INTENSIVE MANAGEMENT OF COASTAL DOUGLAS FIR

West of the Cascades, the Pacific Northwest contains the most productive natural coniferous forests on earth. Since the first settlement, the most important tree has been Douglas-fir, a species remarkable for long life, rapid growth, relative freedom from insect and disease attack, and utility of its wood. Over most of the area it behaves as a light-demanding subclimax species, which grows naturally in even-aged stands and has been maintained in competition with its more tolerant associates by repeated fires in the past, and in recent times by man’s logging operations.

We are now in transition from the wild forests of the past to the managed forests of the future. Our present forests are a combination of remaining old-growth stands, second-growth stands which became established in a haphazard manner after past fires or cutting, and increasing areas of young stands established by planned cutting and regeneration.

Despite a very large growing stock, annual production rates in the wild forests of the past were relatively low. Our new forests are capable of much higher production.

Trees are plants, and the means which can be used to increase production are basically similar to those used with other crops. Intensive culture is really agronomic forestry. First, we must be able to get prompt and adequate regeneration of desired species. Second, we must protect the crop from insects, animals, and disease. Third, we can harvest the crop at ages which take advantage of the naturally high growth rates of young stands. Given these, we can further increase production over that of the wild forest by (1) control of spacing and competition, (2) soil fertility improvement, and (3) genetic improvement.

By control of spacing and competition, we try to develop that combination of spacing and of crown, root, and stem development which gives most efficient use of light, water, and nutrients in production of utilizable wood by plants of given genetic constitution; by fertilization, we seek to increase the nutrient supply where it limits photosynthesis and growth; and by genetic improvement, we try to improve the basic efficiency of the plant in using available resources and its resistance to disease, insect, and climatic injury.

The methods of forestry necessarily differ in some ways from those of agriculture. The long time period required to grow a forest crop involves much greater biologic and economic uncertainties—longer exposure to risks of fire, insects, and disease; changes in value of land, timber, and individual species; changes in value of timber versus nontimber products; and changes in tax systems, tax levels, and interest rates. The less productive nature of the land available to forestry and the lower value of the crop mean that cultural and protective measures must be relatively inexpensive.

And, wood is only one of the products of the forest. The choice of measures applicable in a specific situation depends on their effects on watershed, wildlife, recreational, and scenic values as well as on their direct effects on economic returns from wood production.

COMMERCIAL THINNING IN EXISTING STANDS

Since commercial thinning produces immediate income, it has naturally been one of the first management practices applied to existing stands. We have considerable areas of second-growth stands ready for commercial thinning, and a great deal of this is being done.

Because most of these stands originated in a haphazard manner, without early control of spacing and competition, they are quite variable in stocking,
species composition, and ability to respond to thinning. Tree and stand characteristics gradually become fixed with advancing age; the longer thinning is delayed, the less it can promote tree development and increase usable yields per acre. However, thinning at any time does provide an opportunity to exercise some control over mortality and does increase the growth rate of residual trees to some extent.

There is fairly good information on results of commercial thinning in previous untreated Douglas-fir stands. Such thinning reduces mortality losses but also reduces total growth, with the result that net production is only slightly increased. Gains from commercial thinning of previously unthinned stands are not primarily from increased wood production, but from earlier income, reduced investment in growing stock, improved quality of the final crop, and lessened susceptibility to losses. The results obtained in such stands do not represent the potential under really intensive management.

**INTENSIVE CULTURE**

Intensive culture starts with prompt and complete establishment of genetically desirable reproduction. Early spacing is controlled through regeneration practices and early precommercial thinning. Commercial thinning begins as soon as it can be done at a profit and is continued at intervals which permit forestalling or salvaging of most mortality and maintenance of adequate crowns while avoiding creation of holes which cannot be quickly occupied by the remaining stand. Fertilization is likely to be common practice on sites where response can be anticipated.

**Spacing Control and Subsequent Thinning**

Control of initial spacing through regeneration practices or precommercial thinning, or both, will usually be necessary (fig. 1). The objective is to concentrate growth on relatively few stems, to produce vigorous, rapidly growing trees with full crowns which will reach commercial thinning size in minimum time. The number of stems retained should be sufficient to provide full use of the site and a feasible thinning opportunity by the time commercial size is reached. Initially, this number will leave considerable unoccupied growing space.

The need for early precommercial thinning is most critical on poor quality sites. This is dramatically illustrated by results of the Wind River plantation spacing test (site IV). Average diameters of dominant and codominant trees, 41 years after planting at initial spacings of 4 x 4 through 12 x 12 feet, ranged from 6.0 inches in the 4 x 4 spacing to 10.8 inches in the 12 x 12 (fig. 2).

