

Restoration of Federal Forests in the Pacific Northwest: Strategies and Management Implications

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Preface¹

We conducted this analysis believing that it is important to develop and implement an active management program on federal lands in the Pacific Northwest in order to restore ecological values, and contribute to sustainable local communities. We believe that there is broad societal support for such a program. However, continuing struggles over disposition of the remaining old-growth forests and future use of roadless areas have been major impediments, distracting key stakeholders. New policies are needed that:

- focus on ecological restoration of federal forests;
- conserve old-growth forests and trees;
- retain roadless areas and
- support local communities and work forces

Lack of trust between stakeholders and resource management agencies is an additional impediment to implementing an active restoration strategy. Many stakeholders do not trust foresters in federal agencies to develop and administer programs directed toward ecological restoration and stewardship. To help rebuild such trust, clearly defined goals and boundary conditions, such as which trees and forests will be retained and which can be removed, are needed; trust ultimately will be re-established with verification that these goals and limitations have been fulfilled.

In this paper we focus on conservation of old-growth forests in the context of a general restoration strategy for federal forests of the Pacific Northwest. Toward that end, we suggest and evaluate the potential for utilizing age thresholds as a beginning point in conserving old growth forests and trees while exploring management strategies that will be needed to sustain federal forests into the future in the face of environmental change.

Forest restoration has many facets. Here we concentrate on the conifer forests of the Northwest, while recognizing the inter-connection of forest and watershed restoration and the importance of functioning riparian and aquatic systems. Further, we acknowledge that there are tensions among the different elements of a comprehensive restoration program on the federal forest estate.

We have written this paper to catalyze further discussion and evaluation of policy alternatives. In the last decade federal agencies have largely ceased harvesting mature and old-growth forests in response to changing policies and public pressure. Yet, arguments over management of these forests continue to bedevil restoration efforts. It is time to consider taking the next step and formally developing policies to conserve old-growth forests and the old-growth trees within them. These policies, however, need to be developed in a broader framework of overall forest sustainability that considers historical disturbance processes, the effect of environmental changes, and goals for these lands.

The paper was initiated as part of discussions with the staffs of Senator Ron Wyden and Congressman Peter DeFazio about how to craft policies to conserve old growth forests. However, we found we could only discuss old-growth conservation in the context of broader restoration strategies for federal forests. Thus, the paper grew into the more general discussion of forest restoration presented here.

¹ An earlier version of this report was reviewed by Derek Churchill, Miles Hemstron, Paul Hessburg, James Johnston, Dave Perry, Tom Spies, and John Tappeiner. We also were assisted by resource analysts in the Forest Service Region 6 and the Oregon Office of the Bureau of Land Management. We believe that it is a much better report as a result. Any remaining errors or lapses in judgment are entirely our responsibility. This study was completed without any special financial support.

Summary

In this paper, we suggest a forest restoration strategy for the national forests of Oregon and Washington and the forests managed by the BLM in western Oregon. In addition, we analyze some of the management and timber harvest implications of that strategy.

This restoration strategy focuses on improving 1) the ecological, economic, and cultural contributions of federal forests in the Pacific Northwest and 2) the sustainability of these forests in the face of environmental change. Key goals include making Pacific Northwest forests more resistant and resilient to wildfire and insects; conserving old-growth forests and trees; and creating an immediate and predictable timber flow to support locally-based restoration economies.

A major initiative is needed to restore our federal forests, engage and sustain communities, and prepare the forests for climate change.

We attempt to respond to these goals by focusing on forest restoration activities that achieve ecological goals while simultaneously providing economic and social benefits. We feel that these types of actions are most likely to have public support and, consequently, be rapidly implemented.

In this analysis we develop a relatively simple framework for federal forest management that provides both management direction and some general limitations on those activities. Ideally, this framework would be used in combination with increased agency discretion in interpretation and implementation of the actions needed—i.e., *it would simultaneously both limit agency discretion and protect it.*

Recognizing Moist and Dry Forests

Sustainable forest policies need to recognize historical disturbance processes along with alterations in these processes that are likely to occur with climate change. Thus, we attempt to balance the wisdom of history with probable future changes. Toward that end, we divide federal forests in the Pacific Northwest into Moist and Dry Forests reflecting their composition, growth conditions, and historic disturbance regimes, while recognizing that these represent contrasting ends of a disturbance continuum.

We use plant associations as the basis for grouping federal forests into Moist and Dry Forests. Plant association classifications are based on the systematic study of plant composition and other attributes of forest ecosystems, site attributes including productivity, management potential, and the characteristic fire regime. Of course, landscape context is also an important determinant of fire regime even for areas representing the same plant association, so characterizations of fire regimes for plant associations reflect central tendencies and not absolutes. While plant communities will change as climate changes, they will continue to be valuable ecological reference points for conservation and management.

Moist Forests belong to plant associations that were historically characterized by infrequent high-severity, stand-replacement disturbance regimes, although mixed and low-severity disturbances also occurred, often as a part of a large disturbance event.

Continuing conflict over old growth and roadless areas has consumed stakeholder and agency attention for decades; resolution is needed so we can move ahead.

Moist Forest ecosystems have evolved with severe, stand-replacement disturbance events, whether from wildfire, windstorm, or volcanoes. The composition

Policies must recognize and accommodate the immense variability that exists in forest ecosystems, starting with the differences between “Moist Forests” and “Dry Forests.”

used to create diverse early seral communities and accelerate development of ecological diversity in plantations. We suggest general silvicultural strategies for restoration activities in these young Moist Forests.

Dry Forests belong to plant associations that were historically subject to low- and mixed-severity disturbance regimes, with these lower severity events occurring as more frequent fire. In recognition of the potential for longer fire seasons and more frequent and severe wildfires with climate change, for purposes of policy development, we generally group plant associations typically subject to mixed-severity disturbance regimes with the low-severity forests; this also reflects probable shifts toward more frequent fire regimes with climate change.

Dry Forest ecosystems have evolved primarily with low- and mixed-severity disturbances, predominantly wildfire. Here, the composition and structure of intact existing old-growth forests *often have been significantly affected by human activities*, resulting in increases in stand density and compositional shifts to tree species that are less fire- and drought-resistant. In ecological restoration, silvicultural treatments, including timber harvest, need to focus on conserving remaining old trees, restoring more sustainable forest conditions (e.g. modifying fuel loadings), and reducing stand densities across the landscape. The specifics of these treatments are a function of plant association and landscape context.

Identifying Federal Forests where Timber Harvest Might Occur

We identify land allocations on which silvicultural activities, including timber harvest, appear to be an acceptable tool for achieving restoration goals. We begin with approximately 25 million acres (22 million forested acres) on the national forests and 2.5 million acres (2.3 million forested) administered by BLM in western Oregon. On the national forests, we then remove Wilderness, Inventoried Roadless Areas, and areas withdrawn from timber harvest in the national forest plans from consideration; on BLM lands, we remove land categories withdrawn from timber harvest. We do not include Inventoried Roadless Areas because timber harvest on these areas is questionable even though final decisions on the allocation of these lands have not been made. We also recognize additional existing policy direction that provides the foundation of a regional forest conservation strategy--the Northwest Forest Plan (NWFP). Within the area of the NWFP, we start with the land allocations and direction in that plan, including Late Successional Reserves (LSRs) and the Aquatic Conservation Strategy. Outside the area of the NWFP, we recognize the applicable aquatic conservation strategy such as PACFISH and INFISH.

Utilizing Ecological Forestry to Guide Actions

We base our silvicultural proposals on an approach known as “ecological forestry.” Ecological forestry utilizes principles of natural forest stand development, including the role of natural disturbances in the initiation, development, and maintenance of forest stands and landscapes and operating on temporal scales consistent with recovery of desired structures and processes. Ecological forestry activities are typically planned at the landscape and stand scales, incorporate knowledge developed from the study of pattern and ecological function in natural land-

The principles of natural stand development can provide a guide to action.

To conserve “old growth”, we need to focus on old stands in Moist Forests and old trees in Dry Forests.

scapes, and consider landscape components having special ecological significance, such as aquatic features and early-successional and other non-forested communities within forest landscapes. In both Dry and Moist Forest stands, there is a goal of restoring spatial heterogeneity--a non-uni-

form distribution of forest structural elements, such as trees, snags, and canopy density—when appropriate. Such heterogeneity is characteristic of older forest stands and landscapes on both Moist and Dry Forest sites.

