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CHARACTERISTICS OF OLD-GROWTH DOUGLAS-FIR FORESTS

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ABSTRACT

Old-growth forests in the Douglas-fir region are distinguished primarily by several structural characteristics including a wide range of tree sizes and ages, a deep multilayered crown canopy, large individual trees, and accumulations of coarse woody debris including snags and down logs of large dimension. Old-growth forests are compositionally diverse and include many species for which it is optimum habitat. Old-growth forests are productive although the bulk of the energy is used for respiration. Wood accumulations tend to be stable with growth at least balancing mortality. Nutrient losses and erosion are generally low in old-growth watersheds. The large trees, snags, and logs are the key structural features of old-growth; silviculturalists can use these as critical elements in developing and applying management schemes.

INTRODUCTION

In the Pacific Northwest, old-growth forests connote stands 250-750 years old that contain variable numbers of large Douglas-fir (Pseudotsuga menziesii). Our objective is to provide a more specific working definition of old-growth Douglas-fir forests using information at hand. Current field work is revealing infinite variations in old-growth forests, yet, some general characteristics of composition, structure, function, and age of the ecosystem can be used to put limits on this diverse concept.

Our scope is confined to the Douglas-fir region of the Pacific Northwest--areas at low to moderate elevations west of the Cascade Range where Douglas-fir is or can be a dominant species. It is important to remember that old-growth forests in other regions have their own characteristic composition, structure, and function. Old-growth forests of ponderosa pine (Pinus ponderosa) or lodgepole pine (Pinus contorta), for example contrast sharply with those of the Douglas-fir region.

We begin with a synthesis of old-growth characteristics, developed as part of the Society of American Forester's Task Force on Scheduling of Old-Growth Harvest, and based on field research throughout the Douglas-fir region. More detailed discussions about the features of composition, function, and structure will follow and correct some of the myths surrounding old-growth forests. We conclude by contrasting old-growth Douglas-fir with other old-growth forest types.

HOW MUCH OLD-GROWTH FOREST IS THERE IN THE DOUGLAS-FIR REGION?

The Douglas-fir region had about 15 million acres of old-growth forest in the early 1800's. This figure is based on an estimated 25 million acres of commercial forest land; 60-70 percent of such lands were characteristically in old-growth, based on age class distributions in Mount Rainier and Olympic National Parks. The Sociey of American Forester's Task Force estimates around 5 million acres of this old-growth remains.

Approximately 1 million acres of old-growth forest are reserved in western Washington and Oregon within National Parks, Wilderness areas, and Research Natural Areas. Much of this acreage is subalpine forest at higher elevations, so the percentage of old-growth forests of Douglas-fir is considerably less than 1 million acres. Most of the old-growth Douglas-fir forests are reserved in western Washington in the Olympic, Mount Rainier, and North Cascade National Parks, and in the Glacier Peak and Alpine Lakes Wilderness areas.

A DEFINITION OF OLD-GROWTH FORESTS IN THE DOUGLAS-FIR REGION

It is clear that a simple, precise definition of old-growth forest is unlikely. It is necessary to use a variety of characteristics or criteria because there is wide variability in values for a given characteristic. Some key, objective characteristics of old-growth stands are:

1. Two or (commonly) more tree species with a wide range in size and age and often including a long-lived seral dominant (for example, Douglas-fir) and shade-tolerant associate (for example, western hemlock, Tsuga heterophylla);

2. A deep, multilayered canopy;

3. Individual live trees (more than 10/acre or 25/hectare) that are either old (>200 years) or have become large (>40 in or 1.0 m d.b.h.);

4. Significant coarse woody debris, including snags (>10/acre or 25/hectare over 20 ft or 6 m tall) and downed logs (>20 tons/acre or 50 metric tons/ha); and

5. Snags and logs (minimum 4/acre or 10/hectare) of large dimension (>24 in or 60 cm diameter and >50 ft or 15 m in length).

Old-growth stands also have a number of other attributes, such as a rich diversity of plants and animals, some of which are found primarily in old-growth forests.

Age, alone, is often an unsatisfactory criterion of old-growth conditions, because structural features characteristic of old-growth stands develop over different amounts of time, depending on site conditions and stand history. For example, large, live trees can grow relatively rapidly on high-site lands; Douglas-fir site I land in the Oregon Coast Ranges may produce trees of 40 inches (1 m) in diameter in 100 years, although the trees may lack decadence (for example, broken tops). On poor sites, trees that large may take 200 years to develop and overall stand characteristics may develop even more slowly. On Douglas-fir site III lands, old-growth tree and stand characteristics emerge at around 200 years old, ± 50 years.