We think that precommercial thinning will usually

**Figure 1**

A site IV Douglas-fir stand immediately after precommercial thinning to 400 trees per acre. Before thinning, the stand had about 1,300 trees per acre.

**Figure 2**

Comparison of average stem and crown dimensions of dominant and codominant trees in the Wind River plantation spacing test, 41 years after planting at initial spacings of 4 x 4 through 12 x 12 feet on site IV land.

**Figure 3**

Standing volumes in Wind River plantation spacing test, 41 years after planting at initial spacings of 4 x 4 through 12 x 12 feet on site IV land. CVTS = total volume in cubic feet, entire stem. CV4 = merchantable cubic-foot volume to 4-inch top, etc.
be most cheaply and effectively applied as a single thinning when trees are small, perhaps 12 to 20 feet in height.

Trees grown at the wide spacings were already commercially thinnable and had vigorous crowns able to take advantage of increased growing space. In contrast, trees at the close spacings had not yet reached commercial size, and their small crowns would make rapid response to any present thinning impossible. Throughout the 41-year period, the wide spacings have been far ahead of merchantable volumes and value (fig. 3).

After such initial spacing control, commercial thinning will likely begin when stand diameters reach 8 to 10 inches, perhaps less if strong roundwood markets develop (fig. 4). Thinning intervals should probably be short at first; but thinning intervals should lengthen or cuts become lighter as the stand grows older, since the potential for crown expansion declines with age and cutting creates larger holes in older stands. First cuts will be from above, with cut trees somewhat larger than the stand average, but becoming smaller than average in subsequent cuts.

Current estimates of production attainable on limited uniform areas suggest that on site III commercial thinning alone will produce about a 5-percent gain in production over a rotation, compared with the normal yield table\(^1\) for well-stocked unthinned natural stands; while the combination of precommercial and commercial thinning will increase total production by about 30 percent (fig. 5). The relative gain from precommercial thinning is greater on poorer sites, while that from commercial thinning is greater on better sites.

Since there are no stands in the Northwest which have been carried through the complete sequence of early spacing control followed by intensive thinning to rotation age, estimates of yields over a full rotation are necessarily uncertain. A partial check on the reasonableness of such estimates is provided by comparisons with production figures from European plantations of Douglas-fir, some of which have been under relatively intensive management for as long as 75 years. Although such comparisons are complicated by differences in site estimation systems, climate, thinning regimes, and the possible effect of plantation versus natural origin, all European production tables compared indicate yields greater than the estimates given above, which are clearly conservative.

**Fertilization**

Growth of coastal Douglas-fir is generally improved by application of 150 to 200 pounds of nitrogen per acre, which at present costs about $25. Consistent response to other elements has not been demonstrated. Response to nitrogen has been observed over the full range of site classes, though not in all instances. Average relative increases in 10-year cubic-volume

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Gross

Net

Unadjusted means:

GROSS

NET

Figure 6


Intensive Management of Coastal Douglas Fir

growth, with application of 200 pounds N per acre, are estimated at about 5 percent on site I, 15 percent on site III, and 25 percent on site V. On many experimental plots, short-term increases in growth have been much greater than this (fig. 6). Naturally, increases are greatest where nitrogen deficiency is the principal factor limiting growth.

Gains from fertilization of low-site land are impressive both relatively and absolutely. And, in young stands, fertilization appears to accelerate both differentiation of crown classes and suppression mortality and so may reduce any tendency toward stagnation.

Results from combined precommercial thinning and fertilization are particularly encouraging and in some cases exceed the added effects of either treatment alone. This combination also insures that the increased growth is placed on stems which will actually be harvested.

Growth increases following fertilizer application are temporary. Present estimates are that response will generally last at least 10 years and that it may be possible to fertilize as many as five times at 10-year intervals without diminishing the response per application.

Two hundred pounds of nitrogen per acre applied at 10-year intervals is a small amount, in comparison with amounts commonly applied in agriculture over the same period. This fact, coupled with the high organic matter content of forest soils, rapid uptake by existing nearly complete vegetative cover, and the small amounts of nitrogen measured in run-off from fertilized areas, suggests that when properly applied any possible adverse effects on water quality or other forest values are probably inconsequential and certainly very much smaller than similar effects of fertilizer used in agriculture.

Genetic Improvement

The long-range possibilities of increased production through genetic improvement is shown by the example of agriculture. Realization of its full potential in forestry is obviously further away than that from fertilization and thinning of existing stands.

Present programs are of two main types. The first uses seed orchards composed of grafted cuttings from intensively selected parent trees and depends initially on efficiency of selection for its gains. The second is based on collection of wind-pollinated seed from selected trees in the forest. Here, some gain comes from selection but most from progeny testing aimed at identifying the top quarter of the parentage. A study dating back to 1912 shows this gain to be substantial and sure if the test is long continued.

