Timber Supply in the Pacific Northwest

Photos from the Iron Creek levels-of-growing stock study (Curtis and Clendenen 1994) show adjacent areas with (above) and without (left) thinning, 45 years after planting.

PEER REVIEWED

Managing for Economic and Ecological Values in Douglas-Fir Forests

By Robert O. Curtis and Andrew B. Carey

The Douglas-fir region of western Washington and Oregon and coastal British Columbia contains the most productive forestlands in North America. Yet disagreement among user groups and conflicting goals, policies, and laws *have* nearly paralyzed timber management on federal lands and greatly increased costs and complexity of management on nonfederal lands. Constructive compromise among competing interests is needed. Most private and state lands and some portion of federal lands will have timber production as a major objective for the foreseeable future. To accommodate this objective, we need to provide sustainable production of timber while minimizing conflicts with other forest values. Extended rotations combined with certain other practices to promote nontimber values can be valuable tools in efforts to achieve this objective (Wiegand et al. 1994).

Historical Background

Forest management practice in the Pacific Northwest has evolved from beginnings in the 1850s. Many foresters, however, have only a vague knowledge of its history and the associated cumulative experience and knowledge, and the general public and professionals in allied fields often seem unaware that it exists.

Presettlement northwestern forests were never a continuous expanse of giant old-growth trees. They were never static, but were the product of repeated wildfires occurring at intervals ranging from 50 to 100 years in the southern part of the region to perhaps as much as 700 years in the high rainfall areas of the western Olympics (Agee 1991). Most forests originated as even-aged stands after stand-replacement fires, although unevenaged stands are common in southern Oregon because of frequent light burns, and some occur elsewhere as a result of partial mortality from fire and windfall. This disturbance history produced the extensive stands of Douglas-fir (*Pseudot-suga menziesii*) that are a dominant characteristic of the region. Stands that do not experience fire or other disturbances ultimately develop an uneven-aged structure dominated by the tolerant western hemlock (*Tsuga heterophylla*), redcedar (*Thuja plicata*), and true firs (*Abies* spp.).

Pacific Northwest forests were initially viewed as a static resource to be mined. Large-scale exploitation began about 1850. Change began with the establishment of the national forest system and the Wind River nursery (1909) and planting programs for rehabilitation of the extensive burns, as well as with the concurrent beginnings of forest research. Organized fire suppression began about 1910 and became increasingly effective over time. Early yield research showed the enormous productive capacity of northwestern forests. These events made possible the gradual change from simple liquidation of forest assets to planned forest management on most state and industrial lands.

Experimentation with harvest and regeneration practices also began around this time. The seed tree system—mush like the "green tree retention" cuts we see today, although different in motivation—was one of the first tried, with unsatisfactory results. In the mid-1930s managers tried selective cutting in old-growth Douglas-fir (Kirkland and Brandstrom 1936) on a fairly large scale. A decade of observation on permanent plots showed that in these old stands, selective cutting as then practiced led to widespread stand deterioration, and the effort was quietly abandoned (Isaac 1956). Partial cutting was reasonably successful in the mixed-conifer forests of southwestern Oregon and northern California, and many of these stands are now important habitat for wildlife usually associated with old-growth. Meanwhile, many old liquidation cuts regenerated well, once protected from fire.

Research on biological requirements for natural regeneration began around 1920 and extended through the early 1940s (Isaac 1943). This led to adoption of "staggered settings" in the late 1940s and early 1950s. These were moderate-size clearcuts with adjacent, uncut old timber as the seed source. They served the dual purposes of providing conditions favorable for natural regeneration and rapid development of the road system necessary for future forest management and for recreational access to public lands. The 1950s saw a shift to artificial regeneration. Planting provided quick and dependable stand establishment and removed the clearcut size restriction imposed by the need for adjacent seed blocks. In subsequent decades there was also a shift to increasingly shorter rotations—to as little as 40 to 50 years in some ownerships today.

A concomitant shift also cook place in attitudes toward commercial thinning. In the 1950s many foresters saw commercial thinning as the wave of the future. But markets for small material were poor, and thinning was a far less profitable activity than conversion of remaining old-growth. As rotations became shorter, many owners adopted precommercial thinning, but most lost interest in commercial thinning in favor of early harvest.