Conserving Older Stands and Trees

In Moist Forests, we focus on *conservation of older stands*. We examine consequences of using three different ages to define “older stands:” 80 years, 120 years and 160 years, three age thresholds that have often been proposed and discussed. This range goes from including essentially all of the mature and old growth forests (at threshold age 80 years) to including most mature and all old growth forest (at threshold age 120) to including the most structurally advanced mature and all of the old growth forest (at threshold age 160 years). We also assume that any age threshold applies to older trees (greater than 80, 120, or 160 years of age) that occurred as individuals or small clusters within younger stands. Anxiety over exactly where to draw the boundaries of older stands should be reduced by including scattered trees that meet the age threshold in the conservation strategy.

In Dry Forests, we focus on *conservation of older trees*, with those trees defined as being at least 150 years of age. We recognize that old growth stands can be found in Dry Forests, but conserving the older trees within them typically requires active management within these stands. This age was chosen because: 1) trees in Dry Forests begin to exhibit some characteristics of old growth at these ages and 2) fire exclusion--through suppression of natural wildfires, fires set by Native Americans, and introduction of domestic livestock into these forests--began about 150 years ago.

We utilize age--of stands and of trees--as one of the defining limits on management activities for several reasons:

- Society is interested in conserving older forests and trees.
- Past activities have reduced their occurrence to levels far below historical levels.
- Alternative approaches (e.g. diameter limits) fail to identify and protect many older trees. Many old ponderosa pine and western larch are less than 21 inches diameter breast height (dbh), a common current diameter limit. As importantly, diameter limits can deter the harvest of young, relatively large trees that crowd older trees, greatly increasing the risk that the old trees will die as a result of either wildfire or insect attack.
- Utilizing a more general or less precise definition of old growth has the potential for creating endless debate and delay. Simple rules, on the other hand, have facilitated recent management of Moist and Dry federal forests.

Is an age-based limitation practical? Some question whether an age-based approach can be implemented suggesting that foresters will have to bore every tree in a timber sale to establish its age. We believe that few trees will actually need to be bored based on the process suggested here. First, foresters have aged trees and stands for generations and continue to do so today. Second, most existing stands

No single age defines “old growth”, but age thresholds are useful in old growth conservation and restoration.

Clearly defined boundaries—such as those provided by land allocations, diameter and age limits—have proven effective in recent federal forest management.

in Moist Forests are clearly either above or below the age limits; the vast majority of young stands resulted from clearcutting in which older trees were not left. The question of the age of individual trees does arise in some young natural stands in Moist Forests, and in the Dry Forests where old trees are

often intermingled with young trees. For this situation, we suggest a process in which the agencies develop and implement aging protocols utilizing field studies, and then gather information in timber sale layout and post-sale monitoring activities to improve the protocols over time, all with periodic reviews by scientists, stakeholders, and forest managers.

Dry Forest Restoration Strategies

The majority of existing Dry Forests on federal lands still retain some older trees (defined in Dry Forests as trees over 150 years of age) even though these forests have been drastically modified by human activities. Historically, many of these stands had relatively low tree densities that were dominated by 10 to 20 large older trees of fire- and drought-resistant species, such as ponderosa pine and western larch, and displayed much spatial heterogeneity, consisting of fine-scale, low-contrast structural patchworks. Denser, even-structured stands also existed with up to 50 dominant trees and Douglas-fir, western larch, and ponderosa pine as common species; such forests dominated some landscapes as a result of more severe fires and insect epidemics.

Today most stands and landscapes of both types have been dramatically modified by such activities as grazing by domestic livestock, timber harvest, tree planting, and fire suppression. Both mechanical treatments and prescribed fire can be useful in restoring these forests; we propose that detailed prescriptions should be keyed to plant associations and the landscape context.

Key elements of a restoration strategy for Dry Forest sites are:

- Protect and conserve all older trees (trees greater than 150 years of age), including reducing fire- and competitive risks to these trees;
- Reduce basal areas in overstocked stands;
- Increase the mean diameter of stands;
- Shift composition toward more fire- and drought-tolerant species, such as ponderosa pine and western larch, and away from less fire- and drought-tolerant species, such as white and grand fir;
- Restore characteristic levels of within-stand spatial heterogeneity;
- Manage small and intermediate tree populations to restore and maintain characteristic population levels of old and large trees;
- Restore characteristic levels of ground fuels and understory vegetation, using prescribed fire where possible;
- Encourage hardwood tree and shrub recovery in riparian habitats;
- Retain patches of dense forest scattered across the landscape within the area of the NWFP to help conserve the Northern Spotted Owl and its prey species; and
- Plan and implement restoration activities at larger landscape levels, encompassing the variety of restoration efforts that are needed within a landscape and ensuring that spatial complexity is incorporated at larger spatial scales.

Rapid movement through the Dry Forests, using both mechanical treatments and prescribed fire, is necessary to address threats from wildfire, drought, and insects; coming climate change creates even greater urgency.

Unlike conservation approaches for older stands in Moist Forest sites, mechanical treatments will

Creating fuel breaks will not save Dry Forests and the old growth trees within them.

be needed within many Dry Forest sites where older trees are present. These actions will help sustain and restore these older tree populations in the face of enhanced current threats from fire and insects, the

latter the result of increased competition in the unnaturally dense stands

Given the high potential for catastrophic loss of resource values in the Dry Forests on federal lands, we believe that ecological restoration should be comprehensively implemented across the federal forests over the next 20 years.

With this strategy, we call for restorative treatments that cover up to two-thirds of the landscape. This extensive effort is needed to provide for:

- Restoration of ecologically desirable conditions on the majority of the landscape—including retention of existing and restoration of historic old-tree populations;
- Reduced potential for large, severe wildfires and insect outbreaks, even under conditions of climatic change;
- Increased resiliency – i.e., ability of disturbed forest landscapes to recover when severe disturbances do occur; and
- Restoration of spatial heterogeneity from the scale of small patches to large landscapes.

A recent analysis of conservation strategies for the Northern Spotted Owl in Dry Forests has come to a similar conclusion, i.e.,--treat up to two-thirds of the landscape over time; recent landscape simulations of fuel treatments suggest treating 40-65% of the landscape. Both spotted owl conservation and fuel reduction should be considered within the broader goal of ecological restoration.

We urge that any guidance, regulation, or legislation for Dry Forests be permissive, i.e., they would permit actions but not require them, allowing land management agencies discretion in implementation. However, this discretion must be paired with periodic independent review of whether the actions being taken are achieving stated goals.

Moist Forest Restoration Strategies

Moist Forests were characteristically subject to stand-replacement disturbances at intervals of one to several hundred years and required centuries following a stand-replacement disturbance to develop the massiveness and structural complexity characteristic of old-growth forests. Key elements of a restoration strategy for these forests include:

- Reserving *existing* older forests using a threshold reservation age of 80, 120, or 160 years;
- Accelerating the development of complexity in young forest stands, particularly those originating as plantations, through a variety of silvicultural activities, including variable-density thinning. Extending the maximum age of stands eligible for thinning in Late Successional Reserves from 80 years (current policy) to 120 years would aid in this effort;
- Implementing regeneration harvests in Matrix forests using principles of ecological forestry to help provide a regular flow of structurally-complex, early successional habitat (as well as other early stages of forest development). These actions could help provide ecologically important habitats that have become increasingly rare while also supplementing timber harvests; and
- Planning at the landscape scale so as to incorporate knowledge developed from the study of pattern and ecological function in natural landscapes.

Restoration of sustainable and diverse ecological conditions can serve as a primary goal in managing the Dry Forests.

Thinning Moist Forests can accelerate development of complexity and improve resilience in the face of climate change.

Restoration of Moist Forests is not intended to alter their historical wildfire behavior. Rather it is intended to accelerate the development of older complex forest and provide a modest amount of diverse early successional communities and timber harvest.

While the decision of how much fire suppression to attempt in these forests is certainly a social issue, stand-replacement fires have historically provided ecological benefits. In addition to creating structurally complex early-successional communities, these fires help revitalize streams and wet meadows with wood and sediments.

General Implications of These Restoration Strategies

The forest restoration strategies described above will:

- Accelerate the restoration process for federal forests of the Pacific Northwest by;
 - * Increasing the percentage of the Dry Forest treated per year on the national forests and BLM lands
 - * Addressing the enormous federal plantation acreage over the next 20 years that will achieve initial thinning age of 30-60;
- Protect existing older stands and trees; and
- Assist in the development of structurally-complex late-successional forests (in Late Successional Reserves and Riparian Reserves) and diverse early successional communities (in the Matrix) on Moist Forests; and restore more sustainable and ecologically functional forests and landscapes in the Dry Forests.

The forest restoration strategies will provide timber products and income over the next 15-20 years that will:

- Help pay for needed actions;
- Increase harvest levels on federal forests;
- Make available significant quantities of biomass; and
- Provide employment and community engagement in the restoration process, thereby maintaining a skilled workforce and processing capabilities.