Stand history also plays an important role. Understocked stands produce larger trees earlier, other site conditions being equal. Stands developing after clearcutting will typically take longer to develop appropriate levels of snags and downed logs since few, if any, are carried over from the prior stand. This is in marked contrast to stands destroyed by natural disturbances, such as fire and wind.

Most of the old-growth stands in the Douglas-fir region have developed over 250-750 years since their origin. The most common age classes are probably between 400 and 500 years in the Cascade Range. Stands with Douglas-fir trees over 1,000 years old are occasionally encountered, however (Hemstrom and Franklin 1982). Senescence may appear in some old-growth forests, although it appears that old-growth stands of Douglas-fir typically remain intact for 700 or 800 years. On the other hand, some stands may break up at 500 years, while others last well over 1,000 years.

OLD-GROWTH FORESTS ARE COMPOSITIONALLY DIVERSE ECOSYSTEMS

Suggestions have been made in the past that old-growth forests lack biological diversity. They were sometimes termed "biological deserts," perhaps because of past emphasis on game species. Recent research has clearly shown, however, that old-growth forests have substantial diversity in plants, vertebrate and invertebrate animals, and aquatic organisms.

The diversity of old-growth forests is well illustrated with vertebrate animals. In the Douglas-fir region, many species make primary use of old-growth forests (Harris, Maser, and McKee 1982): 16 species of birds and mammals find optimum habitat in such forests (Franklin, and others 1981). Several of these species are unusual, including a foliage-feeding vole (Arborimus longicadus) (Harris, in press). Occurrence of several species is highly correlated with old-growth forest: the northern spotted owl (Strix occidentalis) is the best known example. Whether this or any other species depends on old-growth for survival is unresolved and is a major topic of research. The relatively high overall diversity and strong association of some species with old-growth forest is characteristic of other groups of organisms in addition to vertebrates.

The major point is that old-growth forests are biologically diverse ecosystems. From a biological standpoint, such a conclusion should have been obvious from the beginning. With the large areas of old-growth forest in existence for such long time periods, it is logical to assume that a significant number of species have become adapted to such habitat. It is also reasonable to expect that some of these species have become dependent on the specialized conditions associated with old-growth for their survival.

Finally, it is important to note that the most biologically diverse stage of succession in the Douglas-fir region is usually the open, cutover or burned site prior to closure of the tree canopy. The least biologically diverse stage is the fully stocked young forest, that is, from closure of the canopy to near culmination of mean annual increment.

OLD-GROWTH FORESTS ARE PRODUCTIVE

Old-growth forests are typically productive ecosystems in terms of the total quantity of energy fixed per unit area per unit time (for example, per acre per year). Old-growth forests could be viewed, along with any other stage in forest succession, as healthy, vital ecosystems, fixing and processing large amounts of solar energy.

It is important to distinguish here between productivity as measured by ecologists and by foresters. Gross production in ecological terms is equivalent to the amount of energy fixed photosynthetically per unit area per unit time. Ecologists define net primary production as the biomass increment plus mortality, including litterfall, and materials removed by grazing. A forester's definition of productivity (wood increment) is, therefore, generally limited to only a portion of the ecologist's net productivity and comments on the low productivity of old-growth forests really refers to the relatively low levels of new wood production.

Old-growth forests represent incredible photosynthetic factories. Stand leaf areas are often huge with 12-18 m^2 of leaves per square meter of ground surface being common (Franklin and Waring, 1980). Individual old-growth trees may have 4,000 m^2 of leaf surface on their 60-70 million needles. Obviously, such huge photosynthetic factories could not be maintained if they were failing to support themselves. The few available calculations that have been done show that gross productivity of old-growth forests is comparable to productivity of younger forests but that the vast majority of the production is utilized in respiration (Grier and Logan 1977).

