Summary of Workshop on Development of Old-Growth Douglas-fir Forests along the Pacific Coast of North America: A Regional Perspective

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Written by

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Abstract

Thirty scientists and managers met recently in a workshop to share information from recent studies of old-growth forest development across the coastal Pacific Northwest and British Columbia and identify major questions and information gaps. Some of the major findings of the workshop were: 1) old-growth forests are regionally more diverse in structure and development than has been appreciated by the scientific community, managers, policy makers and the public; 2) despite this diversity these old forests generally share similar attributes including structure and spatial heterogeneity and presence of large live and dead trees 3) low severity fires have played an important role in the development of old-growth forests in the southern part of the region and fire suppression is changing the character of these old-growth forests; 4) The primary implications to management of these new findings are that old-growth management strategies including definitions, fire management policies, and restoration in young plantations will require a diversity of approaches that are tuned to environment, disturbance regime and forest composition of an area. The group agreed that a better understanding of the pathways of old-growth development is needed and new communication are needed to inform policy makers and the public about the implications of recent findings to policies designed to maintain or restore old-growth forest habitats.

Introduction

Old-growth Douglas-fir forests have been at the center of management and policy debates for over 20 years. In the last 10 years, new policies have been implemented to conserve old forests and their associated species. These management and policy changes have focused more on species habitat needs and less on the processes that maintain these forests and possible future changes to these forest habitats. In recent years we've learned much about the disturbance and development history of old-growth Douglas-fir forests. For example, studies of fire history in Oregon have demonstrated that low to moderate severity fires have played a major role in development of the old-growth stands in the southern part of the region. Other studies in Washington and British Columbia provide a different picture of old-growth development in which stands develop with little or no influence from fire. A fundamental question that has arisen is "Do findings from recent studies of old-growth history and development require reformulating our conceptual scientific models of old-growth forests and/or our strategies for conserving and restoring ecological values associated with old forests?"

A small workshop was held recently on old-growth forest development to address the above question. On November 7-9, 2001 about 30 scientists, managers, and students from Oregon, Washington, and British Columbia met at the HJ Andrews Experimental Forest to begin a dialog about the science of old-growth forest development and its implications to policy and management. The workshop, which was intended to be a beginning of new discussions and communications about old growth rather than an end in itself, was sponsored by the Pacific Northwest Research Station and the Cascade Center for Ecosystem Management. Thomas Spies of the PNW Research Station and Robert Pabst of Oregon State University organized the meeting. Fred Swanson (PNW), John Tappiener (OSU), John Cissel (Willamette N.F.) and Jerry Franklin (University of Washington) assisted with planning.

The objectives of the meeting were to:

1) Share information about old-growth Douglas-fir forest development from studies in areas ranging from S.W. Oregon to British Columbia.
2) Synthesize recent studies and update conceptual models of old-growth development in natural and managed stands.
3) Identify major questions and information gaps.
4) Identify implications to management of current natural and managed stands of all ages.
5) Plan for further communications.

Summary of the Workshop

We summarized the workshop under the following headings:

- Old-growth concepts and definitions
- Variation in old-growth at multiple spatial scales
- Temporal variation
- Multiple pathways of development
- Management implications

Old-growth concepts and definitions

The meeting presentations and discussions focused primarily on coastal Douglas-fir and associated-species (e.g. western hemlock, Sitka spruce) forests from southwestern Oregon to southwestern British Columbia. The workshop was limited in this way to provide focus and address a forest type and region that has been a center of considerable scientific study as well as management controversies. Old-growth Douglas-fir/western hemlock forests of the region have, for better or worse, also become a global model for old-growth ecology and conservation. Several of the attendees pointed out that the excessive attention on coastal Douglas-fir types may have skewed national and global perceptions and management debates because some users of the information from the Pacific Northwest may not understand how to apply the findings to their forest types and environments. While Douglas-fir and other coastal conifer forests are distinctive they do fall into a class of forest characterized by low to moderate frequency fires and dominated by large, long-lived seral species. Many pine, larch, and Eucalyptus forests throughout the world have similar disturbance regimes and structure.