Under both types of program, a second round of tree improvement has been started using controlled crosses from parents in the present programs. For commercial seed production, ungrafted progeny are grown in orchards from which the poorer three-fourths of the families will be removed, with the remainder expected to provide elite seed in 15 to 25 years. Breeding of best individuals from controlled crosses is handled as a separate phase of these programs.

The potential improvement in volume growth has been conservatively estimated at 10 percent for the first round, and at least another 10 percent when progeny from known crosses becomes available as a seed source. Other gains come from such characteristics as improved bole form, hardiness and survival, improved wood traits, and possibly improved responsiveness to intensive culture techniques.

Although improved seed is already in large-scale use, increases in regional growth can occur only as rapidly as present stands are replaced with new stands established with improved seed. And, part of the improvement will merely offset past losses from negative selection and off-site planting.

The long time period required to grow a forest crop leads to somewhat different approaches to genetic improvement than in agriculture and greater concern with susceptibility to climatic injury and pests. Such susceptibility may not be quickly apparent and is far more difficult and costly to correct in forestry than in agriculture.

There are real risks in genetic change from the adapted natural population. In a crop which must
withstand all climatic extremes and pest attacks for 50 years or more, the only safety lies in a very diverse pool of genetic types, so that loss of a single type represents only a small fraction of the stand. Since adaptation to locality is very sensitive in Douglas-fir, local trees are used for the breeding population. Another safeguard is the extremely large base populations which preserve the entire gene pool of the locality.

The genetically improved forest of the future will not consist of the uniform individuals we find in agricultural crops. It will still contain differing proportions of the whole range of forest tree types and diverse genetic composition found today. The goal is simply to shift the average of the stand in the direction of better growth and form and other desired traits.

**FACTORS LIMITING INTENSIVE CULTURE**

The growth rates which are biologically possible on small areas under ideal conditions can never be attained in management of large areas. Rates actually attainable are restricted by both biological and economic factors; and within the framework of biological possibilities, economic factors largely determine what we can actually do.

**Insects and Diseases**

In wild stands, a considerable fraction of growth is lost to insects and diseases. Intensified management will reduce but not eliminate losses, and we can expect that the relative importance of pests will change. Heart rots and bark beetles will become much less important, although we may have some rot arising from mechanical thinning injuries. Defoliators will still be with us. Regeneration pests will become more important simply because prompt regeneration is essential to intensive management.

Dwarf mistletoe will continue to be a problem in south western Oregon, and it may sometimes be necessary to clearcut heavily infested stands at an early age or to convert mixed stands to associate species.

An incompletely evaluated hazard is that of root rots, particularly *Poria weirii*. Our increased awareness of this problem may mean simply that we are now looking for it in young stands. It is certainly going to create holes and increase windfall.

Alder is immune to *Poria*, and the presence of alder in a stand appears to reduce damage to associated conifers. Some Douglas-fir stands of the past developed after an extended period of alder or brush occupancy. It has been hypothesized that this may have tended to eliminate *Poria*, and hence that our current efforts to obtain instant regeneration of fir and hemlock may actually increase the incidence of *Poria*.

It may be wise to maintain some admixture of alder or the less susceptible conifers such as redcedar and pines on sites to which they are adapted. Conceivably, it might become necessary to follow some severely infected stands by an alternate rotation of resistant species.

The natural occurrence of large areas of predominantly Douglas-fir stands is good evidence that widespread catastrophic losses from native pests are unlikely. There remains the unpredictable hazard of introduced pests, which is another argument for maintenance of some admixture of other species rather than striving for pure stands over large areas.

**Regeneration**

Regeneration is not instantaneous, not uniform, and not always of desired species. Sometimes we can't get it. Irregular distribution and poor species control may give young stands which cannot be molded into efficient producers. Harvest cutting and slash disposal practices can have a lasting effect through their influence on regeneration.

Any delay in regeneration means a period of lost production. It also means that present worth of the new stand is reduced because yields must be discounted over a longer period. Thus, with 5-percent interest, a 5-year lag can reduce the present value of the new stand as an investment by about 22 percent.

Prompt, adequate regeneration is essential to intensive management.

**Site and Topographic Limitations**

It is a truism that management will generally be applied first and most intensively on the best sites and there produce highest returns. By and large this is certainly correct, but it does not necessarily apply equally to all practices. For example, precommercial thinning may give large returns on poorer sites prone to stagnation, and fertilization may give highest returns on those sites which are poor because of nutrient deficiencies.

The particular combination of management measures and intensity applied necessarily depends on prospective gains in relation to costs. Economic limitations will likely prevent intensive management on a considerable fraction of our lower site lands in the foreseeable future. And, the rugged topography and inaccessibility of some otherwise potentially productive lands will force less intensive management because of difficulty of commercial thinning by presently available methods.

