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MODIFYING DOUGLAS-FIR MANAGEMENT REGIMES FOR NONTIMBER OBJECTIVES

Jerry F. Franklin, Thomas Spies, David Perry, Mark Harmon, and Arthur McKee

> Even the...best artificial environments cannot of course duplicate the subtleties and complexities of natural environments; but most of them will [can] improve with time.
>
> Rene Dubos, The Wooing of the *Earth* (1980)

This symposium emphasizes the economics and mechanics of wood production. Wood production is often the primary management objective on forest lands but certainly not the only one. Forests provide people with many other goods and services including high quality water, wildlife and fish, recreational and spiritual experiences, and protection of the soils, which are the long-term basis of all the productivity.

Managers of public and private forest lands are involved with nontimber objectives. Providing nontimber goods and service is of particular concern on public lands dedicated to multiple-use concepts. Many interest groups attempt to influence management decisions for these lands and often seek (and achieve) legislative or judicial mandates for their points of view. Nontimber values are also relevant to nonfederal forest lands as more laws and regulations require attention to such values. Moreover, public land policies have a profound influence on the forest products industry. Private forest owners are also looking for additional income from their lands from nontimber uses (Oliver 1986).

This paper deals with the nontimber values of forests, specifically those of the Dougias-fir *(Pseudotsuga menziesii* [Mirb.] Franco) region. At the conceptual level, deficiencies or dangers in the current approaches to intensive forest management are considered and modifications in philosophy suggested. Some specific modifications of Douglas-fir silviculture are then considered that would enhance production of nontimber goods and services and assist in maintenance of long-term site productivity.

Three points are emphasized at the outset: (1) It is not argued that nature is always best, right, or to be slavishly copied. On the other hand, natural systems provide many lessons that can be profitably applied to forest plantation management. (2) Current and intensive single-species management regimes are used as an extreme example of practices being either used or proposed for forest lands in the Douglas-fir region. In fact, many foresters are deeply involved in development and application of silvicultural systems that protect and augment nontimber values. (3) Many of the ideas presented have originated with those same foresters and not with the authors.

CONCERNS WITH CURRENT APPROACHES TO INTENSIVE MANAGEMENT

Current approaches to intensive forest management are fundamentally agricultural: to maximize the desired output by simplifying the ecosystem of interest and subsidizing it with energy inputs such as fertilizers. These approaches relate to the tendency of production-oriented foresters to be highly focused-on wood fiber. With this point of view goes a bias to think that what is good for timber production is also good for other resource values and society, a tendency sometimes reflected in professional dogma.

The tendency toward simplification is very much an ecological concern. It goes on at many levels: genetic, structural, spatial, and temporal. Foresters often simplify forest systems even though the process is no longer essential (if it ever was) to management objectives and is even disadvantageous economically. Perhaps this reflects a human penchant for orderliness and simplicity even when no specific purpose is served.

Genetic simplification takes many forms, including the elimination or exclusion of some species and reduction of variability in others. Local rather than broad-scale simplification is considered here, although global loss of a species or most of a species' genetic variability is a matter of the most serious concern. Local elimination and subsequent exclusion of a species usually take place by accident rather than by design, as in the case of animal species associated with old-growth forests. Exclusion from enough of the landscape can result in eventual extinction of a species, as has been hypothesized for the northern spotted owl *(Strix occidentalis)* (Gutierrez and Carey 1985). Reduction in intraspecific genetic variability is often by design, as in programs of genetic improvement or, even more drastically, in programs for cloning Douglas-fir. Other forest activities, such as artificial regeneration of trees from wild seed, can result in substantial, unplanned modification of the natural genetic variability.

Structural simplification within stands includes eliminating dead trees and downed logs, reducing the range of tree sizes and growth forms, and using geometrical tree spacings. Foresters were practicing the removal of deadwood because of concerns over wildfire long before intensive forest management was initiated. Intensive management generally strives for high uniformity in tree size and form; concentration on one or two species further reduces variability in tree structure. Regular spacing of trees is emphasized to optimize stand growth and to provide ready access for mechanized equipment.