Along with these changes came development of clearcutting dogma. Because the combination of clearcutting, burning, and planting was simple, provided adequate regeneration in most situations, and minimized logging costs, it was applied almost everywhere. It was a short step to the belief that this was the only way to do things. Recent years also saw the rising influence of an urbanized public—concerned about environmental issues—that often emphasized environmenttal, recreational, and aesthetic values over utilitarian values.

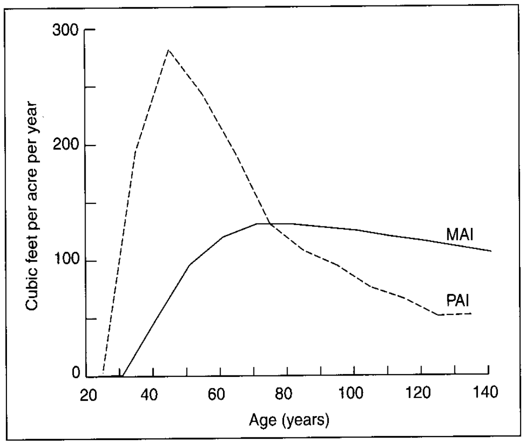

Figure 1. Mean annual increment and periodic annual increment curves for site III Douglas-fir, from McArdle, et al. (1961). Values are adjusted to merchantable volume to a 6-inch top.

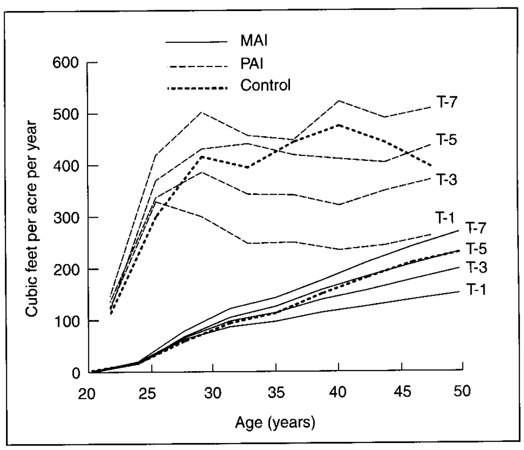

Figure 2. Mean annual increment and periodic annual increment in net merchantable volume (6-inch top) for four thinning treatments (growing stock levels) and unthinned control for Douglas fir on a very good site. At age 50, periodic annual increment is still twice mean annual increment; all treatments are far short of culmination. Data obtained from Hoskins levels-of-growing-stock study (Marshall et al. 1992; Curtis 1995).

Consequences

The history of forest management in the Pacific Northwest involves nearly a century of constructive evolution of forest practices and accumulation of knowledge. But the most recent phase—dominated by large clearcuts and short rotations—has been a political and social disaster.

The public sees clearcuts spread across the landscape, reacts negatively, and becomes a receptive audience for those who depict the clearcutting system as irresponsible destruction. Negative reactions are reinforced by sharply accelerated and highly visible cutting of young stands on private lands and a growing imbalance in age-class distribution, which are in part consequences of withdrawal of federal timber and of regulatory fears and uncertainties on the part of landowners. These reactions create major public relations and political problems, with enormous costs that are not included in conventional financial analyses.

Many scientists also question recent forest management practices as they affect wildlife, fish, species diversity, site productivity, timber quality, and sustainability. Concerns related to regimes in which most or all of the landscape is occupied by relatively young and uniform stands in the stem exclusion stage—with few snags and little coarse woody debris and understory vegetation. Regimes in which stand regeneration and harvest is performed in large units with few edges or corridors, creating possible difficulty for some species in recolonizing the area, have also been questioned. Concerns also arise when harvest occurs before volume and production value have reached their potential and when it precludes development of habitat suitable for some wildlife species. These concerns are not new (Overton and Hunt 1974).

Past practices were appropriate to the economic and social conditions and biological knowledge that existed when they were first adopted. We now need regimes that will meet the public desire for reduced visual effects of forestry operations and for maintenance of species diversity, wildlife, and other environmental values, while providing continued timber production at a relatively high and sustainable level. Active management designed to produce a desired mix of conditions can be far more effective and less costly than blanket attempts at presservation" that eliminate human intervention (Oliver 1992; DeBell and Curtis 1993; Boyce 1995). A variety of management changes can assist in addressing these problems (McComb et al. 1993), including, specifically, a shift to extended rotations on some portion of the landbase combined with increased use of commercial thinning, and—where feasible—a shift to regeneration systems other than the large clearcuts of the recent past. These changes will not solve all problems, but they can be valuable components of any overall strategy.

