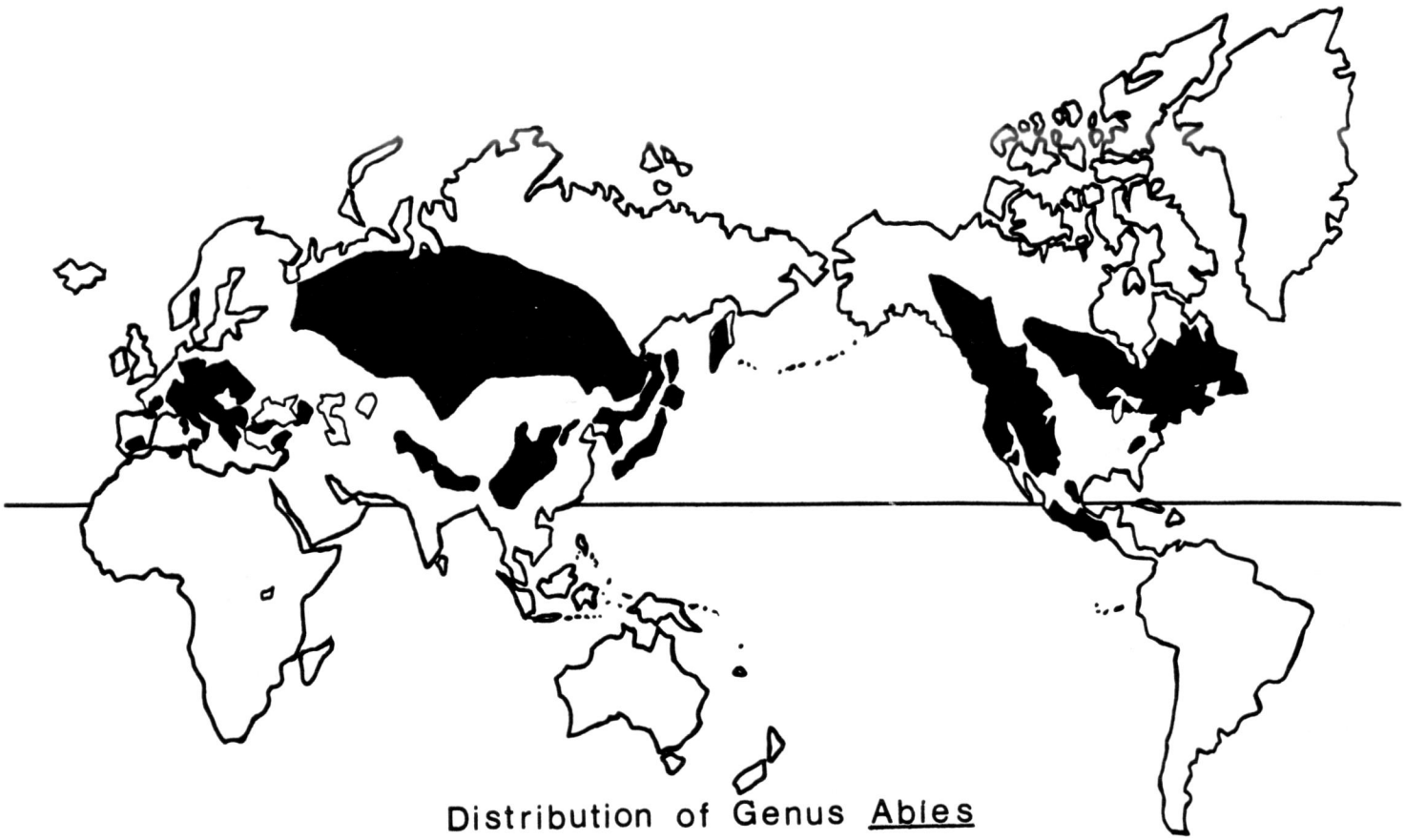

Figure 1. World distribution of the genus *Abies*.

firs. My purpose is to introduce the subject of the symposium and provide some feeling for the importance of true firs in the western North American landscape.