**Use Conflicts**

Further and major limitations are imposed by conflicts with uses other than timber production. The most obvious and important of these is diversion of land to nontimber producing uses. As of 1970, about 6 percent of the commercial forest land in the Douglas-fir region was in various reserved classifications. Present estimates are that by the year 2000 another 7 percent of the present commercial forest land will have been lost to urbanization, roads, powerlines, etc., without considering possible additional reserved areas as Wilderness. Much of the land so lost will be of high site quality.

Other limitations are restrictions on timber manage-
ment practices to accommodate other uses of the same land. This includes roadside screens and modifications of cutting practices and rotations for reasons of watershed protection or aesthetics. These do not prevent timber production but may mean higher costs and lower production, hence lower financial returns and less investment in timber management.

We are all acutely aware of the importance of forest values other than timber, and that neither maximum timber production nor maximum direct financial returns are necessarily the controlling criteria. Rather, we need to maximize returns from some combination of values including social values that are not really measured in dollars. The mix and the objectives are different for different owners and different areas.

**ROTATIONS**

Compared with such species as the southern pines, Douglas-fir is a slow starter. However, once past the juvenile stage, it has a remarkable capacity for sustained growth over long periods of time. Maximum mean annual increment is attained relatively late. The decline thereafter is slow, and the range of biologically reasonable rotations is much wider than in many other species.

Intensified management is usually associated with shorter rotations. Calculations of present worth for newly established stands suggest highest stumpage returns for rotations in the range of 30 to 60 years, according to site, interest rate, and utilization assumptions. For example, with 5-percent interest, constant stumpage prices, and precommercial thinning plus commercial thinning, calculations indicate that present worth of a newly established stand is highest for rotations of about 40 years on site II and 50 years on site IV.

However, such calculations omit a number of considerations, and there are real questions how far we should—or can—go in this direction.

First, the regeneration stage is a period when things can go badly wrong. On some areas there is real risk of extended regeneration delays, possible loss of the site to brush or less desirable species, or severe animal damage to regeneration. Long rotations postpone these problems.

Second, there is a considerable element of uncertainty as to how our new stands will actually behave as they approach maturity. We have no stands which have been carried to a reasonable rotation age through the complete sequence of early spacing control, fertilization, and repeated thinning. We may find that their growth pattern is considerably different from the stands of the past and strongly influenced by the particular thinning regime adopted.

Third, there is the possibility that very close utilization on very short rotations might lead to seriously reduced site productivity, unless we are prepared to apply fertilization and soil management practices comparable to those in agriculture.

There has been a good deal of discussion lately of the possibilities of whole-tree utilization on very short rotations, with removal of nearly all aboveground woody material. Someone has termed this the "hamburger" school of thought.

The stemwood which we utilize today represents a rather small fraction of the mineral nutrient content of the standing forest. Its removal at fairly long intervals has little effect on soil nutrient status or maintenance of soil organic matter. But, we also know that foliage and fine branches contain larger amounts of nutrients; that leaching losses from soils are substantial for short periods after stand removal; that heavy machinery produces some degree of soil compaction; and that site deterioration associated with prolonged removal of litter and small material has been a serious problem in parts of Europe.

Fourth, the shorter the rotation the higher will be the proportion of juvenile zone wood whose warping and low strength make it undesirable for many present uses.

A fifth point is partly social and applies particularly to areas we clearcut. In general, an area looks devastated to the general public for 10 years after harvest. For the next 10 years it looks "cutover." From there on, it looks beautiful. If we operate on a 40-year rotation, we will always have 25 percent of the area looking devastated. With an 80-year rotation, the 25-percent figure is halved. Visual impacts are less striking when shelterwood rather than clearcutting is used as the harvest method, and this is one of several factors which may lead to increased use of the shelterwood system in the future.

Short rotations are bound to intensify conflicts with most other land uses—watershed, recreation, and aesthetics—simply because they mean radical disturbance of larger fractions of the forest area in any given time period. Obviously, the importance of this point will be different for different owners and different areas, but it may sometimes lead to adoption of rotations considerably longer than those indicated by financial calculations based solely on stumpage returns.

We have not treated economics as a separate topic. Economic considerations and decisions are an integral part of all intensive culture plans. We must use our economics tools at every stage to evaluate options and help us select the best alternatives, although economic gain will only be one of the considerations that the land manager must weigh.

**CONCLUSION**

One last thought. We tend to think of our lower site lands as unsuited to intensive management, and no doubt many of them are today. But our ideas of forestry and our economic situation have changed radically in the last 30 years, and no doubt they will continue to change in the next 30. We might remember that even site IV Douglas-fir will out-produce almost anything in North America east of the Rockies and north of the southern pine region.

We believe intensive forestry has a great and exciting future in the Douglas-fir region.