Investments will be required in rebuilding and improving forest roads and in planning and implementing silvicultural treatments.

Timber Harvest Implications of Restoration Strategies

The strategies suggested here generally follow the land allocations and standards in the Northwest Forest Plan and existing aquatic conservation direction in areas outside the scope of the Northwest Forest Plan. In addition, they reserve older forests and older trees, and assume that Inventoried Roadless Areas will *not* be entered. In that context, we estimated timber harvest levels that could result from application of the following restoration strategies:

Dry Forests

- On the national forests and BLM lands, commercial timber harvests are conducted on about ½ percent of the Dry Forest landscape per year, along with significant prescribed burning and shrub removal. Accelerating the rate of commercial harvest, at least doubling it as recommended here, should enable an increase in harvest volume from these forests over the next few decades.

Regeneration harvest of Moist Forests using principles of ecological forestry can help perpetuate biological diversity by providing scarce habitats.

Moist Forests

In recent years, federal agencies have concentrated almost exclusively on restoration thinning—very little old growth has been cut.

- Thinnings from stands less than 80 years of age currently provide almost all harvest volume. Harvest volume from thinning should increase over the next 20 years as large acreages of plantations reach a size and age suitable for commercial thinning.
- Instituting a Matrix regeneration harvest program in the next 20 years, using the principles of ecological forestry. These actions, in the short run, depend on being able to harvest stands between 80 and 120 years of age. Regeneration harvests in the Matrix are a major component of the long-run sustainable harvest level.
- Total potential timber harvest from federal forest lands is not strongly affected by whether the threshold age for reserving existing older Moist Forests is 120 or 160 years. Potential harvest is significantly lower, though, under a threshold age of 80 years.

Comparison to current harvest levels and future plans

- Recent timber harvest from federal forests (Forest Service and BLM) approached 600 million board feet per year, a significant increase from 2000.
- Accelerating restoration thinning and instituting a Matrix regeneration harvest program could raise the harvest to 1 billion board feet per year or higher for the next few decades.
- Harvest levels are difficult to estimate beyond the first 20 years, since they depend on many factors that may change through time. It is likely, however, that long-term sustained yields would be lower. In Moist Forests, longer-run sustained yield would be less than short-run volumes as restoration thinning is completed in reserves. In Dry Forests, a need for stand density treatments will continue although the level and methods of those treatments is uncertain.
- Growth in timber volumes would greatly exceed harvest even at a harvest level of one billion board feet per year.

Carbon Storage Effects

The restoration approach suggested here will have differing effects on carbon stocks in Moist and Dry Forests.

- In Moist Forests, growth will go largely toward rebuilding the carbon stocks that have been greatly depleted during the last 100 years of western settlement and use.
- In Dry Forests, density reduction will reduce overall carbon stocks initially with eventual recovery as the forest structure shifts to larger, older trees. Restoration also can reduce future carbon emissions by limiting the extent and severity of future wildfires, but at the cost of short-term emissions associated with treatments. In addition, utilization of biomass created during logging can reduce these short-term emissions. In sum, the net effect of restoration of Dry Forests on the overall carbon balance remains unsettled.

Accelerating ecological restoration of both Moist and Dry Forests can also increase timber harvests for the next few decades and help prepare forests for climate change.

It can be argued that allowing forests to grow without intervention will result in the highest amount

Federal forests can serve as significant carbon sinks, but a sole focus on “climate reserves” will not restore these forests.

of carbon storage in the short-run. Such an approach, though, would be short-sighted and leave the forests and the old-growth trees within them vulnerable to coming climate change. A strategy that increases structural diversity and resilience in

the face of disturbance, as suggested here, is more likely to achieve conservation goals.

Restoration Strategies in the Face of Climate Change

We have incorporated current expectations regarding climate change in a number of ways including:

- Rapid movement through the Dry Forests to address the threats to these forests from wild-fire and insects, since these threats will probably develop very quickly as the result of climate change; and
- Grouping of most mixed-severity forests with low-severity (frequent fire) forests as candidates for active management, since we anticipate that those forests will shift to more frequent and severe fire regimes with climate change.

With climate change, systematic re-assessment of the proposed restoration strategy will be needed at regular intervals to assess its appropriateness.

Post-Disturbance Strategies

Wildfire and other natural disturbances, such as windstorms and insect epidemics, are an inevitable part of the future of both Moist and Dry federal forests. Some will be high-severity, stand-replacement disturbances, some will be mixed severity, and some low severity but such disturbances will still occur and challenge society’s capability to cope.

What should be done after major disturbances? Should salvage occur? If so, which trees should be removed? What other activities should be undertaken? We respond to these questions based on the focus of this paper--strategies to restore federal forests and the benefits that flow from them. Our approach is relatively simple: *we develop guidance for activities on Moist and Dry Forest sites after a disturbance based upon their management direction before the disturbance.*

Restoration Strategy Challenges

There are several challenges in implementing this restoration strategy discussed in this paper.

- The Dry Forest strategy is an integrated approach that reduces the contrast in landscapes within reserves (LSRs) and Matrix in the NWFP area. Conserving the Northern Spotted Owl in Dry Forest landscapes will take innovative planning and implementation. Current policy uncertainty about approaches to Northern Spotted Owl conservation in Dry Forests could slow restoration efforts.
- Restoring forests while simultaneously conserving and restoring the watersheds within which they are located will create both opportunities and tensions. The strategy outlined here will re-

Rehabilitating a deteriorating road system while reducing impact on aquatic resources will provide a key restoration challenge.

quire maintenance, use, and repair of parts of a deteriorating federal road system. This creates both problems and opportunities for reducing the impact of roads on aquatic resources. Also the positive role that disturbance can play in revitalizing fish habitats needs consideration in large-scale strategies.

- Restoring federal forests will not be complete without recovery of riparian and upland hardwoods. Reintroduction of fire, conifer removal, and control of ungulates will all be needed.
- The social acceptability of regeneration harvests in the Moist Forest Matrix lands, using the principles of ecological forestry, will be a point of controversy.
- Finding ways to utilize the biomass (slash and small trees) left after harvest, rather than burning it, is an important issue. Capturing these short-term sources of climate-change gases for energy production would be beneficial to carbon balances.
- Successfully implementing these strategies will require professional management of the highest level. To do this, society will need to reverse the continued shrinkage of our federal land management agencies and restore them to a critical mass of field-oriented resource professionals.
- Substantial investment will be needed. While timber harvest receipts can help defray costs, they will not be sufficient to cover all the actions needed and the associated infrastructure and planning.

*Significant investment will be needed
to restore the federal forests of the
Pacific Northwest.*

Introduction

There has been much recent discussion about how the ecological, economic, and social productivity of federal forests in the Pacific Northwest can be improved. Key goals for that restoration include making Pacific Northwest forests more resistant and resilient to wildfire and insects in the face of climate change; conserving old growth forests and trees; and creating an immediate, predictable, and a sustainable timber flow to support locally-based restoration economies.

In this report, we respond to these goals by focusing on forest restoration activities that achieve ecological objectives while simultaneously providing economic and other social benefits. We feel that actions that simultaneously address multiple interests are most likely to have public support and, consequently, can be rapidly implemented.

We focus our analysis on the 25 million acres of national forest in Oregon and Washington and the 2.5 million acres of lands managed by BLM within the boundary of the Northwest Forest Plan (Map 1)². We do not consider activities in national parks, federal wildlife refuges, Indian Reservations, military installations, or BLM lands in eastern Oregon.