TRUE FIRS IN A WORLD CONTEXT

True firs are an important genus in the family *Pinaceae*, order *Coniferales*. There are approximately 40 species (Liu 1971; Dallimore & Jackson 1967). Included in the genus are at least seven major species complexes where two or more distinctive taxons intergrade with one another, as well as many varieties and hybrids. As is true in many coniferous genera, taxonomists differ in their application of specific status for a taxon. In species number *Abies* is second only to *Pinus*, but in overall importance probably lags behind *Picea* and *Pseudotsuga*. The genus *Abies* is considered to be most closely related to *Keteleeria*.

Abies is from the Latin name for silver fir, *Abed* (Dallimore and Jackson 1967). True firs are generally recognized as having cylindrical trunks, regular whorls of branches and, on upper branchlets, erect cones that disintegrate when ripe, shedding bracts, scales, and seeds. Soft, odorless, light-colored wood is characteristic, but bark blisters are rich in resins.

True firs are confined to the northern hemisphere (figure 1). They are characteristic of high altitude and boreal regions, although some species do occur in temperate forests. The range of the genus includes Europe, North Africa, Northern and Central Asia, and North and Central America. Liu (1971) recognized four major regions: Mediterranean, with 8 species; Siberia and east Asia, with 17 species; North America, with 9 species; and Mexico and Guatemala, with 6 species.

Each of these regions has one or more commercially important true firs. Silver fir (*Abies alba* Mill.) is important in Europe, Siberian fir (*Abies sibirica* Ledeb.) in the Soviet Union, several species (*Abies mariesii* Mast., *A. veitchii* Lindl., and *A. sachalinensis* [Fr. Schm.] Mast.) in Japan, and balsam fir (*Abies balsamea* [L.] Mill.) in the eastern United States.

Western North American True Firs

It is in western North America that true firs attain their great-

est ecological and economic importance. There are six significant species, widely distributed geographically and elevationally. They are: Pacific silver fir, subalpine fir, grand fir, white fir, noble fir, and California red fir. All of the species are montane or subalpine, although one (grand fir) also occurs in lowland areas some distance from mountain systems. Four of these species form genetic complexes which create significant taxonomic confusion among students and land managers alike. These complexes occur between grand and white fir, and noble and California red fir. Bristlecone fir (*Abies bracteata* D. Don) is a seventh, commercially unimportant species found in the Santa Lucia Mountains of coastal southern California.

Western True Firs As A Resource

True firs play significant resource roles as timber, as vegetative cover protecting watersheds and mountain snowpacks, as aesthetic components of recreational landscapes, and for specialty products such as Christmas trees and greenery. Each of these will be considered in turn.

Timber

Western North American true firs total 81.9 billion cubic feet (over 500 billion board feet) on unreserved forest land, according to the most recent inventory data (table 1). This amounts to approximately 15 percent of the available cubic foot volume. Undifferentiated true fir inventory volumes were not available in all cases, most importantly in British Columbia, so I have arbitrarily allocated volumes to these species in table 1.

There is a wide range in volumes by species (table 1). Subalpine fir accounts for over a third of the true fir volume, due primarily to large stocks in British Columbia. White fir and grand fir are second- and fourth-ranked in volume and, as a complex, are the most important true fir group in the United States. Pacific silver fir is the most important true fir in the Pacific Northwest (Oregon and Washington). California red fir and noble fir lag far behind the other four species in volume but have perhaps the greatest potential among the true firs.

There are significant regional differences in the true fir volumes but little variation in the relative importance of true firs. British Columbia has the largest true fir stock, with 38.2 billion cubic feet; this is 4.5 percent of the available timber volume of all species (table 1). The Pacific Northwest is second in total true fir volume, but true firs account for only 12.1 percent of the total timber volume in Oregon and Washington. California has nearly as much true fir volume as the Rocky Mountains and highest percentage ranking of any region, with 24.6 percent of the available timber volume consisting of true firs. Idaho and Montana account for two-thirds of the Rocky Mountain true fir volume.

Table 1. Western true fir timber volumes by species and regions; approximately 0.2 billion cubic feet are not included in this table.

