

Chapter 5. Looking Ahead: Some Options for Public Lands

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Summary

Intensive and diversified forest management are compared. These approaches represent opposing ends of a continuum of philosophies and of techniques available to the forest manager.

Introduction

Most public forest lands in the Pacific Northwest are and will be used to produce commodities and amenities. We must maintain biological diversity on these lands if we are to achieve multiple-use management objectives that require a healthy ecosystem. The key to a healthy ecosystem is structural and functional diversity across forested landscapes (Franklin and Forman 1987).

We use coarse woody debris as a good example of biological diversity that may be either retained or lost by management decision; each decision will affect forests, streams, rivers, estuaries, and oceans.

We know too little about complex ecosystems (Society of American Foresters 1984b), so we need constantly to re-evaluate management philosophy in light of new information. We conclude this chapter with recommendations for research needed to better understand and maintain biological diversity.

Intensive Forest Management

Intensive forest management is the use of artificial means to produce wood fiber in the shortest time possible. The economic advantage of such management is the continuation of industrial production after the old-growth forest is removed. But biological disadvantages cause concern about the long-term economics of intensive management.

The current approach to intensive forest management maximizes timber output by simplifying forest biology and subsidizing it with energy inputs. This approach homogenizes the forest, thus reducing ecological diversity.

Biological simplification is a serious issue, both ecologically and economically (Old-Growth Definition Task Group 1986). Simplification occurs at many levels, such as genetic, structural, and so forth. Simplification is often carried out when it is not essential to management objectives or is even economically disadvantageous.

Genetic simplification takes many forms, including eliminating or excluding some species and reducing variability in others. Local elimination and subsequent exclusion of a species usually results from accident rather than by design. Exclusion of a species from a significant amount of the landscape can result in extinction, as has been hypothesized for the northern spotted owl (Gutierrez and Carey 1985). Local extinctions in the aggregate cause global simplification through loss of species. Intra-specific genetic variability is often reduced by design in genetic manipulation of Douglas-fir or, even more drastically, in cloning it. Other forest activities, such as artificial regeneration of trees from wild seed, can also result in substantial, unplanned modification of the natural genetic variability.

Structural simplification of stands includes eliminating snags and fallen trees, reducing the range of tree sizes and growth forms, and geometrically spacing trees. Long before intensive forest management was applied, foresters removed deadwood because of concerns about wildfire. Intensive forest management seeks uniformity in tree size and form by concentrating on one or two species. Trees are regularly spaced to optimize stand growth and to provide access for mechanical equipment.

Unmanaged landscapes in the Douglas-fir region are dominated by a wide mix in size of patches, from small to very large, and with a high degree of heterogeneity or structural variability within patches. Patch boundaries often merge gradually or are feathered at their edges. Wildfire and windstorms created most of these patches. Management has increased the number of patches in forested landscapes, particularly with the dispersed clearcutting system used on Federal lands. The patches are much more uniform in size, however, and very homogeneous. The boundaries or edges between patches have also been drastically increased, sharpened, and straightened under intensive management. Management may have increased the number of patches in forested landscapes, but numerous small patches of Douglas-fir less than 100 years of age may not be desirable ecologically or economically (Franklin and Forman 1987, Thomas and others 1979).

The temporal or successional simplification from intensive management affects both early and late successional stages. Rapid establishment of a fully stocked, closed-canopy conifer forest is a major economic objective; planting and elimination of competing vegetation contribute to this objective. Intensive timber management aims to eliminate three successional stages: grass-forb, mature, and old-growth. In coastal Douglas-fir forests of the Pacific Northwest, grass-forb is the earliest stage; the mature stage usually begins at 80 to 100 years of age (culmination of mean annual increment) and persists for about 100 years, during which time substantial growth continues and biomass accumulates. Old-growth conditions develop gradually and begin when the trees are 175 to 200 years old (Old-Growth Definition Task Group 1986). The concept of successional simplification becomes clear when rotations under intensive management are compared with those under unmanaged conditions (fig. 5.1).