It appear's that many old-growth forests manage to maintain wood levels or actually increase them. Only two growth studies of old-growth forests are available (Berntsen 1960, King 1961), but they show growth exceeded mortality, even though stands were subject to major attacks by the bark beetle during the period of measurement:

Location and stand age	Period of measurement	Gross growth	Mortality	Net growth
		- - - -Board feet/acre- - - -		
Clackamas River, Oregon, 250 years	1948-58	1,582	1,156	426
Wind River Washington, 450 years	1948-60	699	614	85

It is logical to conclude that old-growth forests tend to be stable in terms of their biomass or board foot accumulation. Foresters have long recognized the basic stability of wood accumulations in old-growth forests, hence the expression "storing wood on the stump." We have also begun to realize that significant tree and forest growth goes on well beyond culmination of mean annual increment (Williamson and Price 1971). Indeed, by cutting forests at culmination, we are really cutting them as they make the transition from ecologically young to ecologically mature forests; growth and biomass accumulation are far from complete at such a stage.

Wood accumulations in old-growth forests are usually stable over the long run. Stands generally will not disappear in decades or even centuries as a result of mortality and diseases.

OLD-GROWTH FORESTS ARE CONSERVATORS

Probably more data are available on the protective functioning of old-growth forests than any other functional aspect. This would include their role in maintaining water quality and conserving nutrients and soil. Old-growth forest systems are highly retentive of nutrients. Large amounts are tied up in living and dead organic material and are released only slowly. Internal recycling is rapid. Nutrient levels leaching into ground water and appearing in streams is, therefore, very low (Sollins and others 1980). Soil erosion is also typically low compared to the earliest stages in forest succession. The combination of low losses of dissolved nutrients and of particulate matter explains the high quality of water characteristic of old-growth watersheds (Swanson and others 1980).

Old-growth forests also affect water yield, but a recent study indicates the affect may not be as simple or obvious as previously supposed. In an earlier synthesis of old-growth characteristics (Franklin and others 1981), old and young forests were assumed to have similar effects on water cycles; for example, on transpiration losses. Harr (1982) recently reminded us of the importance of cloud and fog condensation on tree canopies in some regions. In a portion of the Bull Run watershed for the city of Portland, Oregon, fog drip from the natural forest cover may contribute up to 30 percent (35 inches) of the measurable precipitation per year. This was discovered after clearcutting some experimental watersheds ultimately reduced rather than increased water yields. Since old-growth forests typically have deep, multilayered canopies and high leaf areas, we can expect them to be more effective than young forests at condensing and precipitating moisture and atmospheric particulates.

A final comment on the protective functions of old-growth forests concerns their role in insect, disease, and fire control. Old-growth forests are sometimes described as insect- and disease-ridden ecosystems that represent a hazard to adjacent managed forests or as forest systems that increase fire risks. In the Douglas-fir region, old-growth forests rarely appear to provide reservoirs of pathogens hazardous to managed stands. In general, contrasting forest conditions have different arrays of insects and diseases. Those that might be common in the old-growth stands (for example, dwarf mistletoes or shoestring root rot) can either be isolated or have low rates of spread. Intensively managed young forests are proving to have a number of pest problems but few are likely to have their source in adjacent natural forests. Similarly, fire risks are very low in old-growth Douglas-fir forests because of several factors, including the type of microclimate created within the forest. Once fires are ignited in old-growth forests, however, they are difficult to control because heavy fuel loading and abundant snags that help spread the fire.

OLD-GROWTH FOREST ARE STRUCTURALLY DIVERSE

Structural diversity is the characteristic where the greatest contrasts are found between intensively-managed commercial timber stands and unmanaged forests, including old growth. Wide ranges in tree size, dense and deep forest canopies, and abundant dead wood are common structural features of old-growth stands (Franklin and others 1981). Average diameters and heights in old-growth stands may be similar to those of much younger stands, but the range of values is much greater in old-growth and size-class distributions tend strongly towards inverse J-shaped curves. Old-growth canopies are commonly multistoried or continuous to near ground level. Dead wood in the form of snags and downed logs is generally common or abundant. Although a notable part of old-growth stands, such material is actually common in unmanaged stands in all successional stages in the Douglas-fir region.

The obvious structural elements characteristic of the old-growth forest are the large live trees, large snags, and large downed logs on land and in streams. This is important because many of the special features of composition and function found in old-growth forests relate to these structural elements. Managers can use these structural features as critical elements in developing and applying management schemes. It is noteworthy that two of the tree structures (snags and logs) are composed of dead wood; dead wood plays extremely important roles in natural ecosystems.

Live old-growth trees are commonly 40-60 inches (1.0-1.5 m) in diameter and 160-270 ft (50-80 m) tall. Long-lived seral species, such as Douglas-fir or western redcedar (Thuja plicata), provide structures of more fuctional value than do some climax species, such as western hemlock and Pacific silver fir (Abies amabilis). The climax species do not attain comparable sizes or persist as long as snags and downed logs.