Species	*Region**				
	CA	PNW	BC†	RMT	ALL
	— — — Billions of Cubic Feet — — —				
Subalpine fir	—	1.0	27.2	7.3	35.5
White fir	9.7	3.1	—	1.4	14.2
Grand fir	— ‡	4.9	3.8	5.0	13.7
Pacific Silver fir	—	6.9	7.2	—	14.1
California Red fir	2.9	0.3	—	—	3.2
Noble fir	—	1.0	—	—	1.0
Total	12.6	17.2	38.2	13.7	81.7

* Regions are: CA = California, PNW = Oregon and Washington, BC = British Columbia, RMT = Idaho, Montana, Colorado, Utah, Nevada, Wyoming, Arizona and New Mexico.

† True fir volumes for all British Columbia species were lumped in the inventory; I have arbitrarily divided the volume between species.

‡ Less than 0.06 billion cubic feet.

Watershed

True firs are important (often the most important) tree species found in the upper-slope and subalpine regions. These are critical headwater areas for major river systems. Although it is difficult to quantify, true firs clearly do make major contributions in these rones by protecting soils from erosion and, as pioneers, stabilizing raw substrates. Whether other species could adequately substitute is not clear; in any case, we are certainly better off with than without these species.

True fir forests are also critical sites for snowpack accumulation over much of western North America. Forest cover is important for development of maximum snowpack accumulations, and true firs, along with mountain hemlock (*Tsuga mertensiana* [Bong.] Carr.), provide cover and often constitute forests of very desirable structure.

Recreation

High mountain environments are favored for recreational pursuits varying from wilderness backpacking to skiing. True firs impart character to many of these sites. The dark green, symmetrical and spire-like true firs are highly aesthetic components of the subalpine parklands; they provide the contrast for flowery subalpine meadows. Closed forests of true firs are also attractive (although occasionally somber) with their light-colored columnar trunks.

Specialty Products

True firs have a variety of specialty uses. They are classical favorites for Christmas trees and bring premium prices. In re-

True Fir Resource

cent years true firs have accounted for approximately 15 percent of the Christmas tree market. Noble fir and California red fir bring a substantial premium in price over those paid for more common species, such as Douglas-fir. True firs are also utilized as greenery in both the United States and Europe. This is a primary use for noble fir in Denmark. Another specialty product is balsam or resin found in the bark blisters. Horticultural uses are made of various species and special varieties.

ATTRIBUTES OF TRUE FIRS

Generalizations can be dangerous, but I would like to attempt a few for the true firs as background for the following talks. Timber production wood, silvicultural characteristics, and pathogens are the categories in which I will consider some positive and negative attributes.

Production

True firs can produce truly prodigious stand volumes. The only normal yield tables available for native true firs are for white and California red fir, both by Schumacher (1926, 1928). White fir yields at 100 years are 74 thousand board feet per acre (Mbf/acre) on average sites and 147 Mbf/acre on the best sites (Schumacher 1926). California red fir volumes at one hundred years are 16,700 cubic feet per acre (ft^3/acre) on high sites and 10,550 ft^3/acre on average sites (Schumacher 1928).

Yield tables for managed grand fir stands in eastern Washington and Oregon indicate a live volume of 14,250 ft^3/acre at 100 years breast height (b.h.) age, when the site index is 85 feet at 50 years (Cochran 1979). Gross yields at that age would be 20,250 ft^3/acre. Yield tables for grand fir and noble fir plantations in Great Britain indicate volumes of 16,220 and 12,176 ft^3/acre, respectively, at 80 years on top quality sites (Hamilton and Christie 1971). Total yields at 80 years, including thinnings, amount to 30,112 and 24,781 ft^3/acre for grand fir and noble fir, respectively. Grand fir produced greater volumes than any other species for which the British had prepared yield tables (Christie and Lewis 1961).