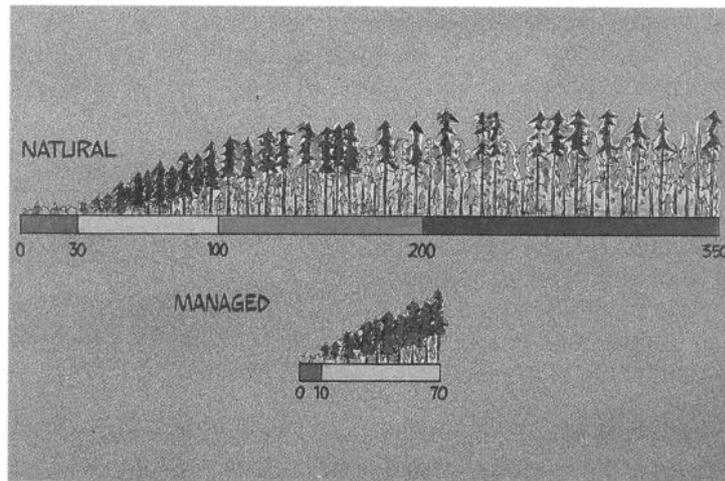


Figure 5.1—Contrast in duration of successional stages under natural and human disturbance regimes. Typical frequency for fire return under natural conditions is 350 to 450 years in northern Oregon and Washington. Normal rotation for managed stands is 70 to 90 years. Managed rotations eliminate the mature and old-growth stages of stand development and abbreviate the open, preforest canopy stage.

Diversified Forest Management

Diversified forest management emphasizes maintaining long-term site productivity through ecological diversity in the forest portion of the ecosystem. This method includes rotations longer than 80 years, reinvesting organic matter and nutrients in the site in the form of large snags and down stems, and producing diversified forest products.

The biological advantage of diversified forest management is that forest health is maintained indefinitely. But the social and economic disadvantage is disruption of industrial and community stability during the transition period to diversified management. Essentially, the choice is between short-term or long-term effects.

Maintaining Options

Maintaining options is the basis of diversified forest management. A manager retains the ability to respond to changes in product needs, in environmental conditions, and in knowledge about how forests function. Economic conditions and markets have changed drastically in the last two decades. Is there any reason to expect greater stability in the future? Climatic changes and increasing pollutant loads can be expected. Do our tree-breeding programs take these changes into account?

Diversified management accommodates change and recognizes our limited knowledge of how forests function. The amount of fundamental information, such as that concerning the dynamics of the belowground forest component, is growing rapidly. Only about 20 percent of the biomass is belowground, but turnover of fine roots and mycorrhizae may be so high that most of the photosynthate is needed for their maintenance. Other examples of recent scientific findings are: (1) the importance of photosynthesis that occurs outside the normal growing season—including such sites as the productive coastal Sitka spruce-western hemlock forests (Franklin and Waring 1980); (2) the significance of tree canopies as sites for condensing and precipitating water,

nutrients, and pollutants-producing, on some sites, 25 percent or more of the water input (Harr 1982); and (3) the many locations at which nitrogen fixation occurs in forests-in canopy lichens (Carroll 1980), in fine litter (Silvester and others 1982), in rotting wood (Harmon and others 1986), through small mammals (Li and others 1986), and in the rhizosphere (Li and Castellano 1987). The importance of coarse woody debris has been recognized only since the late 1970's.

Maintaining Forest Productivity

Compared with an intensively managed forest, a diversified forest provides a greater array of timber products and biological organisms and much greater inputs of soil organic matter and nutrients. Safeguarding the genetic diversity of a forest contributes to sustained productivity because the potential for loss of trees to pathogens, climatic change, or pollutants is less.

A diversified forest contributes significantly to the stability of streams, rivers, and estuaries; it provides coarse woody debris, essential to the stability, diversity, and productivity of the tributary aquatic portion of the ecosystem. Intact riparian zones help maintain high water quality and provide large pieces of organic material.

Accommodating Early and Late Successional Species

Intensive forest management shortens the early stage in succession that precedes tree canopy closure and eliminates the late successional stages. In contrast, diversified management accommodates all successional stages.

Many organisms use early successional stages. The herb and shrub stage has the highest diversity (number of species) of any stage in forest succession. This is also the stage of succession during which nitrogen-fixing plants, such as alder, ceanothus, and lupine, carry on most of their activity; the largest single input of nitrogen occurs during this successional stage.

The young, closed-canopy forest, by contrast, is the least diverse stage of succession; here also, the trees mobilize all resources of the site. The relation between species diversity and successional stage is exemplified by mammals (fig. 5.2). Other groups of organisms, including higher plants and terrestrial and aquatic invertebrates, show similar relations.

The time of full canopy closure can be delayed by using wide spacings, which also might reduce planting and thinning costs (Oliver 1986). Results of spacing trials suggest that such stands produce lower total yields but produce trees with much larger diameters (Reukema 1970).

Maintaining mature and old-growth stands can be facilitated by reserving existing stands and creating new stands with long rotations. Management regimes can be designed to generate old-growth characteristics earlier than would occur under natural conditions (Old-Growth Definition Task Group 1986). Harris (1984) suggests a scheme that combines old-growth islands with much larger, long-rotation buffer areas.