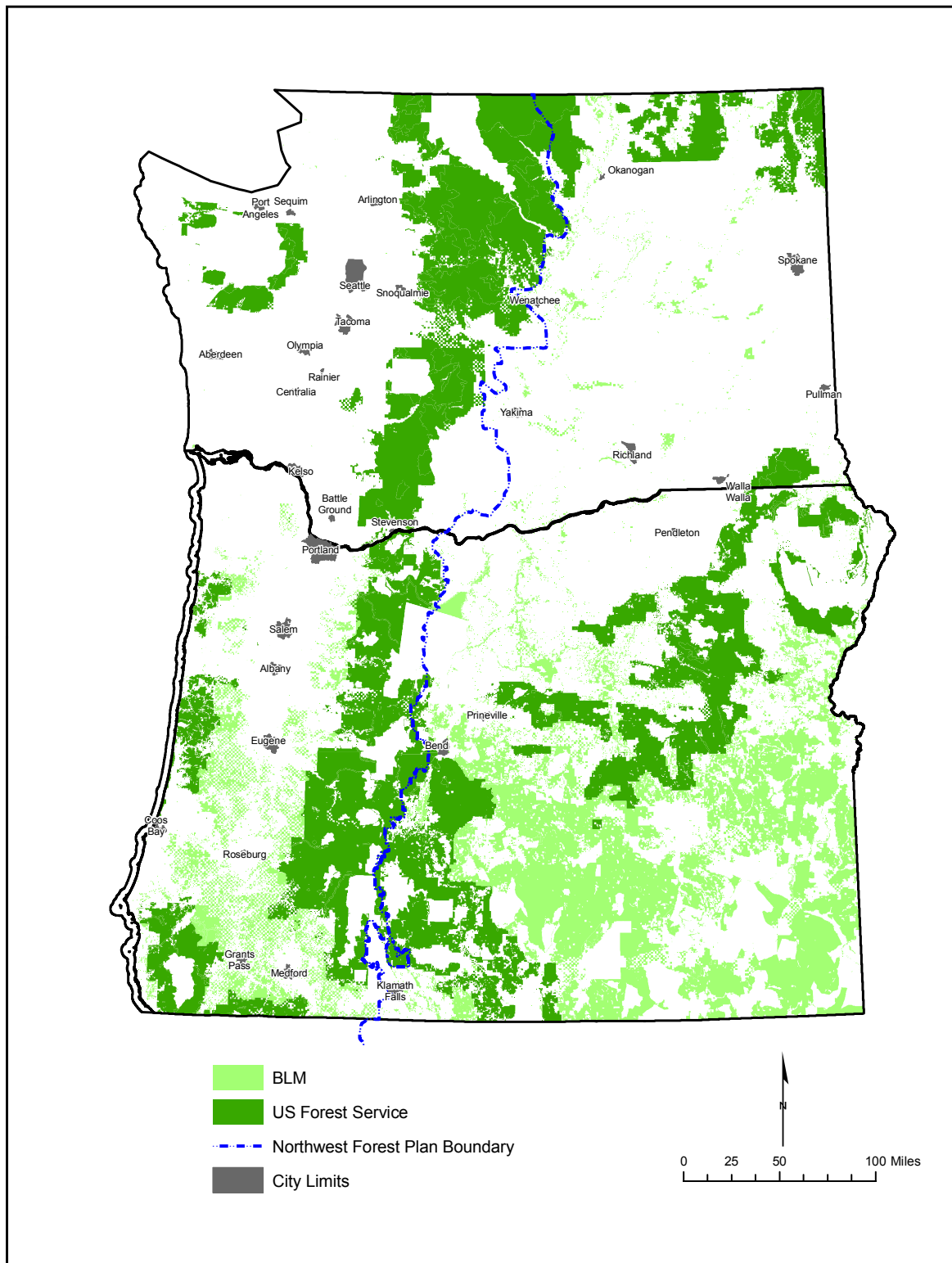
Specifically, we evaluate the implications for management and timber harvest of actions that undertake landscape-level ecological restoration of the federal forests of Oregon and Washington. We do this by identifying areas where activities, such as thinning and prescribed fire, are needed to restore characteristic forest structures and reduce fuel loadings. We concentrate proposed active management on the Federal lands that are most in need of restoration because they are outside their natural range of structure and composition. Some of these--on dry fire-frequent sites--are at risk of uncharacteristic fire and insect outbreaks as a consequence of their current condition.

Policies and practices must respect the immense diversity in forest conditions that exist, even within a single region, such as the Pacific Northwest. Hence, we begin with the principle of using plant associations and historical landscape analysis as a basis for management. However, we recognize that sustainable forest policies need to strive for resource conditions consistent with historical disturbance processes with adjustments that reflect alterations in natural disturbance regimes that are predicted to occur with climate change. Thus, we attempt to balance the wisdom of history with likely future changes.

As an initial step in this analysis, we contrast the federal forests associated with moist growing conditions (hereafter, Moist Forests) and those associated with dry growing conditions (hereafter, Dry Forests), while recognizing that these represent two ends of a continuum. Then we discuss management strategies that could be employed to achieve restoration goals in these two broad categories of forests. As part of the discussion, we estimate the areas that would be available for actions, levels of activity, and amounts of sawtimber that might be produced.

Within the area of the Northwest Forest Plan (NWFP), we assume that current major land allocations serve as the foundation for management. These include Wilderness, the allocations in national forest plans and BLM plans that limit and allow different types of activities (Late Successional Reserves and Matrix), and the Aquatic Conservation Strategy (including Riparian Reserves). We examine alternative ways to achieve the goals of those allocations but, in general, we view these land allocations and their goals as a given. Thus, we rely on the NWFP and related conservation strategies to provide terrestrial and aquatic habitat for endangered and other at risk species. The

². A very small amount of BLM land considered here lies outside the NWFP.



Map 1. Forest Service and BLM lands in Oregon and Washington. (The BLM “Western Oregon Lands” considered here are generally within the boundary of the Northwest Forest Plan.)

NWFP has stood for 15 years without major revision of its land allocations; it seems a logical starting point for our analysis.

Outside the NWFP area, the imposition of the “eastside screens” in 1995 combined with the over arching concern about the buildup in fuels on the national forests have softened the division between reserves and timber produc-

Forest management should create options, not reduce them, and reduce risks, not increase them.

tion areas identified in the forest plans of the 1990s. The “eastside screens” placed a prohibition (with exceptions) on harvest of trees over 21”, imposed an expanded systems of stream buffers, and made numerous other changes to the forest plans to favor conservation of biodiversity in those forests. The screens were designed to be an interim strategy while a more comprehensive conservation strategy was developed. In addition, recent wildfires and the fears of communities about future fires have caused the Forest Service to develop prescriptions different from those in the forest plans and apply them broadly across the landscape. Thus, we assume that a primary goal in these forests is to reduce stand densities and risks to wildfire and insects, while protecting aquatic systems and the habitat of threatened, endangered, and sensitive terrestrial species.

Our purpose in conducting this analysis and preparing this report is to provide information for stakeholders engaged in discussions about future directions for management of the federal forest lands in the Pacific Northwest. Current discussions in Congress have stimulated us to undertake this work.

Recognizing Fundamental Differences between Moist and Dry Forests

Policies and management practices need to reflect the rich diversity of forest conditions that exists in the United States. This need has been understood and respected in many of management guidelines, but recognizing the widely differing nature of forests has not always been done in policy development. Attitudes toward wildfire exemplify the potential problem; different forest types have very different natural relationships with fire. The policy of uniform fire suppression adopted by most forest agencies early in the 20th century did not reflect these differences and failed as a consequence, resulting in creating of dense, fuel-loaded stands and the potential for intense stand-replacement wildfires on sites where they were previously uncommon.

Policies for other resources, such as old-growth and biodiversity (e.g., Northern Spotted Owl), similarly need to reflect contrasts and differing approaches among forest types and in different parts of a species’ range.

In the Pacific Northwest, people have discussed federal forest management in terms of the “westside” and the “eastside” with the Cascades being the dividing line. This division was a general recognition that the two subregions required different policies and management practices. Effectively, geography was used to separate the forests of the region into Moist Forests and Dry Forests that differed dramatically in productivity and historical disturbance regimes. Moist Forests were highly productive, dense, and subject to infrequent stand-replacement disturbances, such as intense wildfires and windstorms. Dry Forests were characterized by more frequent low- to mixed-severity disturbances, primarily wildfire. Douglas-fir and western hemlock typified the westside and ponderosa pine the eastside.

In reality, Moist and Dry Forests are found on both sides of the Cascade Range. For example, forests at higher elevations in the Interior Columbia Basin occupy moist sites and are characteristically subject to high-severity disturbance regimes. Similarly, Dry Forests that were subjected to relatively frequent low- and mixed-severity wildfire occur in western Oregon and Washington, most

Plant associations provide an excellent way to identify and incorporate variability in forest ecosystems in policies and regulations.

prominently in the Klamath-Siskiyou region. Hence, policies that attempt to recognize the fundamental contrasts between these two forest conditions need to be based on something better than gross geography.

Plant associations provide a constant and geographically comprehensive guide for dividing our northwestern forest landscape into Moist and Dry Forest lands. Plant association classifications are based on the systematic study of the plant composition and other attributes of forests and other ecosystems. Federal and academic ecological scientists have developed a comprehensive classification of plant associations for the federal forest lands in the Pacific Northwest. They have also established the relationships between the plant associations and the management potential of the sites, such as with productivity and regenerative behavior, and characterized their dominant disturbance regimes.³

This comprehensive classification provides a basis for recognizing the Dry and Moist Forests on federal land. We have obtained this information for the forests of western Oregon and western Washington (Maps 2, 3, and 4).