Management effects on spatial or landscape diversity are mixed.. Natural landscapes in the Douglas-fir region tended to be dominated by relatively large patches—a consequence of major catastrophes, primarily wildfire. Boundaries between patches were typically gradual or feathered. Management regimes have generally increased the number of "patches" in forested landscapes, particularly with the staggered-setting system used on federal forest lands. On the other hand, management practices are drastically reducing the range of conditions represented by the patches. The amount of boundary or edge between patches has been increased, sharpened, and straightened. It can be argued that management has increased this aspect of diversity in forested landscapes, but many small patches representing eighty or ninety age classes of Douglas-fi may not be the most desirable situation either ecologically or economically (Franklin and Forman 1986).

The temporal or successional simplification that results from intensive management affects both early and late stages in succession. For economic reasons, rapid establishment of a fully stocked, closed-canopy conifer forest is a major objective, and planting and control of competing vegetation contribute to this objective. An ideal for many foresters probably is full recovery of Douglas-fir leaf area in the year following harvest. In addition to truncating preforest stages in succession, intensive management eliminates the mature and old-growth stages of succession, which are less efficient at producing merchantable timber volume. In westside Douglas-fir forests of the Pacific Northwest the mature stage typically begins at 80 to 100 years of age (culmination of mean annual increment) and persists for about 100 years. The mature stage represents a period of substantial continued growth and biomass accumulation, albeit at a slower rate than in the young forest. Old-growth conditions develop gradually and begin at 175 to 200 years of age (Old-Growth Definition Task Group 1986). Harvest of stands managed for timber production normally occurs at culmination of mean annual increment at the latest; this represents the point of transition from youth to maturity. Successional simplification as practiced under intensive management becomes very clear when it is contrasted with the natural forest rotation in the Douglas-fir region (Figure 1).

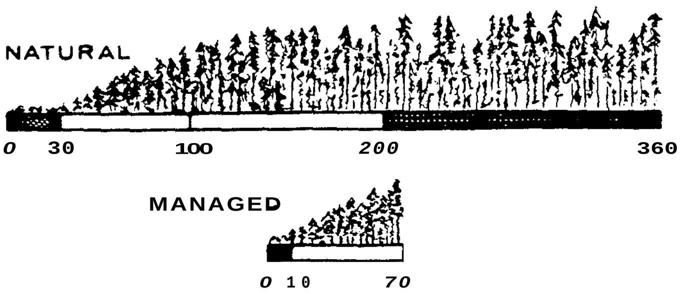

Figure 1. Contrast in duration of successional stages under natural and human disturbance regimes. Typical frequency for fire return under natural conditions is 350 to 450 years in northern Oregon and Washington. Normal rotation for managed stands is 70 to 90 years. Managed rotations eliminate the mature and old-growth stages of stand development and abbreviate the open. preforest canopy stage.

What occurs under intensive management, then, is nothing less than homogenization of the forest. The simplification that is taking place is not necessarily bad, and much of it is required to achieve management objectives. But a universal application of such an approach is unwise, since it reduces the options of managers and of society. It also ignores major elements of the ecosystem, something done only at peril.

Indeed, uniform application of intensive management suggests that we understand how these ecosystems function—an assumption best approached with a great deal of humility! Scientists and forest managers do not know either these ecosystems or the future all that well. Every forester is aware of the large mass of scientific information that has been developed about forests during the last fifteen years, much of it very fundamental in nature and dramatic in implications for forestry. An outstanding example is the dynamics of the below-ground forest component. Research has shown that although only about 20% of the biomass is below ground, turnover of fine roots and mycorrhizae may be so high as to require as much as 70% of the photosynthate for their maintenance. The silvicultural implications of this finding may be great; for example, fertilization may simply alter the ratio of energy going into above- and below-ground portions of the forest (Grier et al., this volume). Waring and Schlesinger (1985) explore other implications of the turnover and energy requirements of the below-ground component of forests.

There are many other examples of recent and important scientific findings: the importance on many sites—including the productive coastal forests---of photosynthesis that occurs outside the normal growing season (Franklin and Waring 1980); the significance of canopies as sites for condensation and precipitation of water, nutrients, and pollutants—producing, for example, 25% or more of the precipitation on some sites (Harr 1982); the multiple locations at which nitrogen fixation occurs in forests, including in canopy lichens (Carroll 1980, in fine litter (Silvester et al. 1982), in rotting wood (Harmon et al. 1986), and in the rhizosphere; the importance of natural enemies in controlling insect pests; and the importance of mammals as vectors for mycorrhizae-forming fungi (Maser et al. 1978).