Extended Rotations

Possible advantages of extended rotations (combined with commercial thinning) include:

- reduced land area in regeneration and early development stages (reduced visual effects; lower regeneration and precommercial thinning costs; less need for herbicides and slash burning; reduced frequency of ecological "crunches" that reduce biodiversity);
- larger trees and higher quality wood;
- opportunity to improve present unbalanced age distributions;
- improved habitat for some wildlife;
- hydrological and long-term site productivity benefits; and
- increased carbon storage associated with larger growing stock.

Extended rotations also imply a great expansion of commercial thinning. Thinning can provide intermediate income and employment, maintain live crown ratios and individual tree growth rates, promote stand health and stability, forestall or salvage considerable mortality, and develop stand structures favorable to wildlife. Systematic thinning begun early can produce striking changes in tree size, stand structure, and under development over relatively short time periods.

Maximum volume production is attained at the age of culmination of mean annual increment [*MAI* = (standing volume + thinnings)/age], at which the MAI and periodic annual increment (PAI) curves intersect. This is the minimum rotation age specified for national forest lands under the National Forest Management Act of 1976. Financial rotations used by other owners are usually shorter, but still related to these curves. But culmination age is not a fixed quantity. It is influenced by management regime and obscured by differences among available estimates.

For many years estimates were based on McArdle, et al. (1961; *fig.1),* first published in 1930. Incorporation of modern Douglas-fir height-age curves produces estimates with later culmination. Comparisons of a number of currently used growth and yield simulation programs also show later culmination (Curtis 1994; Curtis and Marshall 1993). In a recent analysis of 17 long-term thinning trials-ex-tending to maximum ages ranging from about 70 years on the best sites to 117 years on a relatively poor site-MAI had not culminated in any of the stands examined (Curtis 1995). PAI remained nearly constant or only slowly declined over an extended period, to the upper limits of the data. These MAI and PAI curves *(figs. 2, 3)* differ markedly from McArdle's *(fig. 1).*

Coast Douglas-fir is long-lived and can maintain rapid growth rates to advanced ages. Thus, short rotations involve substantial reductions in yield (Curtis 1994). The MAI curve is relatively flat in the vicinity of culmination age, and a range of possible rotation ages (beyond those in common use) will produce approximately the same MAI. Curtis (1994, 1995) and Curtis and Marshall (1993) show that moderate extension of rotations would not reduce long-term volume production and would probably increase long-term value production.

The economic and biological aspects of rotation length have been argued for a century and a half (Newman 1988). A widely used economic criterion is maximization of soil expectation value-the discounted value of all future costs and returns. This criterion gives a rotation that is usually shorter than that of maximum MAI. In its most common and simplistic form it considers only timber values and ignores wildlife, water, fish, and amenity values (which usually do not accrue to the landowner).

Attempts to incorporate nontimber and social values are hampered by difficulty or inability to express such values in monetary terms. Yet, public policy considerations demand maintenance of all values and avoidance of actions with unacceptable effects on public values. Both these considerations and public perceptions (which are influenced by management regime) lead to pressures for regulation and for land withdrawals for special uses. Nontimber values and public perceptions have become dominant influences on management of USDA Forest Service and some other public lands. And their political and regulatory con sequences involve large costs that cannot be ignored by any owner.

Rotations are influenced by financial and supply considerations and owner objectives, as well as by biology, and the rotation that maximizes MAI is not appropriate for all owners. But continuation of the recent trend toward very short rotations can only mean sharply reduced productivity relative to potential, restriction of future management options, reduction in nontimber benefits, and exacerbation of antiforestry attitudes among the general public.

The fact that most nontimber benefits accrue to the public rather than the individual land-owner may justify provision of tax or other incentives to offset reductions in soil expectation value associated with lengthened rotations and other measures needed to promote societal values (Lippke and Oliver 1993; Johnson 1995; Lippke et al. 1996). This might be less expensive, less disruptive, and politically more acceptable than attempts to impose change by regulation. (For example, landowners are often reluctant to adopt measures that increase wildlife habitat because of the risk that it may result in a "taking" through regulatory requirements for habitat preservation.)