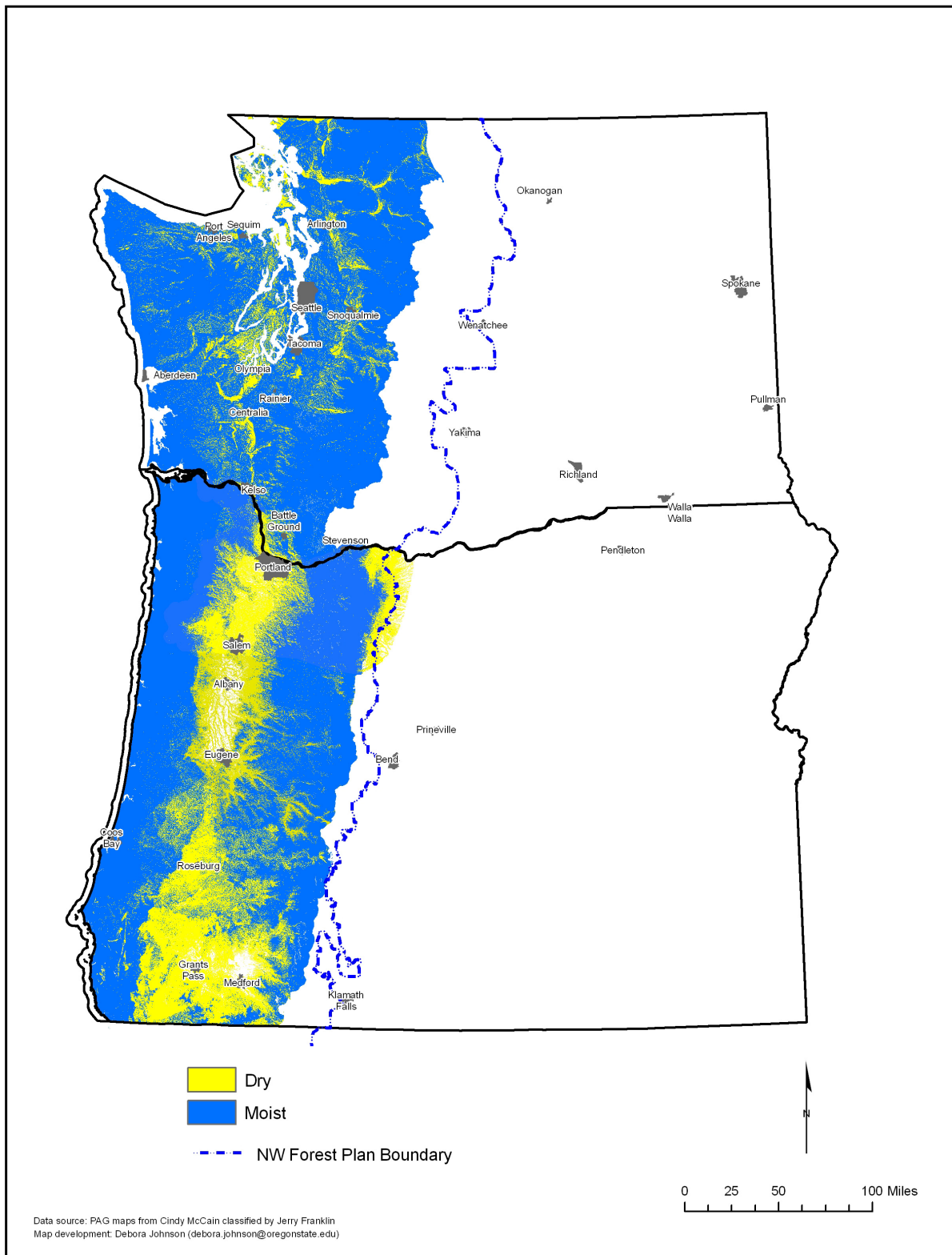
The plant association series or groups that compose most of the Moist Forest category include: Western Hemlock, Sitka Spruce, Pacific Silver Fir, Mountain Hemlock, Subalpine Fir, Shasta Red Fir, Tanoak, and Coast Redwood. As noted, these plant association groups were notable for being historically subjected to infrequent high-severity, stand-replacement disturbance regimes. Mixed- and low-severity events also occurred, often in association with high-severity events. In general, however, Moist Forests are characterized by stand-replacement disturbances that occur at long intervals and associated even-aged forest regeneration.

Dry Forest sites are generally characterized by the following plant association series or groups: Ponderosa Pine, Oregon White Oak, Douglas-Fir, Grand Fir, White Fir, Jeffrey Pine, and Incense-Cedar. Historically these plant association groups were commonly subject to low- and mixed-severity disturbance regimes that resulted in stands that were of low- to medium density, dominated by large pioneer trees, and consisted of fine-scale, low-contrast structural patchworks containing mixtures of young, mature, and old trees. Stand-replacement disturbance events due to fire, insects, and wind did also occur in the Dry Forests, particularly in some localities (e.g., northeastern Washington) and in the moister plant associations within the White Fir and Grand Fir plant association groups.

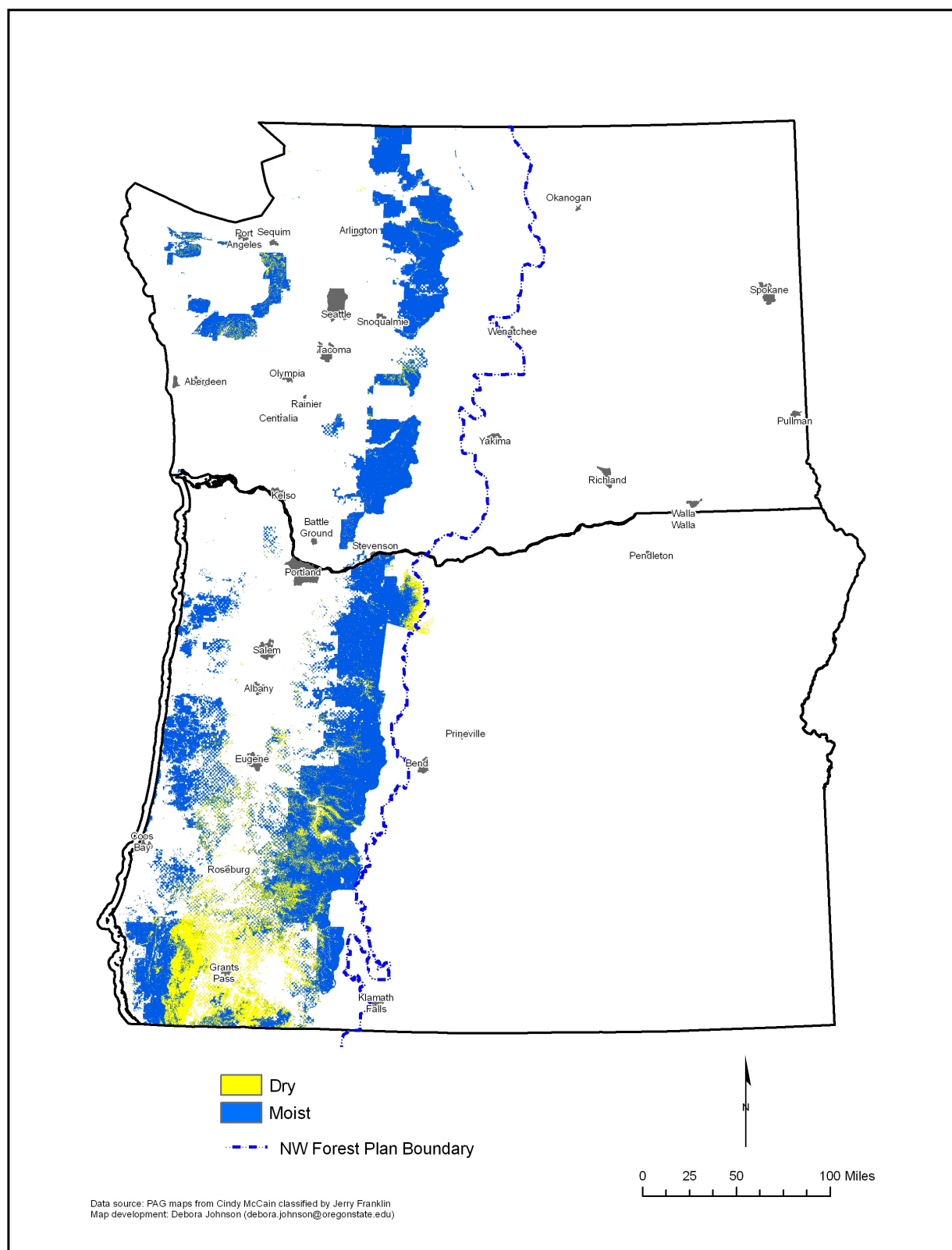
There is a broad gradient in fire behavior that reflects both variability in site conditions (as reflected in plant associations, for example) and landscape conditions (Figure 1). Sites that have dominantly low- and mixed-severity fire regimes (Dry Forests) are those where active management may be required to reduce the potential for uncharacteristic and ecologically damaging wildfire, including in forests that have existing populations of old-growth trees. Forests that have dominantly high-severity fire regimes (Moist Forests) have no ecological requirement for management to alter fuels and fire behavior, including old-growth stands. The most moist of the Grand Fir and White Fir plant associations span the threshold between the Dry and Moist Forests and, depending upon local circumstances, active management may or may not be required; we have included them with the Dry Forest in the belief

Climate change will shift forest landscapes toward fire regimes characterized by greater fire size and intensity.