It is not even known what all the parts of a forest ecosystem are, let alone what they do. And past experience suggests that they are important. Tree species maintain more genetic diversity within populations than any other life form. For example, more than 90% of the range-wide allozyme variation present in Douglas-fir is contained within populations. There is no clear idea what role, if any, genetic diversity plays in stabilizing forests against pests, pathogens, and climatic fluctuations, nor is it known with any surety how it influences productivity. Estimates of the growth of selected genotypes are seldom made under the conditions and over the time periods that trees are grown in the field. It may well be that genetic diversity enhances productivity under some conditions.

Foresters will doubtless experience many surprises. Scientists will generate new knowledge. There will be unexpected changes in the physical and economic environment. Climatic changes and increasing pollutant loads can be expected. Are tree-breeding programs taking these into account? Almost certainly the trees being planted today will come to maturity in a physical environment different from what we know. Economic conditions and markets have changed drastically in the last decade. Is there any reason to expect greater stability in the future? As a society, we do not seem to be creating forests with built-in options that will allow us to respond easily to dramatic changes in conditions.

POLICY APPROACHES

The uncertainties created by the limited knowledge of forest ecosystems and of the future suggest a general approach to management of all forest resources. The basic principle is to maintain or enhance complexity whenever possible, including genetic, structural, and spatial variability. Adherence to this principle will require creativity in developing approaches that allow for retention of the complexity.

Foresters can maintain much of the complexity inherent in natural ecosystems at relatively low cost in terms of timber yields. Most attempts seem to take one of two approaches: by zoning areas to compartmentalize nontimber values, and by incorporating nontimber objectives directly on commercially managed timberlands.

Compartmentalization has been a common approach to amenity values. It appears to work for at least some resources, such as old-growth forests and streams, at least some of the time. Certainly, “set-asides,” such as areas removed from intensive timber production to protect unstable soils, streams, and visual areas, and to provide Research Natural Areas, can do part of the job of maintaining the desired complexity.

Set-asides cannot, however, carry the entire (or even a majority of the) responsibility for maintenance of ecological complexity. They are not uniformly distributed over the landscape but are biased toward the low quality, high elevation lands that are generally poorer in ecological resources (see Hams 1984 for examples of animal distribution with elevation). More important reasons why nontimber values cannot always be compartmentalized are (1) the pervasive nature of many such values, (2) the greater proportion of lands dedicated to intensive management, and (3) the desirability of integrating some nontimber objectives, such as perpetuation of nitrogen-fixing species, with timber objectives.

It seems that foresters are going to have to make nontimber objectives an integral part of intensive timber management regimes. The specifics of prescriptions will depend on the nontimber resource(s) of interest and the type of ecosystem.

SOME NONTIMBER MANAGEMENT STRATEGIES

This brings us to some examples of nontimber objectives and possible strategies for the achievement of those objectives in the Douglas-fir region. Discussion of long stand rotations is not included since emphasis is on incorporating nontimber objectives into management regimes on commercial timberlands. Rotations of 200 to 250 years are under consideration for federal lands to provide for old-growth forest conditions. Long rotations could also be used to accommodate some of the other nontimber objectives discussed below.

Accommodation of Early Successional Species

Accommodation of early successional species is a nontimber objective with a variety of rationales. Many organisms use early stages of forest succession (the period prior to canopy closure). Indeed, the herb and shrub stage typically has the highest diversity (number of species) of any stage in forest succession. Many of these species are weedy generalists, but others are of direct interest and include game birds and mammals. This is also the stage of succession during which nitrogen-fixing plants, such as alder, ceanothus, and lupine, carry on most of their activity; it is probably the successional stage during which the largest single input of nitrogen occurs.

The young, closed-canopy conifer forest, by contrast, is the least diverse stage of succession, since essentially all the resources of the site are mobilized by the trees. The relationship between species diversity and successional stage can be exemplified by mammals (Figure 2). Other groups of organisms, including higher plants and terrestrial and aquatic invertebrates, show similar patterns.