In his presentation to open the workshop, Spies pointed out that from a scientific perspective old growth has been defined in several different ways, including definitions based on structure and those based on processes. In 1989 Spies and Franklin developed a "generic" definition of old growth for the Forest Service. According to this definition "Old-growth forests are ecosystems distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from younger stages in a variety of characteristics that may include tree size, accumulations of large dead woody material, number of canopy layers, species composition and ecosystem function." Since this definition was developed researchers have learned that vertical and horizontal structural heterogeneity is an important definitional element of old-growth forests.

The workshop did not attempt to reach a consensus on a definition and it was clear that attendees had different opinions on wording of old-growth definitions, or even whether it was useful to spend time trying to define old growth. Some managers felt that it was important to define old growth in both operational ways and in ways that can be communicated with the public. Some attendees advocated using the term "late successional" to refer to old growth and mid and early successional to refer to mature age and young forests, respectively. Others, were not comfortable using a term that lumped all stands over about 80 to 100 years of age into one type called "late successional". While there was relatively little consensus in defining old growth, there appeared to be a strong general belief that stand age alone was not a useful criterion in defining old growth, particularly in areas where old-growth forests were maintained by patchy low-severity fires or canopy gap dynamics that create multiple aged stands that can not be assigned to a single age class. In these situations, some participants believed that definitions should focus on the spatial scale and pattern of the entire forest mosaic, not just the patches of large old trees. There was also general agreement that specific definitions of old growth for planning and operational purposes needed to be local (at scale of subregions and major plant community types) and based on scientific knowledge of disturbance regimes and autecologies of individual tree species. Draft definitions for many forest types were prepared by the Forest Service in the early 1990's, but it is not clear how they have been used since then.

The discussions of definitions and presentations on forest development across the region suggest that while old growth is typically seen as a stand-level phenomenon, it requires a multi-scale context ranging from individual trees, to landscapes, and to regions. Old growth is perhaps most tangible at the tree level. Van Pelt presented some outstanding drawings of individual trees of different ages that clearly show the continuous nature of tree growth and the structural changes that occur in boles and crowns as trees senesce with age. At landscape scales, old growth is one component of a spatially and temporally connected shifting mosaic of forest structures and developmental pathways. At the regional scale many of the attendees were quite struck by the evidence of the regional variation in old-growth forests. It is the multi-scale variability in old-growth forests that was a central theme of the presentations and discussions.

Franklin traced the history of old-growth science from the early 70's to the present day. He noted that we have made major advances in our understanding since the early 1980's when the first synthesis paper on ecological characteristics of old growth was published. These advances have occurred especially in our appreciation for the role of old-growth legacies in younger forests, canopy development, epiphytic communities, disturbance history, and nutrient and hydrological cycles.

<u>Variation in Old-growth at multiple spatial scales</u>

At the tree level, the work of Van Pelt and David Ford and his student Hiroaki Ishii, demonstrate that the structural complexity of individual Douglas-firs increases with age in a fairly continuous (but not necessarily uniform) fashion. Crowns become more massive and multi-branched. Epicormic branches become much more common and are produced continuously, maintaining and extending the crown in response to changing canopy conditions (e.g. light) and branch damage or loss. Somewhat surprisingly, epicormic branch formation does not appear to require damage to the crowns or changes in the microclimate of the stands as a result of disturbance that decreases stand density. Instead, it appears to be a function of internal hormonal controls of dormant buds that change with stem elongation and death of the primary buds. The process of epicormic foliage regeneration maintains the photosynthetic viability of the canopy in Douglas-fir for many centuries in contrast to other pioneer tree species whose crown growth and development stops at much earlier ages. These findings suggest that epicormic branches replace most of the primary branches on the mid to lower boles of Douglas-fir trees regardless of stand density. However, the pattern of crown development is probably variable; Winter found that long old-growth crowns at her site developed without epicormic branching from the bole. Future work needs to examine how efforts to retain the primary branch systems through thinning affect crown development given that epicormic branching is a natural process though which Douglas-firs can maintain deep crowns.