Some data for natural noble fir stands also exist. Site II stands (110 to 130 ft at 100 years b.h. age) contain 21,900, 31,600 and 43,400 ft^3/acre at 100, 163, and 315 years, respectively (Franklin, this symposium). The record noble fir stand in Goat Marsh Research Natural Area near Mount St. Helens, Washington, averages 69,600 ft^3/acre over ten acres (329,200 Mbf/acre) with the best hectare averaging 407,950 Mbf (gross) per acre; this stand volume is second only to volumes recorded on coast redwood (*Sequoia sempervirens* Endl.) and giant Sequoia (*Sequoiadendron giganteum* [Lindl.] Buchh.).

High stand densities and form factors are major contributors to production of the large stand volumes, along with a sustained growth rate. Comparative data indicate that natural true fir stands typically have much higher densities and larger basal areas than natural Douglas-fir stands. California red fir has twice as many trees and basal area per acre as Douglas-fir at 100 years in stands of similar site index (table 2). Noble fir and Douglas-fir stands generally show similar contrast (Franklin, this volume). High form factors are characteristic of true firs and result in maximum volumes for trees of a given height and diameter. The British noted that "the volume increment per one foot height growth [for noble fir] . . . is larger than that of any other conifer for which we have prepared yield tables" (Christie and Lewis 1961). This was attributed to the "high crop form factors which are greater than those given in any of the other . . . conifers."

Table 2. Mensurational data for normally stocked, natural Douglas-fir and California red fir stands on comparable sites at 100 years; California red fir site index age is 50 years, site index age for Douglas-fir is 100 years

Species and site index (SI)	*Tree* height ft*	*Average d.b.h. in*	*Trees no/acre*	*Basal area ft^2/ac*	*Volume ft^3/ac*
Red fir, SI 60	103	16.3	279	478	16,700
Douglas-fir, SI 100	100	12.2	276	224	7,300
Red fir, SI 40	67	11.1	580	400	10,550
Douglas-fir, SI 80	80	10.5	301	178	5,100

* Dominants and codominants
(from Schumacher 1928 and McArdle, Meyer, and Bruce 1930)

An obvious consequence of the higher stand densities and better forms is that true firs typically produce much greater wood volumes than associates such as Douglas-fir, given comparable site indices. This is illustrated with California red fir in table 2 and noble fir elsewhere in this volume (Franklin, this volume). This is also true for grand fir, where volume production on the same site can be so much larger for grand fir than for Douglas-fir that the disparity in wood density is overcome, resulting in greater weights as well as greater volumes of wood production by the grand fir.[1]

True firs do have some disadvantages in productivity, including slow initial growth rates for most species on most sites. Slow initial growth was found by Aldhous and Low (1974) to be a key factor in an economic rejection of noble fir for general use in Great Britain. They conclude that "there appears to be no case for any large scale planting of this species timber." Initial growth does vary by species and site, with grand fir probably being the fastest growing of the western true firs. Early growth of Pacific silver fir is even slower than for noble fir, which takes from 7 to 11 years to reach breast height (Williams 1968).

1. P. H. Cochran, personal communication.

Regardless of the exact values, true firs are "distance runners," not "sprinters." While their initial growth is usually slow, growth is sustained well into the second and even third centuries. This pattern is, of course, undesirable if you are interested in short rotations. True fir stands may yield a much larger total volume of wood: the best possible annual yields from a site. Rotations must be longer, however, to capture that volume, and rotations based on culmination of mean annual increment will turn an economist's hair grey. Mean annual increment in California red fir on high sites culminates at about 145 years. Similarly, culmination appears to occur around 125 years for Site II noble fir (Franklin, this symposium).

Wood

Perhaps the most outstanding attribute of true fir wood is its abundance. As I indicated earlier, there is a lot of it. The light weight, light color, and soft wood, characteristic of most true firs, is suitable for light construction and makes this species suitable for pulping (although not the best). Noble fir is a desirable specialty wood which has been used for ladder rails and airplane construction because of its high strength-to-weight ratio.

True firs are an important component of the "white woods" exported to Japan. In 1979, white wood exports totaled about 1.9 billion board feet, although the bulk was western hemlock. In this market, noble fir again brings a premium: noble fir and western hemlock were exported at $685.00 and $428.00 per Mbf, respectively. Japan is expected to remain an important market for white woods, including true firs, for use in housing construction.