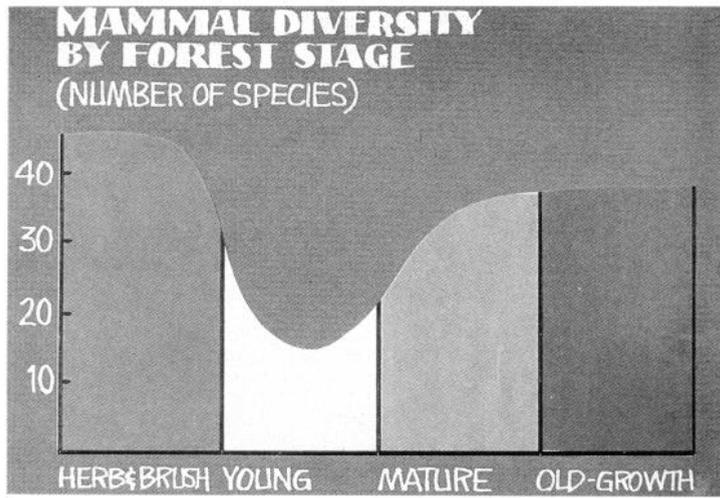


Figure 5.2—Relation between successional stage and number of mammal species using each stage as primary habitat (data based on Harris 1984).

Reservation and creation approaches are both needed because some reserved mature and old-growth stands will be lost to catastrophe as reserved forest patches in highly fragmented landscapes are lost now (Franklin and Forman 1987, Ruediger 1985). Loss of old-growth stands to natural successional processes does not appear to be a serious problem because changes are slow and stands appear stable for many centuries.

Natural old growth is a finite resource from which we must learn to simulate the old-growth condition in the managed forest. Our ability to successfully implement long rotations is unproved, even with the current knowledge of old-growth forest characteristics. Ecological theory suggests that reserved old-growth islands will have greater diversity than old-growth islands created from managed forests (Harris 1984).

Mixed Stands

Soil improvement is a major objective of growing mixed-species stands. The classic example is using alders in mixture with conifers because of alder's nitrogen-fixing capabilities; other species also have favorable nutrient benefits. Cedars and related species (Cupressaceae and Taxodiaceae) are calcium accumulators (Kiilsgaard and others, in press; Zinke and Crocker 1962). Cedar litter contributes to development of soils comparatively rich in bases, low in acidity, and more favorable to biological productivity (Alban 1967, Turner and Franz 1985). Many hardwoods also produce a base-rich litter.

Hardwoods mixed into coniferous stands may be appropriate for a variety of non-timber objectives besides their effects on soil nutrients. Deciduous hardwoods result in an open canopy for part of the year and thus influence conditions on and in the forest floor. Some invertebrate and vertebrate populations respond favorably to increased sunlight. Hardwood trees themselves provide a very different habitat for epiphytes, invertebrates, and some kinds of predators. Bigleaf maple, for example, is an outstanding substrate for epiphytic plants.

Mixed-structure stands could be created to provide truly uneven-aged stands with the classic, inverted-J, size-class distribution, which means that the large number of small trees decreases as the size of individual trees increases. This is often interpreted as indicative of a stable population. A single-tree selection system could be used to manage such a stand for continuous yields. Consequences of such a harvest system on specific species will vary from site to site and will depend on the mix of shade-tolerant and shade-intolerant species. A much simpler and broadly relevant example of a mixed-structure stand is 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 could create greater canopy diversity (perhaps for wildlife habitat or moisture condensation), provide a source of large deadwood structures, or produce higher quality wood.

Protecting Riparian and Wetland Habitats

Healthy riparian habitat is an important goal of diversified management. Coarse woody debris provides much of the basic structure for the smaller streams. Litter from streamside vegetation provides the primary energy base of the aquatic community.

Riparian management should conserve as much structural and compositional diversity as possible. A mixture of herb, shrub, and tree species is desirable for perpetuating litter and wood inputs that vary in timing and quality. Maintaining multiple-canopy layers contributes significantly to structure and composition, as well as to a more varied physical environment in which canopies include both deciduous and evergreen components.

Streambanks may be protected by maintaining vegetated corridors, especially along large streams. Prescriptions for managing riparian zones must include methods for maintaining needed structure, composition, and windfirmness over a long period in harmony with treatments on adjacent lands.