A silviculturist can easily construct prescriptions that will delay full canopy closure and maintain open forest conditions for long periods. These include using much wider spacings in plantings and using wide spacings in early precommercial thinnings. Such strategies might have favorable economic benefits by reducing planting and thinning costs (Oliver et al., this volume). Furthermore, spacing trials in the region suggest that economic yields from such stands might suffer very little; although total yields are less, such stands typically produce trees with much larger average diameters. Early wide spacings could also be coupled with pruning to produce high quality wood.

Foresters in New Zealand practice exactly this type of silviculture in their intensive management of radiata pine *(Pinus radiata)*. Stands are precommercially thinned to very wide (crop-tree) spacings early in stand development, typically about nine years. Although of harvestable size, the thinned material is not used, because of its marginal economic value. The crop trees are pruned in a series of three steps or “rises.” The thinned stands are very open in structure and can produce a variety of other products, including forage for domestic animals

Provision of Coarse Woody Debris

Standing dead trees (snags) and downed logs fulfill several functions in both forests and streams. Ecologically, a dead tree is nearly as important to the forest ecosystem as a live one (Harmon et al. 1986, Maser and Trappe 1984, Franklin et al. 1979). At the time a tree dies it has probably fulfilled only about half its roles in the ecosystem; the importance of deadwood, especially snags, for wildlife has been recognized the longest (e.g., Brown 1985). But coarse woody debris is also an important component in nutrient and energy cycling, as a source of soil organic matter, as a site for nitrogen fixation, and in erosion control. In streams and rivers, coarse woody debris provides the major structural devices and thereby generates half or more of the habitat in small forested streams. Logjams are energy dissipating devices that reduce channel erosion. Logs also provide major structures for retaining food and sediments in stream reaches and provide habitat for an array of organisms, including cover for fish (Triska et al. 1982). Additional functions for woody debris exist in larger rivers and estuaries (see, e.g., Swanson and Lienkaemper 1982).

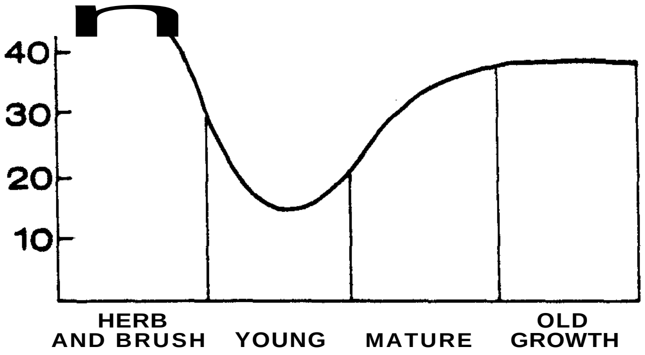

Figure 2. Relationship between successional stage and number of mammal species utilizing each stage as primary habitat (based on Harris 1984).

Snags and downed logs are transitory structures, however, and must be continuously produced. Snags are especially short-lived in the Douglas-fir region, rarely persisting (in forms useful to cavity dwellers) beyond sixty or seventy years. To fulfill all functions, snags must also be renewed in large sizes (e.g., greater than 24 inches dbh). It is often overlooked that natural processes provide large amounts of woody debris at all successional stages. Young stands typically had very large loadings of wood, because most catastrophes, such as wildfire and windstorms, generally killed trees but removed only small amounts of the wood. Lowest levels of woody debris in natural stands were found in mature stands and in young stands that had regenerated after multiple wildfires (Spies et al. 1985).

Approaches to managing coarse woody debris on commercial timberlands are to preserve existing material or to create new material, or both. Preservation of some existing material, particularly downed logs, is often a good strategy. Ecologically, the practice of yarding unmerchantable material (YUM) is undesirable, at least when pursued to the extent that all larger woody material is removed from a cutover. Where coarse woody debris is desired, YUM practices need to be modified or entirely eliminated. Scientists urgently need to provide foresters with guidelines for levels of woody debris needed (amounts, sizes, and decay stages) to fulfill various objectives.