Negative features of true fir wood include relatively poor strength properties and low durability.

Silviculture

True firs provide silviculturists with a large array of options because of their shade tolerance. They are often present as advance regeneration and can be managed under any silvicultural system. It must be admitted that these numerous options often can be viewed as problems in the short term because of inadequate knowledge. In the long view, however, the tolerance must be viewed as a silvicultural plus. The practice of silviculture should be increasingly sophisticated in the future, especially on public lands, with increased interest in using species mixtures to maximize production, in using advance regeneration to reduce regeneration periods, and in using uneven-age management for severe sites and in recreational areas. Silviculturists in the western United States with such interests will often find true firs critical in developing their management prescriptions. On some sites the silviculturist may also find true firs the most productive species in volume and, perhaps, even in weight. While there is currently limited recognition of true fir productive superiority (e.g., noble fir in many locations in the Cascade Range), there is liable to be an expanded list of sites where its productive superiority is recognized (e.g., with grand fir east of the Cascade Range).

The negative silvicultural feature of true firs is their sensitivity to disturbances such as fire, scarring, and stand openings that drastically increase exposure. True firs range in fire sensitivity from moderately to very sensitive. The thin bark and shallow root systems of true firs are major factors in this susceptibility. Several species, particularly in drier regions, are very susceptible to rots and are apparently readily infected when entry courts are provided via scarring. In one study 90 percent of the logging scars on grand fir and Pacific silver fir became infected (Wright and Isaac 1956). This susceptibility to rots suggests, incidently, that intermediate entries or salvage operations in true fir stands should probably be much more limited than is the case in species such as Douglas-fir. Mature specimens of several true fir species also show sensitivity to exposure when stands are opened up. For example, Pacific silver fir typically sun scalds when used as a leave tree in shelterwood cuttings low in the Pacific Silver Fir Zone. Some noble fir appear to undergo gradual decline when exposed along cutting boundaries, possibly because of physiological stresses; death may not come for several decades. Physiological stress, leading to extensive waves of stand mortality, is actually a common phenomenon in the forests of short-lived true firs in Japan (Oshima *et al.* 1958) and the eastern United States (Sprugel 1976).

Pathogens

There are so few positive points to be made for true firs with regards to pathogens that I will consider the negative first. Wood rots, defoliating and bark-infesting insects, balsam woolly aphid, and mistletoes (*Arceuthobium* spp.) are all important pests. True fir-infecting heart rots are numerous and varied in their characteristics but Indian paint fungus (*Echinodontium tinctorum* Ell. & Ev.) stands out as a problem in true fir stands, especially in drier parts of western North America. Defoliating insects such as the Douglas-fir tussock moth (*Orgyia pseudotsugata* McDunnough), western spruce budworm (*Choristoneura occidentalis* Freeman), and western blackheaded budworm (*Acleris gloverana* Walsingham), create problems for white fir, grand fir, and subalpine fir. Western balsam bark beetle (*Dryocoetas confusus* Swaine), fir engraver (*Scolytus ventralis* LeConte), and related species cause problems in white fir, grand fir, subalpine fir, and Pacific silver fir. Balsam woolly aphid(*Adelges piceae* Ratz), an introduced insect, is a very serious pest of Pacific silver fir, subalpine fir, and grand fir on better sites for these species in western Washington and western Oregon. This pest has also created ques-

tions about whether Pacific silver fir is an acceptable species to manage even outside the current range of the aphid and on habitat types within the aphid range which are not known to be subject to infestation. Mistletoes are primarily a problem in white and California red firs.

Two positive points can be made for true firs and their associated pathogens: (1) the hope that managed stands can be made relatively free from most of these pests, and (2) noble fir. Greater care in logging, modified silvicultural systems, and appropriate rotation should drastically reduce disease problems below levels encountered in old-growth forests and many partially cut stands. None of the major categories of pests, including balsam woolly aphid, is a significant problem on noble fir. During the recent spruce budworm epidemic, the lack of defoliation on noble fir east of Stevens Pass, Washington, was a notable example. Dwarf mistletoe is a problem in some noble fir stands in the southern part of its range.