At the stand level the focus expands from the development and structure of individual old trees to the development and structure of aggregations of live and dead trees, other vegetation, and the influence of disturbance history. The development of old-growth stands has been observed directly only for less than 100 years from a few permanent plot studies, so chronosequences and historical reconstructions are the primary scientific tools to gain insights into the long-term development of these forests. The workshop attendees briefly discussed the limitations of these approaches. Chronosequences or existing stands of different ages in similar environmental settings, do not necessarily have the same developmental history (e.g. starting conditions, climate, partial disturbances) thus information about old-growth development from this approach can be misleading. Nevertheless, many of the participants found that chronosequences can provide some insights into general trends that occur with stand development if enough stands are included and results are used with caution. Stand reconstructions are limited to the surviving trees and the larger more recently dead trees. Spies and Trofymow used chronosequences of stands in Oregon, Washington, and British Columbia to show the variability that occurs in stand structure with age (for forest types where stand age was relatively easy to determine) and the general trend in increasing structural complexity with time. Trofymow found that with succession by far the greatest changes in biodiversity indicators occurred with canopy closure, that general species diversity indices were of little or no value in differentiating mature from old-growth stands, and that the abundance of specific species or species groups were better differentiators. Hansen observed that pathogens increase with age, in stands resulting in increased fungal species diversity and increased decadence. The comparison of stand-level studies indicates that each method has strengths and weaknesses and that they can complement each other, if used together.

Several stand reconstruction studies provided valuable information about old-growth development, indicating that old-growth forests develop along many different pathways. Poage and Tappeiner presented data from 38 sites indicating that the largest trees in sampled stands in western Oregon began with relatively rapid growth compared to smaller trees in those stands or small trees in nearby stands of similar age. They hypothesize that these trees developed under relatively wide spacing that enabled rapid early growth. Wide spacing may have resulted from low-density regeneration following large fires and/or subsequent partial disturbances that opened the stands up or kept them open. The suggestion that old forests developed under wide spacing generated some heated discussions. Some attendees countered that the fast early tree growth did not necessarily indicate that the stands developed under wide spacing. Another explanation could be that height differentiation within relatively dense stands could result in differences in growth rates even in dense stands. Winter presented results from a stand in Washington in which old-growth Douglas-firs established only during a relatively short 20 year period of time about

500 years ago. The stand remained relatively closed during its lifetime with variable regeneration of hemlock. Medium-sized canopy disturbances occurred that accelerated the growth of understory hemlocks but not result in regeneration of Douglas-fir. Goslin presented case studies of two stands on mesic sites in western Oregon that developed complex forest structures as a result of multiple moderate severity fires. This work demonstrated that remnant trees could affect the subsequent development of young stands that regenerate after fires. He also observed a 30- to 40-year period of Douglas-fir establishment that could have enabled the early colonizers to achieve rapid growth rates.

A series of individual case studies presented a picture of regional variation in old-growth forest structure and development that was amazing to many at the workshop. Swanson showed how widely fire regimes vary across the region. In southwestern Oregon, old-growth stands developed under a regime of almost continuous regeneration of trees driven by fires that occurred with an average frequency of 7 to 13 years (Atzet and Sensenig). Stand age in these landscapes has little meaning as individual trees of all ages can be found and old trees frequently exist as widely scattered individuals. It may be more valuable to use age distributions in these forest types rather than average or dominant stand age. In contrast, at the other end of the regional gradient in British Columbia, Lertzman demonstrated that where fire is rare or absent in old-growth forests, shade tolerant trees regenerate and reach the canopy in small gaps created by wind and disease. In such landscapes old-growth conditions are ubiquitous because forests are typically a fine-grained mosaic of old and young trees.

Between the extremes old-growth forests appear to have developed along a gradient of decreasing fire frequency and increasing fire size from south to north. Wimberly pointed out, that these intermediate forests are shaped by complex interactions between fire disturbances and small gap disturbances. For example, if fire frequency is relatively high, canopy gap processes do not exert much influence on stand development. In western Oregon and Washington, fire frequencies range from about 100 to over 400 years and fires occur in a complex spatial pattern that is weakly controlled by topography and local climate. In the Oregon Coast Range, the amount of old growth is estimated to have ranged from about 30 to 70 percent over the last several thousand years, occurring in a complex mosaic of patch sizes from individual trees to tens of thousands of acres in size. In the Olympic Peninsula and North Cascades of Washington, old-growth stands have developed in very large patches of discrete age classes that developed following a few large, severe fires that occurred in this region over the last 700 years (Henderson).