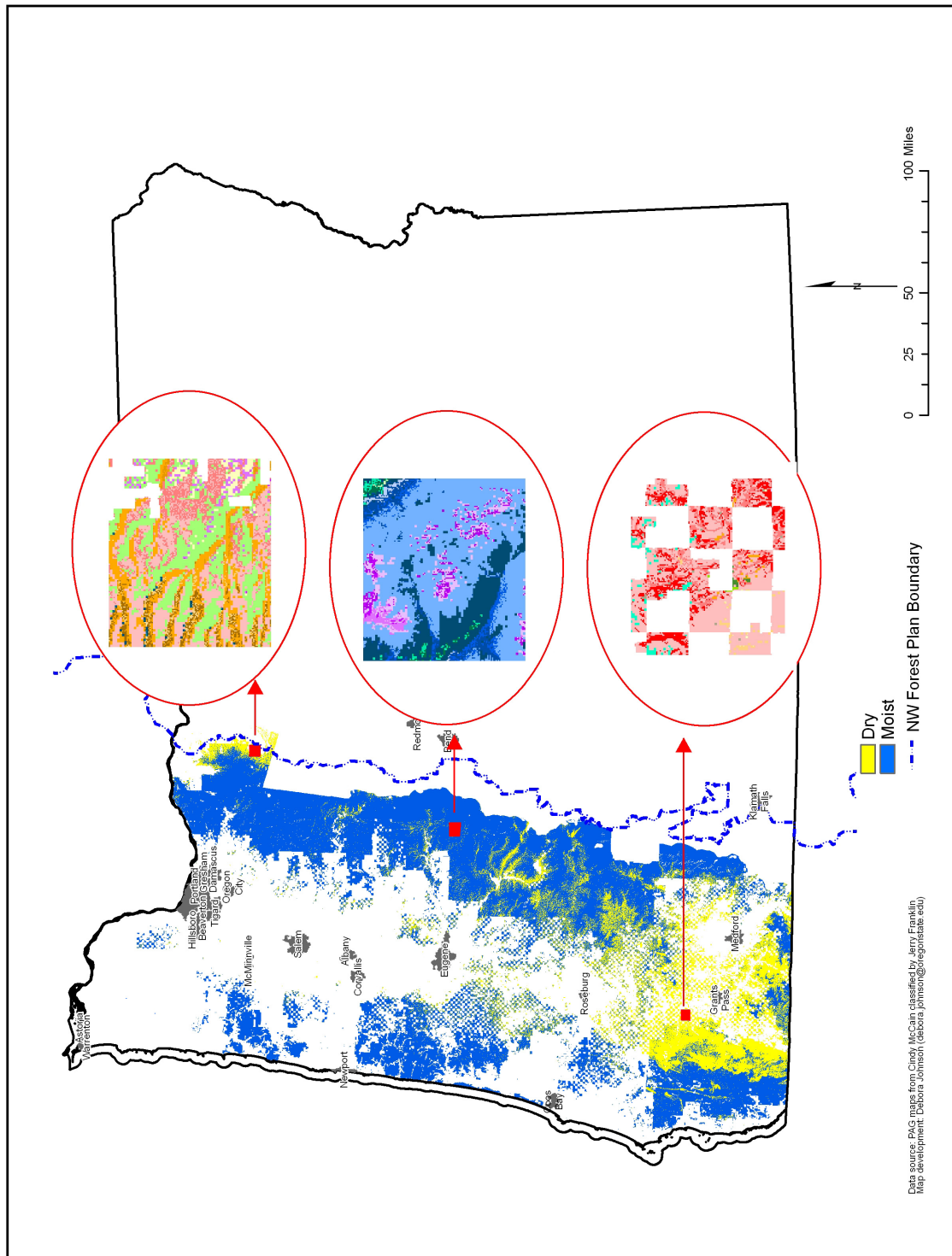
³The plant association information comes from the USDA FS R-6 scientists and analysts. Cindy McCain, ecologist USFS, Siuslaw and Willamette NFs, was the source of the plant association maps and data. This local PAG data fits into the "Ecology program potential natural vegetation model" of Dr. Jan Henderson, ecologist, USFS, Mt. Baker-Snoqualmie NF.



Map 2. Moist/Dry plant associations of western Oregon and western Washington.



Map 3. Moist/Dry plant associations of western Oregon and western Washington on Forest Service and BLM lands.



Map 4. Moist/Dry plant associations on Forest Service and BLM lands in western Oregon with three cutouts showing the underlying plant associations on federal land.

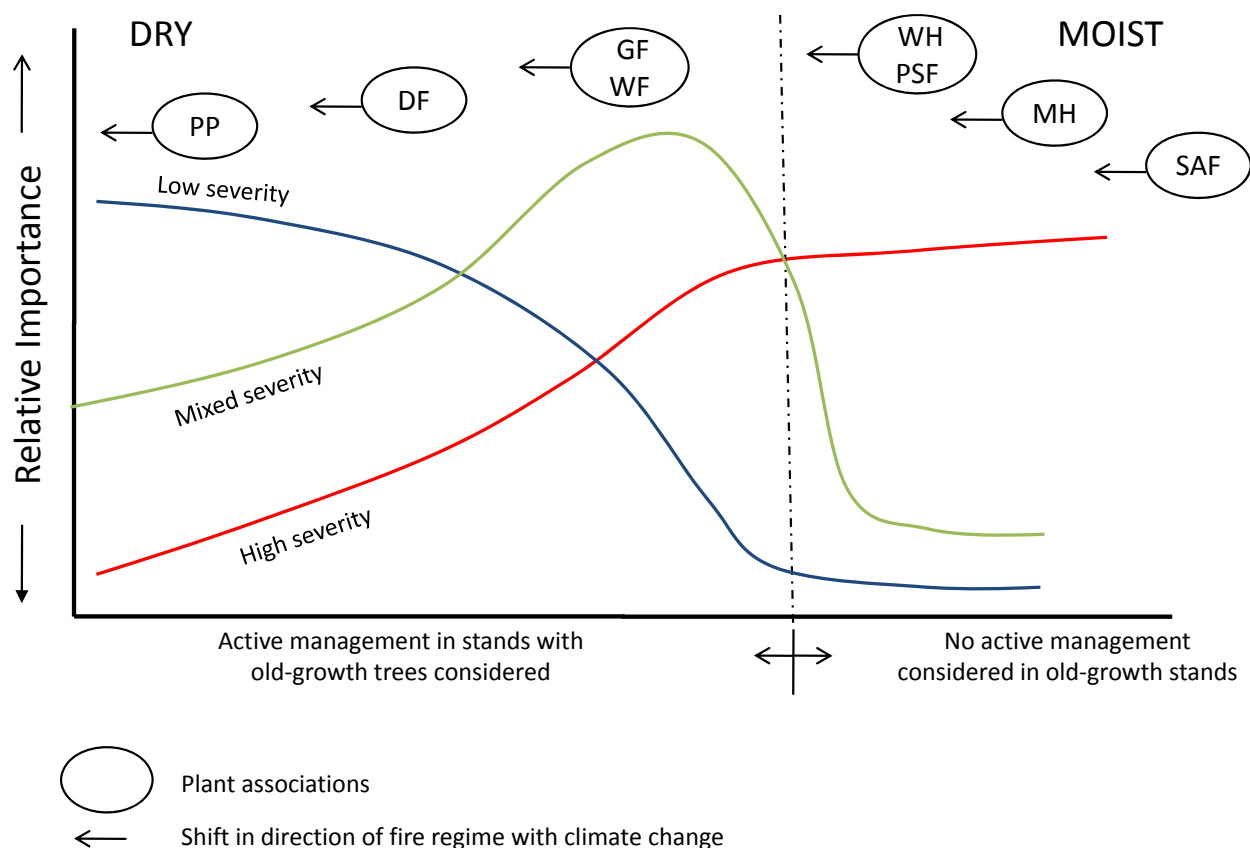


Figure 1. Diagram illustrating shifting importance of low-, mixed-, and high-intensity fire regimes along the moisture gradient and the position of major plant associations along this gradient in the Pacific Northwest. (The arrows indicate how the plant associations are shifting in response to climate change.) Landscape context, stand condition, topography, and weather also influence fire behavior. Note: High severity events (as we define them) typically include significant acres of mixed and low severity fire effects and unburned areas.

that policy should allow for active management, particularly since climate change will move them toward increased drought and wildfire.