Preservation is probably not the best approach to snag management. It is difficult to protect snags even without considering safety problems. Snags that are left after logging are typically in an advanced state of decay (because they are the shorter snags which lack merchantable wood volume and present fewer safety problems) and will persist only for an additional decade or two.

Creation of new snags is probably a better management approach than preservation of old snags. This can be accomplished by retaining selected green trees as future snag sources on cutover areas. Various marking criteria are possible, but selection of trees with crown and upper bole defects, such as top rot, broken top, or fork, may be desirable. Trees with some level of decay are likely to produce more desirable snags for cavity dwellers than those with completely sound boles. Lower bole, butt, or root defects are to be avoided, because they may be more susceptible to windthrow, which would reduce their longevity as snags. Green trees can be converted to snags by broadcast burning or girdling. One useful strategy may be to space out the mortality of the leave trees to provide a continuing source of snags throughout the next rotation.

Development of management strategies to provide a continuing source of coarse woody debris is a major challenge to silviculturists, a challenge comparable to that of managing live trees for given timber objectives. There are typically multiple objectives, such as provision of snags of a given size and condition for specific cavity dwellers and downed logs of a given number and size for maintenance of soil organic content. The link between snags and downed logs is one reason why saving snags in patches is probably not a preferred approach. In addition to spacing considerations, concentrating snags ignores the importance of snags as a continuing source of the large down wood needed on cutover areas. Tree size and species, habitat type, and subregion are all important variables in calculating the longevity of deadwood as either downed logs or snags (Harmon et al. 1986). Consequently, prescriptions will have to be very site specific, comparable to the situation for green trees. Much more information is needed on requirements for and behavior of snags and logs, but a substantial body of data and some integrating concepts and models do already exist.

Development of Mixed Species and Multistructured Stands

Mixed stands can be used to achieve a variety of nontimber and timber objectives, such as enhancement of soil fertility and to lessen problems with pests and pathogens. Foresters have typically avoided planning for such stands, because it is simpler not to do so and because timber objectives have not required such an approach.

Development of improved soil properties is one potential objective of mixed species stands. The classic example is using alders in mixture with conifers because of alder's nitrogen-fixing capabilities. But there are other species with favorable nutrient benefits. Cedars and related species (Cupressaceae and Taxodiaceae) are calcium accumulators (Kilsgaard et al., in press, Zinke and Crocker 1962). Their litter contributes to development of soils richer in bases, lower in acidity, and generally more favorable to biological productivity (see, e.g., Alban 1967). Many hardwoods also produce a base-rich litter that has a low carbon to nitrogen ratio.

Including hardwoods in the coniferous stands of the Pacific Northwest may be appropriate for a variety of nontimber objectives, besides the effects on soil nutrients. Deciduous hardwoods result in a more open canopy for part of the year, thus influencing conditions on and in the forest floor in a variety of ways. Responses of invertebrate and vertebrate populations to the increased insolation are to be expected. The hardwood trees themselves provide a very different habitat for epiphytes, invertebrates, and some kinds of predators. Big-leaf maple *(Acer macrophyllum)* is, for example, an outstanding substrate for development of epiphytic plants.

Stands of mixed structure could be created to provide truly uneven-age stands with the classic, inverted J size distribution. A single-tree selection system could be used to manage such a stand for continuous yields. A much simpler and more broadly relevant example of a mixed-structure stand might be the development of a two-layered forest consisting of two distinct age classes. One approach being tested is the creation of shelterwoods in which the leave trees are left through the entire next rotation. This might be done to create greater canopy diversity (perhaps for purposes of wildlife habitat or moisture condensation), to provide a source of larger deadwood structures, or to produce some higher quality wood. Marking procedures would vary with specific objectives.

Protection of Riparian Habitats

Maintenance of healthy riparian habitats is a major nontimber objective on many forest lands because of the important linkages between forest and streams. Natural riparian ecosystems are complex in structure and composition (Swanson et al. 1982). Coarse woody debris provides much of the basic structure for the smaller streams. Streamside vegetation provides the litter that is the primary energy base of the aquatic community. Because of the diversity of riparian vegetation, these inputs are highly varied in their timing, quality, and quantity.