Temporal Variation

Forest development has also varied over time because climate and disturbance regimes have not been constant. Whitlock pointed out that fire occurrences were not uniform over the last several thousand years. Fires that initiated many of today's mature and old-growth stands occurred most frequently in the 1800's when Euro-Americans were settling the region, about 500 years ago, when many of the current old-growth Douglas-firs established, about 1000 years ago when the climate was warmer, and also in the early Holocene, 8,000 to 10,000 years ago. Some observations of Henderson suggest that Douglas-fir could grow at higher elevations during previous warm periods and that the current composition of old-growth forests may reflect a past environment for development that does not occur today. Such stands may not be reproducible given that future climates and disturbance regimes will probably not be identical to those of the past. Differences in climate can affect the species that regenerate, tree growth rates, mortality, and frequency, type, and severity of disturbance. The implications of this are that historical amounts and patterns of old growth varied over time and one should be careful in using historical information as a reference for the present or the future. The variability observed suggests that using the concept of the historical range of variation will be more useful than relying on a single reference point in the past (e.g. 1850 or time of Euro-American settlement).

Multiple pathways

Many at the workshop believed that the spatial and temporal diversity of old-growth conifer forest development in the coastal Douglas-fir region argues for broadening our conceptual models of old-growth development. Models of old-growth development based on central western Cascade forests dominate both scientific thinking and policy-making in the region. The workshop revealed that not only are these models inadequate to explain old-growth structure and development across the region but they may even be too simple to explain old growth within the central western Cascades where much recent research has been conducted. For example, Swanson pointed out that low severity relatively frequent fires could sustain old-growth characteristics. One approach to incorporating this newly appreciated complexity is to use a multiple pathway approach to characterizing old growth. Spies presented such a framework for Douglas-fir forests in the central western Cascades (Figure 1).