As befits their antiquity, live old-growth trees tend to be individualistic with large branch systems and deep crowns and often have multiple or dead tops and heart rots. All of these characteristics contribute to their value as habitat for animals and other plants (Franklin and others 1981).

Large snags are best known for their value as wildlife habitat. Large, hard snags (>24 inches or 60 cm in diameter and 50 ft or 15 m tall) are particularly valuable sites for primary cavity excavators. Snags have other values, similar to those of downed logs, in carbon and nutrient cycles.

Large, downed logs serve many important ecological functions on both upland and in streams. On land, downed logs function as wildlife habitat; sources of organic matter, carbon, and nutrients; sites for nitrogen fixation; nurse logs for plant reproduction; and impediments to erosion. In streams, downed logs function (Swanson and others 1982b; Triska and others 1982) as: components and creators of habitat and, consequently, biological diversity; dissipators of stream flow energy dissipators, reducing channel cutting and other erosion; sites for nitrogen fixation; and retention devices to help trap and hold plant litter along stream reaches until it can be utilized by stream organisms.

NOT ALL OLD-GROWTH FORESTS ARE AS ABOVE

General features of old growth are similar in many other western forest types--the presence of relatively large trees and of dead wood, for example. Details of structure, composition, and age vary widely, however.

Old-growth forests of coastal Sitka spruce (Picea sitchensis)-western hemlock have a varied composition in which the spruce, Alaska-cedar (Chamaecyparis nootkatensis), and western redcedar, provide the larger trees and longer-lived dead-wood structures. Old-growth spruce-hemlock forests typically have a better developed understory of herbs and shrubs than younger stands, of great importance for wildlife (Alaback 1982). The ratio of snag to downed log volume is generally lower than in Douglas-fir old-growth forests.

Mixed conifer types in the Rocky Mountains and Sierra Nevada are highly variable in their old-growth characteristics, but large, live trees, large snags, and large downed logs are important as are deep, multilayered crown canopies. Most stands are mixtures of long-lived seral species that can attain large sizes, such as the pines or western larch (Larix occidentalis), and tolerant climax species, such as white fir (Abies concolor). High levels of wildlife use are characteristic (Thomas 1979).

Pine forests probably differ most markedly from Douglas-fir in old-growth characteristics. With ponderosa pine, large live old-growth trees and large snags are important, but levels of downed logs are typically low because of frequent fires. Old-growth lodgepole pine forests may lack large trees, relative to other types. Snags and downed logs may be abundant but small in size, reflecting maximum tree sizes typical of the site. Senescence and deterioration occur much earlier and more commonly in lodgepole pine than in the other old-growth conifer types discussed.

Old-growth forests in the eastern United States also share many characteristics with western old-growth forests. High levels of biological diversity, structural heterogeneity, and functional vitality are characteristic of old-growth, deciduous, hardwood forests. Large, individualistic live trees and major accumulations of dead wood in the form of snags and logs are common. Residual trees carried over from earlier stands may be important as cavity trees.

CONCLUSIONS

Old-growth forests in the Douglas-fir region appear to provide highly specialized habitats that are neither unproductive ecosystems nor biological deserts. There are major contrasts in composition, function, and structural features between old-growth and managed young-growth stands. Differences between old-growth stands and unmanaged young-growth stands are often one of degree because much structural material, such as large snags and logs, is carried over from the old stand to the new stand. Management schemes for old-growth forests can be keyed to three structural components: large live trees, large snags, and large downed logs. It is also possible to create many of these attributes in less than 200 years through appropriate management practices.

Professional foresters need to see old-growth forests more clearly; we sometimes emphasize only attributes consistent with our current management goals or policies. Viewed objectively, old-growth forests are neither the paragon of virtue and beauty imagined by some, nor the purposeless wastelands imagined by others. These forests have value and perform some functions as well or better than managed forests. We need to acknowledge this in our resource planning and, in some cases, to incorporate attributes of natural forests in our schemes for intensive management. Decadence is not a standard characteristic of old-growth forests nor are all managed forests vital. Objectivity in viewing either our handiwork or nature's handiwork is essential to our professional credibility. In the short run, such knowledge and acknowledgment may sometimes make it harder to do our job, but it will ultimately result in a better job of land stewardship.

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