Maintaining Coarse Woody Debris In the Ecosystem

Providing coarse woody debris to the terrestrial and aquatic portions of the ecosystem is a major challenge in land management because of the linkages involved. These include a continuous flow from (1) producing large trees to (2) creating and maintaining large snags to (3) creating and maintaining downed stems and, finally, to (4) producing and transferring wood from the terrestrial to the aquatic environment.

Snags and downed stems are transitory structures, so they must be produced continuously. Snags are especially short lived in the Douglas-fir region, rarely persisting (in forms useful to cavity dwellers) beyond 60 or 70 years. To fulfill all functions, snags must also be renewed in sizes greater than 24 inches in d.b.h.

The practice of removing unmerchantable material is ecologically undesirable when all large woody material is removed from a site. Such practices need to be modified or eliminated.

Some live trees can be retained as sources of future snags. Saving trees with crown and upper stem defects, such as top rot, broken top, or fork, is desirable because they are likely to contain some decay that produces desirable snags for cavity dwellers. Lower stem, butt, or root defects should be avoided because they may be susceptible to windthrow that would reduce their longevity as snags. Live trees may also be converted to snags by fire or girdling. One strategy may be to kill trees at intervals to provide a continuing source of snags through the next rotation.

Need for a Landscape Perspective

The size, shape, and location of individual forest patches or stands have profound effects on landscape stability and productivity (Franklin and Forman 1987). The spatial arrangement in the landscape of management activities, stand types, stream habitats, and so forth is also critical to diversified management. In some cases, the importance of spatial arrangement is well known, such as the juxtaposition of feeding and hiding habitat for wildlife. But many other relations, such as those between forests and streams, are poorly understood. One of the most difficult spatial issues is the movement and changing roles of wood in a river drainage, from headwater to estuary. Aggregates of wood in aquatic ecosystems have great significance for productivity and biological diversity.

Size, shape, distribution, and context (degree of contrast with the surrounding landscape) of diverse patches are important landscape considerations. Shape and location of clearcuts have dramatic effects on windthrow in adjacent forest stands (Gratkowski 1956, Ruth and Yoder 1953) and the amount of recently cutover forest can significantly influence hydrologic regimes (Christner and Harr 1982, Geppert and others 1984).

The staggered-setting system of clearcutting, used widely on Federal lands in the Douglas-fir region, intersperses 25 to 40-acre clearcuttings with live timber and results in a patchwork that maximizes the amount of high-contrast edge within a landscape. Such landscapes are particularly vulnerable to catastrophic windthrow or other disturbances once 20 to 30 percent of the landscape is cut over. Forest patches large enough to provide an environment suitable for species that inhabit the forest interior generally disappear by the time half the landscape is cut over. Furthermore, creating small management areas and dispersing management operations over the landscape is economically inefficient. Many effects of management could be reduced by aggregating rather than dispersing cuttings, although cumulative effects on hydrologic regimes would need to be carefully considered. Evaluating specific ecologic, economic, and social implications of staggered-setting clearcutting and alternative approaches of managed landscapes is badly needed (Franklin and Forman 1987); however, the general importance of a landscape perspective in management decisions is already clear.

Information Needed for Developing Improved Management Regimes

Little biological research was done in Pacific Northwest forests before about 1950. Then research facilities were expanded to allow some scientific focus on the more obvious and practical issues of that time, such as growth and yield of forest stands, methods for tree regeneration, and control of various tree-damaging agents. We have only recently begun to identify critical ecological questions. Quantifying many of the relations, such as those between levels of coarse woody debris or habitat for specific

organisms, is demanding and expensive. Much research is still needed to convert the qualitative information to management prescriptions and to confirm hypotheses about the role of woody structures in the world ecosystem.

Needed research appears to fall into three major categories: (1) long-term site productivity, (2) roles of coarse woody debris, and (3) dynamics of coarse woody debris.

Long-Term Site Productivity

No more important forestry issue exists than that of the sustainability of commercial forest-land productivity. This requires more than simply insuring that soils are not compacted or eroded or that some critical level of soil nitrogen is maintained. But, unfortunately, our knowledge does not go much beyond this simple perspective. We must have more insightful information; at the least, we need to determine what is required for sustaining forest production.

One major component of needed research is quantifying the effects of coarse woody debris on site productivity, including the contribution of coarse woody debris to the physical, chemical, and microbiological properties of the soil. What role do decay-resistant components of wood play in soil structure? How important are pockets of woody material in a soil matrix in the functioning of specific belowground components, such as mycorrhizae, at specific times of year and in different forest types? What role do dead roots play in maintaining soil structure and providing belowground energy and nutrient sources?