Wildlife and Conservation of Biodiversity

Public attitudes and scientific concerns now place increased emphasis on nongame wildlife and endangered species, and on biodiversity in general. The most famous example is the spotted owl. But one lesson from the re-cent past is that targeting individual species can be extremely disruptive and expensive. It is not possible to determine requirements and monitor populations for each of the myriad existing species and then provide for each individually. We must develop management regimes that provide both commodity production and support of most forest-dwelling species. This will only be politically and economically feasible if severe conflicts involving the economic and social wellbeing of rural communities and forest-based industries can be avoided.

Carey et al. (1995) proposed a biodiversity pathway

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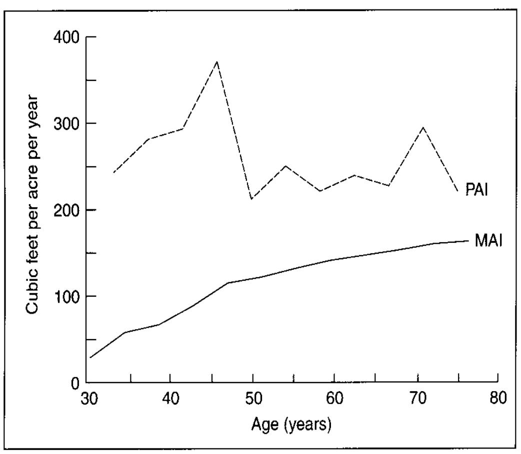

Figure 3. Average values of mean annual increment and periodic annual increment in net merchantable volume (6-inch top) for Douglas fir in the four thinned plots in the Schenstrom experiment, Cowichan Lake, British Columbia (Curtis 1995). Rather than declining sharply as shown in normal yield tables, periodic annual increment has remained nearly constant.

(CURTIS, continued from page 7)

pathway for forest management based on comparesons of biotic communities in old-growth, young natural, and managed forests (Carey 1995; Carey and Johnson 1995). This proposal is based on conserving biological legacies during harvest and regeneration; minimizing time in the stem exclusion stage of stand development; ensuring diversity and niche diversification in later stages through thinnings and coarse woody debris management (logs and cavity trees); and using extended rotations (90-130+ years versus 40-50 years) on a significant part of the landbase.

The flying squirrel (*Glaucomys sabrinus*), a major prey of the spotted owl, is usually more abundant in old-growth than in managed forests, but Carey (1995) found that second-growth forests with appropriate structure and composition could be as productive of flying squirrels as old-growth forests. Similar results were found for diverse members of forest-floor small-mammal communities (Carey and Johnson 1995). Carey et al. (1995) concluded, on the basis of published reports, that forests actively managed for biodiversity could support virtually all the species occurring in western Washington, whereas conventional timber management on a 50-year rotation could support a maximum of 87% and a mode of 64% of the species potentially present. The biodiversity pathway was better than traditional timber management for species as diverse as elk (*Cervus elaphus*), pileated woodpecker (*Dryocopus pileatus*), and spotted owl. Hansen et al. (1993) came to similar conclusions for birds in western Oregon.

Several aspects of extended rotations (and associated thinning and regeneration options) directly affect biodiversity and productivity for wildlife, and thus make such rotations an important component of the biodiversity pathway.

- Extended rotations allow development of a wide range of age classes and tree sizes.
- The combination of extended rotations and alternative regeneration systems can minimize the influence of the stem-exclusion stage and of clearcuts on dispersal and colonization processes, promote development of biologically rich forest floors and complex trophic pathways, and reduce spatial isolation of high-quality forest habitat.
- Thinning entries will usually be infrequent during the latter part of the rotation, so there will be some natural unsalvaged mortality providing snags and coarse woody debris additional to that from thinning slash. Additional trees can be killed or treated as needed to provide additional snags, cavities, and coarse woody debris.
- Thinning provides control of stand density and structure to promote wildlife and aesthetic values, through development of the understory and creation of small openings and density variation within stands that influence understory and forest floor characteristics.

An economic analysis of alternatives by Lippke et al. (1996) indicated that adoption of the "biodiversity pathway" on a portion of the landbase would-compared to current management regimes-increase overall economic returns to the community, over and above the cost of publicly funded landowner incentives. The study also showed that this could develop late seral habitat at less cost and over a shorter time period than could be done by setting aside additional young stands in preserves.