Recognizing Moist and Dry forests is becoming increasingly common in analyses. As an example, the Oregon Forest Resource Institute (OFRI) biomass analysis grouped forest types in Oregon into those that historically had forest types that tended to have surface or mixed severity regimes (Group I) and those that tended to have high-severity fire regimes (Group II) (Biomass Project Team 2006).

Land Base for Analysis

The national forests and BLM lands analyzed here cover 27.4 million acres in Oregon and Washington. They include all the national forests in the two states and the Western Oregon District BLM lands. We were especially interested in those forests that are potentially available for a combination of restoration approaches, including thinning and prescribed fire.

National Forests

Looking at the national forests with that goal in mind, we excluded the following lands from our analysis: 1) Wilderness, 2) areas allocated to “no-harvest” status in forest plans, and 3) Inventoried

Roadless Areas (Figure 2, Map 5a and 5b)⁴. The Inventoried Roadless Areas were excluded because of the social polarization over their use and the relatively high road costs associated with entering them. Most remaining Inventoried Roadless Areas cluster around designated Wilderness.

After excluding those land allocations and non-forest areas, we are left with about 12.9 million acres of national forest—a little more than half of the *total* national forest area. These 12.9 million acres also are a little over half (56%) of the *forested* area (estimated as 22.9 million acres) within those national forests. Thus, approximately 44% of the forested area on the national forests is excluded from this analysis.

We then divided the remaining 12.9 million acres into Moist and Dry Forests (Figure 2). We approximated the division between Moist and Dry in western Oregon and western Washington by overlaying the national forests on the Moist/Dry maps. While there are Moist Forests in the eastern Oregon and eastern Washington national forests, we believe that most are in Wilderness, “no harvest management areas”, or Inventoried Roadless Areas—the higher elevation, often subalpine, forests. Therefore, for purposes of this analysis, we assume that the all of the forest east of the Cascades outside of these allocations are Dry Forests. Field review will be needed to actually determine how to classify the plant associations of these forests, but we are confident that most will fall into Dry Forests. In total, we found that 12.9 million acres of forest outside of Wilderness, roadless areas, and other withdrawals, are divided about one-third Moist and two-thirds Dry (Figure 2)⁵.

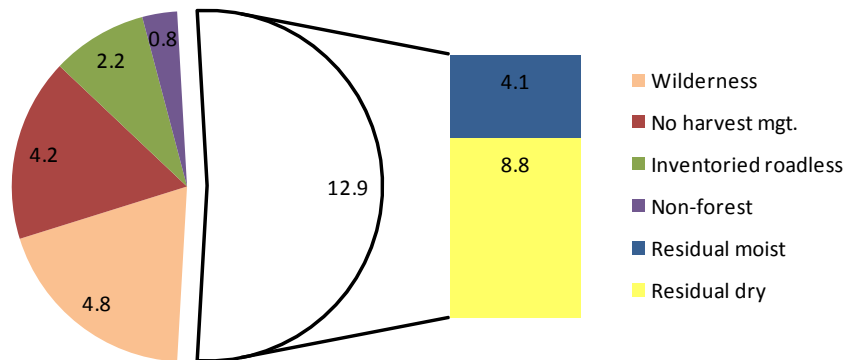
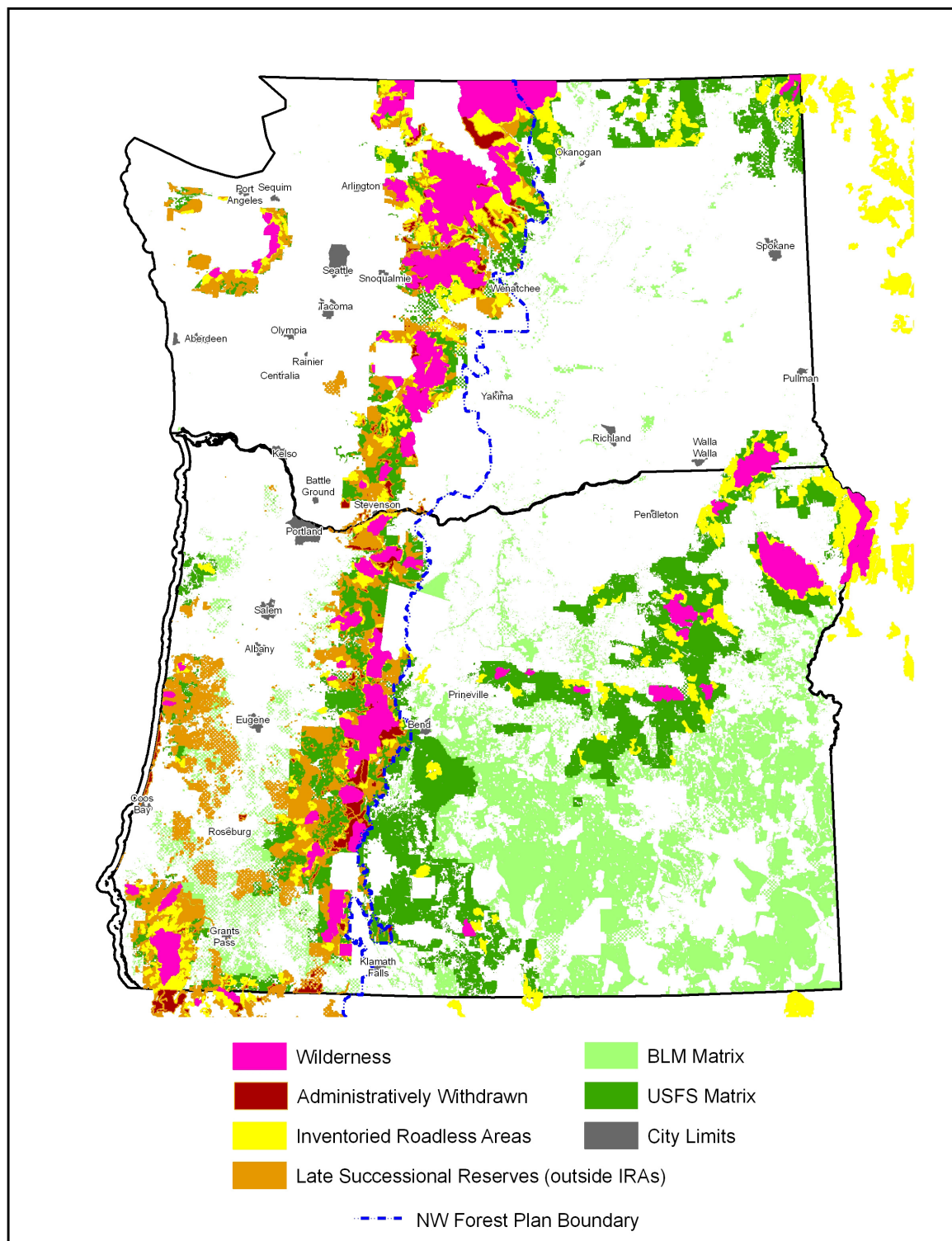


Figure 2. Distribution of the national forests of the Pacific Northwest between different allocation categories and between Moist and Dry. (Note: some Inventoried Roadless Areas are included in the “No harvest management areas.” The nonforest shown here was estimated after removal of Wilderness, “No harvest management areas”, and inventoried roadless areas.) The residual Moist and Dry Forest would receive further analysis to assess whether timber harvest is permitted and would be desirable.