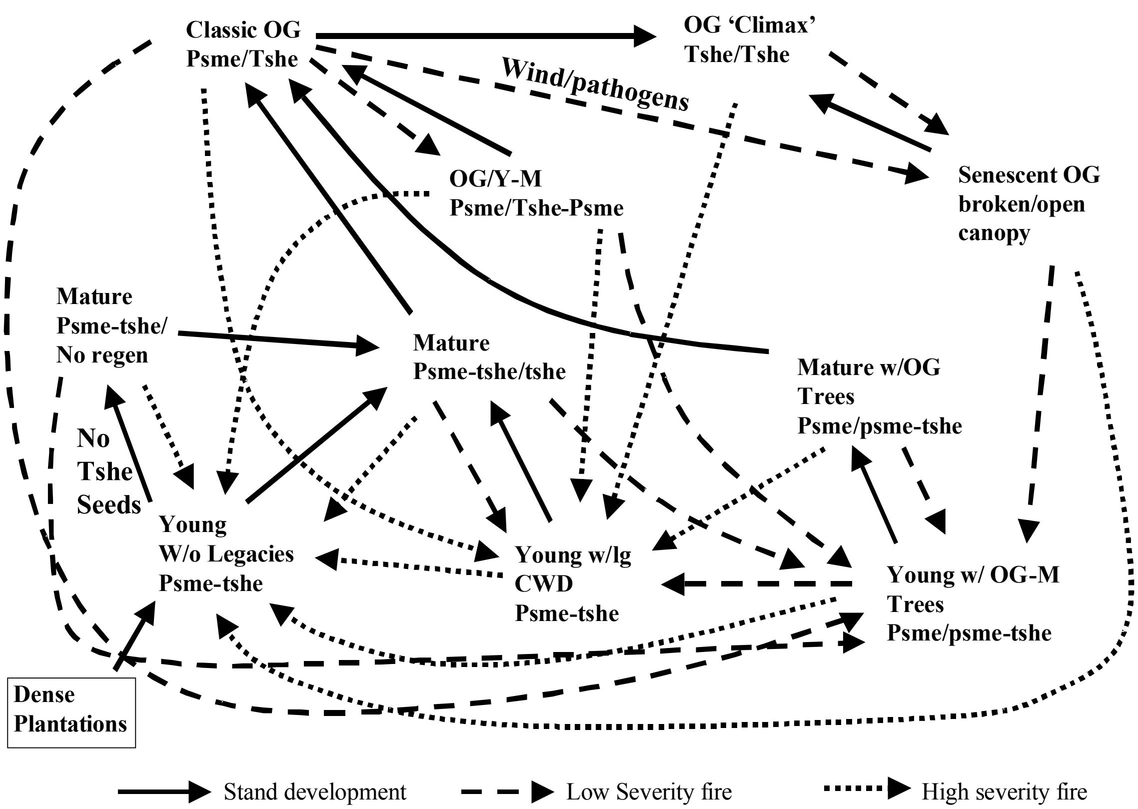

Figure 1. Hypothesized pathways of old-growth development in the western Cascades of Oregon. Psme=Psuedotsuga menziesii, Tshe=Tsuga heterophylla, OG=old growth, M=mature, Y=young, CWD=coarse woody debris.

Such pathway diagrams serve several purposes. First, they can give us insights into the diversity of old forests and the processes that create them. Second, they illustrate that old-growth forests are part of a dynamic web of forest development and diversity, and that it is impossible to understand and manage old growth without understanding the diversity of all developmental stages that lead to old growth. Third, they may give managers more options for maintaining or restoring the diversity of all forest developmental types including old growth. Fourth, they also suggest limits of plot systems with selection criteria that may avoid important parts of the web of alternative pathways. Fifth, they underscore the importance of all successional and structural stages in landscapes that contain old forests.

Management Implications

Discussions of management implications occurred throughout the workshop. Managers at the workshop thought the conceptual discussions helpful, but felt that more specific recommendations need to be developed for this type of information to be useful for most managers. The discussions fell into the following areas:

- Old-growth definitions
- Management of fire-frequent old-growth types
- Management of existing forest plantations
- Landscape management and planning

Old-growth definitions. There may never be a single, widely accepted definition of old growth. The term “old growth” did not originate as a scientific term but came from foresters in the early days of logging. After many forest ecologists adopted the term, some members of the public also picked it up and have used the term broadly to be any forests that lack obvious evidence of human impacts. The diversity of definitions causes confusion in management, policy and public arenas. Some policy makers are pushing for a single definition of old growth to facilitate legislation and rule making. The presentations at the workshop support the notion that multiple scientific and management definitions are needed, given the diversity of forest types. It may be possible to converge on a single or small set of generic definitions, but specific definitions of old-growth forests in terms of quantifiable structural measures will require local input from scientists and managers. An alternative to specific structural definitions is to use an index of structural diversity that includes all stands, including young ones that might contain old-growth habitat elements. While some members of the workshop supported abandoning the term old growth (for other terms such as late successional), many, including most of the managers, felt that the term and definitions of it are still needed.

Fire-frequent old-growth forests. Managers of dry, old-growth forests in some parts of the coastal region, especially southwestern Oregon, face the same problems that managers face in dry, fire-frequent mixed conifer and ponderosa pine forest in the interior parts of the region. As fire incidence in these forest types has declined as a result of decades of fire suppression, fuels have built up, the incidence of insects and disease has increased, and the vigor of old stands has declined. It is quite clear that without reducing understory densities in these stands and/or restoring frequent surface fires, this type of old-growth forest will be lost in the coming decades to insects outbreaks, disease and high severity fires.

<u>Management of existing forest plantations.</u> Many stands within late successional/old-growth reserves contain dense young plantations originally intended for timber production. There was some discussion in the workshop of the prospect for these stands to develop old-growth characteristics in the future without thinning, although thinning effects in plantations were not a major theme of the workshop. Opinions differed about the likelihood that dense plantations would eventually develop old-growth structures (e.g. relatively large old trees, relatively large accumulations of dead trees, and patchy distribution of live vegetation) without careful thinning to restore spatial heterogeneity and increase diameter growth rates in these stands. If left unthinned, retrospective studies indicate that development of very large old-growth trees (e.g. >150 cm) in dense plantations would be retarded unless some natural disturbance such as wind, pathogens or partial fires open the stands up in the near future. In some cases, very dense stands may have a high risk of severe disturbance from blowdown. On the other hand, some existing old growth probably developed from relatively dense young stands that were subsequently diversified by natural disturbances. Some current old-growth stands have relatively small diameter live and dead old-growth trees suggesting that they developed along a dense-young-forest pathway. Garman and Poage presented results of model simulations suggesting that the onset of some features of old growth and northern spotted owl habitat could be accelerated by 30 to 100 years by certain thinning actions. The greatest gains in these modeling studies came in the development of large trees and complex forest canopies from one or two heavy thinnings between stand ages 40 and 80 in dense stands. However, modeling studies also indicate that very high levels of thinning could reduce the numbers of large trees and the accumulation of large dead and down wood. The most immediate and certain benefit to thinning in plantations was to diversify the live and dead structure of young plantations which can make up as much as 40-50% of some federal landscapes. While most of the workshop attendees supported silvicultural manipulations to diversify young plantations, they also cautioned against doing the same thing everywhere across the landscape (including thinning all plantations) and supported the practice of using variable-density thinnings within stands rather than simple heavy thinnings. Similar ideas have been expressed by Andrew Carey (PNW Research Station) in his "biodiversity pathways" approach to managing second-growth stands for ecological goals. Managers cautioned that increased complexity and costs associated with variable-density thinnings would significantly reduce the area that could be thinned.