Riparian management should conserve as much of the rich structural and compositional diversity as possible. Continuing sources of deadwood, especially bigger pieces and more decay-resistant species, are critical. A mixture of herb, shrub, and tree species is desirable for perpetuating litter inputs that vary in timing and quality. Maintenance of multiple-canopy layers can contribute significantly to the structural and compositional objectives as, well as produce a more varied physical environment when canopies include both deciduous and evergreen components.

Riparian protection may be accomplished in some cases by leaving streamside corridors, especially along larger streams. Development of prescriptions for managed riparian zones will be challenging for numerous reasons, including maintenance of desired structure, composition, and windfirmness, over long periods and in the context of fluvial disturbances and treatments on adjacent lands.

LANDSCAPE ISSUES

The previous sections have considered primarily stand-level treatments, but the spatial arrangement of activities and stand types in the landscape is an important consideration in achieving nontimber objectives. This is a large issue that can be raised only briefly here. The importance of spatial arrangement is well known in some cases, such at the juxtaposition of feeding and hiding habitat for wildlife. But many other relationships (e.g., between forests and streams) are poorly appreciated. Some of the most difficult spatial issues involve the arrangement of forest patches on the landscape. The size, shape, and location of individual patches or stands can have profound effects on the overall stability and productivity (for both timber and nontimber objectives) of the landscape (see, e.g., Harris 1984 and Franklin and Forman 1986).

Size and context (degree of contrast with the surrounding landscape) are important considerations when areas are reserved for long periods, as might be the case with old-growth forests. Harris (1984) reviews these issues and proposes a strategy to maintain old-growth patches in the context of an area of long-rotation forest. Size of the core old-growth area is minimized and its viability is maximized by maintaining high forest cover around most of the patch's periphery. Other considerations include the importance of comdors (Forman and Godron 1986) and of reserved areas at low elevations and on more productive forest lands (Harris 1984).

Size, shape, and distribution of patches are also important in the unreserved portions of the landscape. Shape and location of the clearcutting is known to have dramatic effects on windthrow in adjacent forest stands (see, e.g., Gratkowski 1956). The cumulative effects of management activities in a landscape are receiving increasing attention. It is known, for example, that the amount of recently cutover forest can significantly influence hydrologic parameters (see, e.g., Christner and Harr 1982).

Analysis is needed of the long-term, landscape-level implications of the staggered-setting system of clearcutting used on federal lands in the Douglas-fir region (Franklin and Forman 1986). This system, which involves interspersing 25 to 40-acre clearcuttings with green timber, results in a patchwork that maximizes the amount of high-contrast edge within a landscape. Such landscapes may be especially vulnerable to catastrophic windthrow or other disturbances once 30 to 40% of the landscape has been cut over. Furthermore, creation of small management areas and dispersal of operations throughout the landscape may create economic inefficiencies. Ecologic, economic, and social implications of staggered-setting clearcutting and of alternative approaches to managed landscapes need to be carefully evaluated.

CONCLUSIONS

The various alternative management proposals boil down to a basic management principle: maintenance or enhancement of complexity—genetic, structural, and spatial—whenever possible. This is not a plea to stop all activity or to "go natural." Nature is not necessarily right or best. But nature is complex. Processes and organisms have evolved intricate relationships in forest ecosystems.

Forestry needs to put these "lessons" from nature to work for human benefits. Foresters need to reexamine some basic premises and to operate as more ecologically prudent managers. There can be ecologically healthy ecosystems and many forest services and goods with relatively low penalties to wood production. There can be net economic benefits in the short term by adopting these management techniques. Forests can be more productive in the long term because of maintained or increased site productivity. Forest ecosystems that are more resilient and that contain a greater diversity of wildlife and high quality wood can also result. There will certainly be reduced social and economic costs of opportunities lost to future generations.

Incorporating this lesson—managing forests to maintain the variety—is the real challenge for the next generation of silviculturists. Foresters must develop an appreciation of nature's complexity, the merit of that apparent "disorder" or chaos, and must conserve it whenever possible. Foresters need to make natural processes work for society.

There are even fewer absolutes in ecology than in forestry, but an emerging operating maxim is "Simplification is rarely beneficial.

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