The relation between woody debris and long-term productivity is critical for freshwater, estuarine, and marine portions of the ecosystem just as it is for the terrestrial portion. Developing information for aquatic communities may be more difficult because the supply and dynamics of wood in rivers must be considered over an entire drainage.

We must synthesize existing and new information. Computer models can now address some questions of long-term site productivity (Kimmins and Scoullar 1979, Shugart 1984). Such models are valuable tools in synthesizing and identifying information needs. Models are also the only way we can explore the effects of various management activities as they might develop over decades or even centuries; thus, refining old models and developing new ones are high priority. Such models are as much management tools as research tools.

Quantifying the Roles of Coarse Woody Debris

We know that snags and downed stems are important in terrestrial and aquatic environments, but we do not know how much of this material is needed in what sizes, decay states, or spatial arrangements. These questions must be primary research objectives because management costs associated with creating and maintaining coarse woody debris are considerable.

Quantifying needs for coarse woody debris to achieve both game and nongame wildlife objectives is a pressing management issue. We know that coarse woody debris is an essential resource for animals, but we do not have detailed information on how much is needed. Important variables include snag and down stem densities, tree species, decay state, and size. The spatial arrangement of downed stems on cutover areas is also important. How much continuity is required from the standpoint of animal movement into and across cutover areas?

A long-term experiment at the H.J. Andrews Experimental Forest in western Oregon will examine the effects of several management treatments on site productivity. Coarse woody debris is one major variable in the experimental design that has the specific objective of quantifying the effects of downed stem density and spatial arrangement on mammals' movements into and across clearcuts. Studies of this type are expensive but essential for getting quantitative information needed for long-term management decisions.

Research also needs to be conducted on the roles of coarse woody debris in geomorphic processes and in aquatic environments from headwater streams to deep ocean habitats. How do stem size, density, and spatial arrangement (parallel or at right angles to the slope) affect surface erosion? How are the quantitative relations between stem or log-jam numbers related to aquatic productivity? What densities and sizes of stems are necessary for essential structural diversity and substrate in estuarine environments?

Dynamics of Coarse Woody Debris

Snags and downed stems are transient structures, so knowledge of their dynamics is essential. Much useful information has already been generated from various ecosystem and wildlife-oriented research programs. Among other things, this information has created an understanding of the highly variable nature of coarse woody debris and its decomposition.

The factors that affect patterns and rates of disappearance of snags and downed stems are important variables for which information is inadequate. These variables include tree species, cause of death, size of piece, wood quality as reflected in growth rate and proportions of heart and sapwood, and patterns of decomposition along major environmental gradients. Some contrasts are already apparent between mixed-conifer and ponderosa pine forests east of the Cascade crest and the Douglas-fir-western hemlock forests to the west, but information is fragmentary. Patterns of decomposition relative to moisture and temperature need to be learned. Other variables that need to be investigated are comparisons of wood decay in clearcuts and forests and comparisons of decay of burned (charred) vs. unburned material of comparable type.

Similar wood decay variables require investigation in aquatic environments. There are additional important dimensions, such as how does mechanical battering affect fragmentation of large wood in streams and the ocean? How does transport and aggregation of woody debris in aquatic environments differ from that on land?

A long-term study of wood-decay processes at the H.J. Andrews Experimental Forest (fig. 5.3, color) is designed to examine the effects of tree species (Douglas-fir, western hemlock, western redcedar, and Pacific silver fir), wood size, and early insect colonizers on pattern and rate of decay. Nearly 500 logs about 24 inches in diameter and 19.5 feet long have been placed in a replicated design that should allow sampling to continue for about two centuries. This study has already provided some surprising results, especially on the effects of invertebrate populations. A related study of decomposition in aquatic environments has been established in a third-order stream with smaller logs of Douglas-fir, red alder, and western hemlock.

Synthesis of information on the dynamics of snags and downed stems should take the form of simulation models. Only one model deals with the dynamics of woody debris over long periods (Graham 1982); such models need much greater emphasis. Simulators are needed that can provide managers with information on the yield of coarse woody debris for different environments and under different management regimes—yield models for dead material instead of live trees!

Conclusion

The challenge to managers of public forest lands is to maintain ecological diversity in perpetuity. We must understand and accept biological complexity. We must follow the basic principle of maintaining or restoring genetic, structural, and spatial complexity.



Figure 5.3—An experimental study of log decomposition planned to span a 200-year period has been installed at the H.J. Andrews Experimental Forest in the central Oregon Cascade Range; major variables include species, size, and presence or absence (log enclosed in insect-proof tent) of invertebrates during early stages of decomposition.