CONCLUSIONS

It is apparent that true fir is both an important and underrated genus. A part of the problem has been the inferior status of true firs as compared with the "glory" species, such as Douglas-fir and ponderosa pine (*Pinus ponderosa* Laws.). The nation's wood supply is such that true firs can no longer be ignored. In fact, we are beginning to appreciate that these species constitute a major silvicultural resource. There are true firs with abilities to tolerate some very tough environments. Also included in the genus are some species with high productive capabilities, with the potential of maximizing production on particular montane and subalpine sites. True firs need no longer be viewed as poor relatives.

The management of true firs will require significantly different practices from those associated with Douglas-fir management. This may be a reason why true firs have not been fully accepted by the forester. Practices in true fir management may require that we make more use of advance reproduction to overcome slow initial growth and avoid regeneration problem sites, use higher stocking levels, minimize intermediate entries to reduce damage to the stands, and, probably, utilize longer rotations to capture more of the productive capacity of the sites.

Insufficient knowledge is clearly a barrier to full utilization of the true firs. This symposium will help to set us on the road towards correcting that deficiency.

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REFERENCES

Aldhous, J. R. and Low, A. J.
1974. *The potential of western hemlock, western redcedar, grand fir and noble fir in Britain.* [Britain] Forestry Commission Bull. 49, 105 pp. Her Majesty's Stationery Office, London.

Christie, J. M. and Lewis, E. A.
1961. *Provisional yield tables for* Abies grandis *and* Abies nobilis. [British] Forestry Commission Forest Record 47, 48 pp. Her Majesty's Stationery Office, London.

Cochran, P. H.
1979. *Gross yields for uneven aged stands of Douglas-fir and white or grand fir east of the Cascades in Oregon and Washington.* USDA For. Res. Pap. PNW-263, 17 pp. Pac. Northwest For. and Range Exp. Sta., Portland, Oregon.

Dallimore, W. and Jackson, A. B.
1967. *A Handbook of* Coniferae *and* Ginkgoaceae. Ed. 4, revised by S. G. Harrison. 729 p. St. Martin's Press, New York.

Franklin, J. F.
1982. *The ecology of noble fir* (this symposium).

Hamilton, G. J. and Christie, J. M.
1971. *Forest management tables* (metric). [British] Forestry Commission Booklet No. 34, 201 p. Her Majesty's Stationery Office, London.

Liu, Tang-shui.
1971. *A monograph of the genus* Abies. 608 p. Dept. Forestry, College of Agriculture, National Taiwan Univ., Taipei.

McArdle, B. E., Meyer, W. H., and Bruce, D.
1930. *The yield of Douglas-fir in the Pacific Northwest.* USDA Tech. Bull. 201, 74 pp. Ed./ rev. Oct. 1949, slightly rev., May 1961.

Oshima, Yasuyuki; Kimura, Makoto; Iwaki, Hideo; and Kuroiwa, Sumio.
1958. Ecological and physiological studies on the vegetation of Mt. Shimagare I. Preliminary survey of the vegetation of Mt. Shimagare. *The Bot. Mag*, Tokyo 71 843:289–301.

Schumacher, Francis X.
1926. *Yield stands and volume tables for white fir in the California pine region.* Calif. Agr. Exp. Sta. Bull. 407, 26 pp.

Sprugel, Douglas G.
1976. Dynamic structure of wave-regenerated *Abies balsamea* forests in the north-eastern United States. *Jour.Ecology* 64:889–911.

Williams, Carroll, B., Jr.
1968. *Juvenile height growth of four upper-slope conifers in the Washington and northern Oregon Cascade Range.* USDA Forest Service Res. Paper PNW70, 13 p. Pac. Northwest For. and Range Exp. Sta., Portland, Oregon.

Wright, Ernest and Isaac, Leo A.
1956. *Decay following logging injury to western hemlock, Sitka spruce, and true firs.* USDA Tech. Bull. 1148, 34 pp.