<u>Landscape management</u>. Sustainability of old-growth forests requires planning and evaluation at landscape and regional scales and over long time frames. Simulations of landscape dynamics on public lands managed under the Northwest Forest Plan by Cissel and Reger indicate that over the long run (200+ years) the extent of mature forests (about 80-200 years old) will decline to low levels which could be a problem because this age class is the source of future old growth. They argue that some planned cutting of stands will be needed to create younger age-classes, both as a replacement for old-growth Douglas-fir stands that are lost through succession or disturbance and as a means of maintaining successional diversity in the landscape. The significance of this concern was questioned by some who felt that we are not going to have a problem maintaining old forests during the next several centuries. The group debated the source of future young stands. Many felt that they would come from unplanned events such as wildfires. However, data from the Willamette N. F. showed that fire suppression has been very effective at greatly reducing the area burned. It is not clear how many wildfires there would be in the future and if

they would be extensive enough to maintain the diversity of all forest stages. From a multi-ownership perspective the forest structure/age class distribution in the region will become increasingly bimodal—young plantations for timber production on private lands and old-growth forests on federal lands. This could result in a net decline in forest diversity as diverse, early successional stages and mature forest age classes decline because neither of the large landowner groups will explicitly produce them. This also produces a relatively static landscape in which stands experience short cycles on private lands while old forest accumulates on federal lands with fire suppression. The presentations at the workshop of landscape simulation studies by Cissel and Spies indicate that planners and managers need to take a broad spatial and temporal perspective to help insure that the goals of biodiversity policies will be met.

Conclusion

The findings from recent studies of old growth suggest that our conceptual models need to be updated to incorporate the variability that occurs in old-growth Douglas-fir structure and development at regional and landscape scales. For example, old-growth Douglas-fir forest development in the region did not follow just one or two courses, but has followed numerous pathways that vary regionally. The concept of “age classes” of old growth does not serve us well in situations where the Douglas-fir trees have a wide range of ages and the beginning of the stand it is difficult to determine. In some landscapes old growth is structurally distinct from younger natural forests but in other landscapes patches of old forest and young forest are intermingled in heterogeneous mixtures that can appear relatively uniform at one scale and very patchy at another. Repeated fires have been important in creating and maintaining old growth in some landscapes but not in others. Developing policies and management practices to maintain or restore this complexity is a major challenge because policy makers typically seek rules that that are simple and easy to implement. We need new ways of conceptualizing and communicating the complexity and heterogeneity of forests. We hope this workshop is a start of a process that meets those needs.

Missing Pieces

The group identified some related topics that were not discussed or did not receive enough attention at the meeting:

- Genetics issues in old forests
- Other forest types, such as coastal spruce-hemlock in Alaska, and interior ponderosa pine
- Social dimensions of the issue including perceptions of old growth by different stakeholder groups.
- Climate change effects and uncertainties—both past and future
- Scientific methods for studying long-lived, old forests (e.g., problems with individual approaches and strategies for using multiple approaches.)