Associated Considerations

Several other issues are associated with extended rotations and management for biodiversity.

The short-term timber supply problem. A practical problem in implementing extended rotations is the need to maintain acceptable timber harvests during any transition period. Reductions in short-term supply could be partially offset by increases in thinning and by possible reduction in pressures for withdrawal of land from the timber base. A number of examples (Curtis 1995) suggest that thinning regimes can be designed that combine high levels of intermediate yield and relatively infrequent entries with development of stands that possess acceptable timber and nontimber values. We need further evaluation of existing information and large-scale trials of radical thinning regimes.

Many currently perceived problems stem in part from stand-age distributions that are badly unbalanced on both regional and local scales. Private ownerships consist predominantly of young age classes, with little mature and negligible old-growth timber; whereas federal ownership consists predominantly of mature and old-growth stands and very young stands. A move toward more balanced age distributions implies that some stands should be carried to advanced ages, and that some should be harvested at ages less than might otherwise be desirable. Spatial distribution as well as total areas involved is important.

Regeneration. Douglas-fir is, on most sites, best adapted to even-aged management. Extended rotations and commercial thinning are easily applied to existing stands established on past clearcuts. We can expect future public opposition to clearcuts, beyond current regulatory restrictions on clearcut size. Reduced site preparation, elimination of burning, wide spacing, planting of mixed species, and retention of occasional green trees could offset some of the visual and ecological impacts of clearcutting (Carey and Johnson 1995). Alternative regeneration systems will also be needed, including shelterwood and partial removals aimed at establishment of two-aged stands, in which the younger age class is likely to be dominated by the more tolerant hemlock and redcedar.

Another alternative is regeneration in small even-aged patches of 1.5 to 10 or more acres; gradually creating a mosaic of small, even-aged stands covering the full range of age classes. There should be little difficulty in maintaining Douglas-fir as a major component within these. The lower limit on patch size is set by the need for direct light (Isaac 1943) and the need to avoid felling trees into existing regeneration. Costs may be prohibitive on steep topography. But, where feasible, there could be major advantages from both public relations and wildlife habitat standpoints. To our knowledge, small patch cuts have not been adopted as a management system by any major landowner in western Washington and Oregon, even though adequate regeneration can be obtained in such cuts (Worthington 1953). Small patch cuts are found on many small private ownerships, and experiments in progress use even smaller (possibly excessively small) patches for wildlife habitat purposes. They should also be effective in conversion of root rot pockets to resistant species.

Group selection may have applications to certain visually critical areas and some warm, dry sites, as in the mixed conifers of southwest Oregon. It is unlikely to maintain Douglas-fir on mesic sites with an aggressive component of tolerant tree and shrub species.

Most plantations were established as pure Douglas-fir, although many acquire an admixture of other species through natural seeding, and planting of other species has increased in recent years. On most sites, there is good reason to maintain Douglas-fir as a major component. Establishment and management of stemwise or groupwise admixtures of other species, however, has potential advantages for wildlife and biodiversity, aesthetics, the matching of species to local site conditions, improved stem quality, and resistance to root rots.

Plantation management. Millions of acres of young plantations in western Washington, Oregon, and British Columbia are at or will soon attain commercial thinning age. There will soon be large acreages where harvest and regeneration is feasible whether or not it is desirable. The choice between harvesting now with continued short-rotation management versus repeated thinning on long rotations will have major effects on long-term productivity of all forest values, the nature of the future forest, and future land-use conflicts. Short rotations are already recognized as unwise and inconsistent with legal direction for federal lands, and not politically feasible in any case. For other lands, the question is open. This is a major management question of the near future.

In Conclusion

Possible management options can be categorized as:

- intensive timber production on a semi-agricultural basis, with incidental nontimber values;
- extended rotation management with timber production as a major goal, but with considerable associated nontimber value production;
- a biodiversity pathway combining extended rotations with other measures to produce nontimber values and maintain biodiversity, while producing substantial associated timber outputs; and
- natural reserves, aimed exclusively at wildlife, aesthetic, and recreational uses.

There are legitimate arguments for allocation of some lands to each, and allocations must be strongly influenced by existing land ownership and owner objectives. The extended rotation and biodiversity pathway options can be important in efforts to reduce the land-use conflicts and economic and social disruption experienced in recent years, and to combine timber production with production of some of the ecological and amenity values that many people associate with old forests.

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