Future Plans

The group discussed possible future communications and products. These included:

- Book on the development of natural forests in PNW region
- An article for journal Science or other high profile outlet on ecology and management of old-growth forests
- Public workshops and symposia that build on these discussions
- Short policy paper for journal Science addressing old-growth management/policy issues such as:
  Variation and need for multiple definitions
  Continuous nature
  Special needs in fire-prone types
  Need to broaden to all ages and stages of forest
  Landscape view to deal with conflicts
  Allocation versus integration with other management goals

Summary of Major Points

1. Old-growth forests are more diverse regionally than is generally appreciated by the scientific community, managers, policy makers and the public. Some of this diversity stems from regional differences in climate history, fire history, site productivity, and species composition.
2. Despite this diversity these old forests generally share similar attributes including structural and spatial diversity, and presence of large live and dead trees.

3. However, because of this diversity multiple quantitative definitions are required for inventory, monitoring and restoration objectives. These definitions should be made and evaluated by individuals who are familiar with the local patterns of plant community types and disturbance regimes.

4. In several areas of the region, the Douglas-firs and other shade intolerant trees in old-growth stands have a wide range of ages, implying multiple establishment events throughout during the life of a stand. This is especially true in southwestern Oregon, the Oregon Cascades, parts of the Oregon Coast Range and parts of the Washington Cascades. In other cases, the old-growth Douglas-fir have relatively narrow age ranges. Where ages ranges are very wide, the notion of a stand's age is not very useful because it is impossible to say when the "stand" began since it is a patchwork of groups and individual trees of different ages.

5. The composition and structure of old-growth stands are a function of disturbances and climatic conditions that existed centuries ago. The particular compositional and structural characteristics of these stands may not be reproducible under modern climates and disturbance regimes.

6. Old-growth development can be conceptualized as a network of pathways in which different types of old growth develop depending on several factors, including disturbance severity and timing.

7. Some old-growth forests have developed under relatively open conditions created by multiple fires with different degrees of live and dead legacies, while others have developed from relatively closed, dense stands following a single major fire or other disturbance.

8. Some old-growth forests in very wet, cool parts of the region have developed without fire. In these landscapes old growth is dominated by shade-tolerant tree species that occur in a mosaic of structural patches including small gaps and areas of dense canopies that cover the most of the landscape. Old-growth Douglas-fir typically occurs where there is a history of fire in the landscape.

9. Douglas-fir trees and crowns have immense renewal capabilities from maturity through old age as a result of the process of epicormic branch initiation and development; studies from a few localities indicate that epicormic branches will replace primary branches as a normal process of tree ontogeny. However, this may not occur in all old growth trees.

10. The primary implications to management of these new findings are that old-growth management strategies, including definitions, fire management policies, and restoration in young plantations require a diversity of approaches that are tuned to the environment, disturbance regime and forest composition of an area.

11. Studies in the Oregon Cascades and Coast Range and southwestern Oregon indicate that unless dense uniform young plantations experience thinning or other natural disturbances, the future old-growth of these stands will have smaller diameter old trees and less

heterogeneity than many current old-growth stands. Where plantations are uniform and dense, thinning and underplanting will increase the diversity of these stands in the short term and increase likelihood that in the long term they will develop the same levels of structural diversity as many current old-growth stands. Some conifer plantations have relatively low densities and high heterogeneity because of the presence of hardwoods or recent natural disturbances. In such cases thinning may not be needed or effective in the development of desired old-growth structures.

12. Modeling studies suggest that thinning in plantations may enhance the diversity of these young, relatively uniform forests, and in many cases accelerate the development of some old growth characteristics by at least several decades. However, modeling studies also indicate that high levels of thinning can eventually reduce the numbers of large trees and the accumulation of large dead and down wood.

13. The general opinion of the group was that where thinning is planned in plantations, diversity would be enhanced by using variable density thinning prescriptions within stands, including areas of no tree removal and areas of heavy thinning.

14. Current fire management policies on federal lands will not maintain old-growth types in fire-frequent landscapes where fires naturally thinned the understories every 10 to 50 years. Management actions (such as thinning and/or prescribed fire) are needed to maintain or restore old-growth in these environments.

15. Broad scale landscape and regional analyses indicate that in the long run (>100 years) under current federal policies the amount of mid-successional forest will probably decline and some form of disturbance, either wildfire or logging, might eventually be required to create young stands that could become old growth in the future.

16. Under current policies, some forest developmental stages such as snag-rich early successional types and mid-successional types are not being created or are actively managed against by fire-suppression and wildfire salvage programs. This will result in high contrast, static landscapes with old forests on federal lands and young, intensively managed forests on private lands.

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