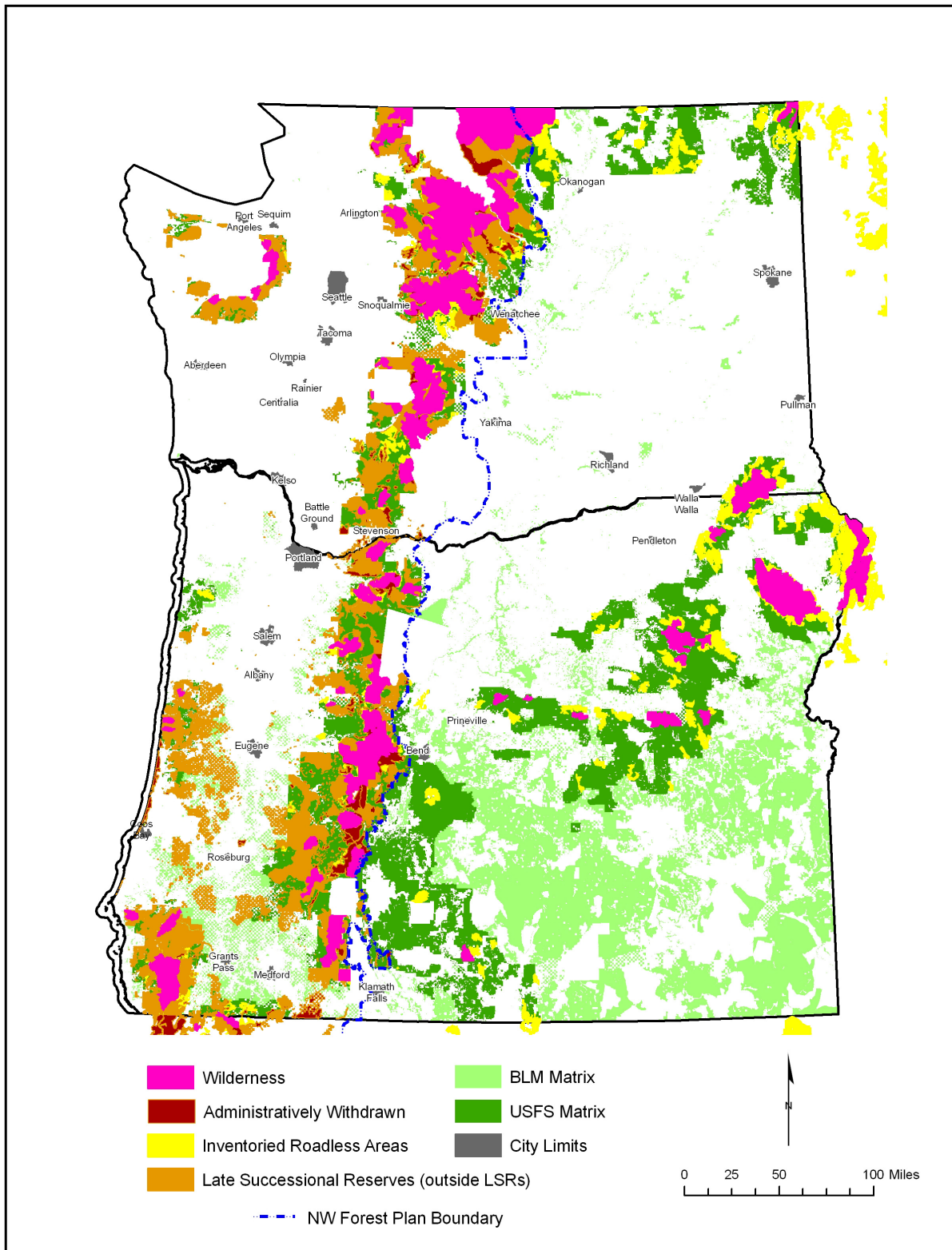
⁴. Information on land allocations, age classes, stand densities and harvest volume for the national forests are based on information in documents and spreadsheets provided by Natural Resources, USDA FS Region 6 in Winter and Spring 2008 including an internal report entitled “Region 6 Thinning Potential Analysis.” Much of the inventory data is from plots taken in the mid-1990s. We discuss the limitations imposed on the analysis due to the age of this information throughout this report.

⁵. The USDA Forest Service Region 6 analysis we utilize here used a Moist/Dry classification based on Province definitions from the Northwest Forest Plan. We have adjusted those results, as best we can, to account for our slightly different Moist/Dry splits. We do not believe that these differences and adjustments alter our conclusions.



Map 5a.

Map 5. Wilderness, Administratively Withdrawn, Inventoried Roadless Areas, and Late Successional Reserves on the national forests of the Pacific Northwest. In addition, individual national forests have designated “no harvest” areas in their forest plans not shown on this map. Map 5a shows Late Successional Reserves outside of Inventoried Roadless Areas where they overlap. Map 5b shows the reverse-Inventoried Roadless Areas outside of Late Successional Reserves where they overlap. Notice the significant overlap between the two allocations within the area of the NWFP, especially in southwest Oregon and the northern Cascades.



Map 5b. Some land allocations on the national forests (showing Inventoried Roadless Areas outside of Late Successional Reserves).

BLM

We used BLM's land base associated with the recent Final Environmental Impact Statement (FEIS) for the plan revision for the Western Oregon Districts (BLM 2008) and subsequently will refer to them as the "BLM lands" or the "BLM forests⁶." These lands cover 2.5 million acres with 2.4 million within the area of the NWFP and the remainder east of Klamath Falls. A portion of these lands have been withdrawn from timber harvest in the recent BLM plans; some are part of the National Land Conservation System, such as Wild and Scenic River corridors, and others are Administratively Withdrawn, such as unstable slopes or Areas of Critical Environmental Concern. Many of the administratively withdrawn areas are within the Late Successional Reserves of the NWFP.

We divided BLM's forests into Moist and Dry by overlaying BLM Districts on our plant association classification (Map 4). We estimate that 75% of the Medford District and 40% of the Roseburg District are Dry Forests by this classification. We assumed that the rest of these forests are Moist, except for some forests near Klamath Falls in the Lakeview District. Thus, we estimated a gross forested area of 1.4 million acres of Moist Forest and 0.8 million acres of Dry Forest on BLM lands.

Forest Conservation Strategies: An Ecological Approach

The silvicultural actions described below are based on an approach known as "ecological forestry" (Franklin, Mitchell and Palik 2007). Ecological forestry reflects forest practices that are based on (1) principles of natural stand development, including the role of natural disturbances in the initiation, development, and maintenance of forest ecosystems (Long 2009), (2) operate on temporal scales consistent with recovery of desired structures and processes, and (3) view forests as complex adaptive systems (Puettmann et al. 2008). Elements of ecological forestry include: (1) Retention of structural and compositional elements of a forest at the time of a regeneration harvest; (2) Manipulations of established stands to direct their development to desired structural and compositional conditions, such as by variable density thinning and prescribed burning; and (3) Determining return intervals for activities based on recovery periods for key structures and processes. Ecological forestry also typically incorporates spatial considerations from the distribution of individual structures (e.g., logs) within stands to patch diversity at the landscape scale. Ecological forestry programs are typically planned, implemented and evaluated at the landscape scale, incorporating knowledge developed from the study of pattern and ecological function in natural landscapes. This includes consideration of landscape components of exceptional significance, such as aquatic features and early-successional and other non-forested communities within forest landscapes (Lindenmayer and Franklin 2002). (For more discussion, please see Appendix I).

Utilizing Ecological Forestry principles in Dry Forests, we focus on restoration of more characteristic and sustainable ecological conditions and functions by conducting silvicultural activities that remove trees that function as ground and ladder fuels; reduce risks to older trees from wildfire and competition; re-establish more characteristic ground cover; and favor more fire- and drought-tolerant tree species. This approach typically focuses on removal of many small and some medium-sized trees, but may also call for removal of some larger young trees, particularly when they increase risks to older trees.

Using these principles on Moist Forest sites, we focus on accelerating development of complex forest structure in young forests that have been simplified through past management. This includes activities that will create more diverse structural conditions, including spatial heterogeneity or

⁶ Information on land allocations, age classes, stand densities and harvest volume for the BLM are based on information in documents and spreadsheets on the "No Change" (Northwest Forest Plan) Alternative, from BLM's 2008 FEIS for the Western Oregon lands (BLM 2008), and related documents and spreadsheets provided by the Oregon State Office of BLM.

patchiness in stand conditions, and create wild-life habitat. In these forests, restoration-based variable-density thinning commonly will be used to create structural (including multiple canopy layers) and compositional diversity within stands; this will often involve removing some dominant and co-dominant trees.

Forest policies must recognize that different approaches for conservation of old-growth forest conditions are required on historically fire-frequent sites (Dry Forests) and on sites where fires were historically infrequent (Moist Forests).

Where Moist Forest sites are eligible for regeneration harvest, such harvests can be conducted using a variety of approaches from variable retention to individual tree selection (Franklin, Mitchell and Palik 2007). Where a significant percentage of the stand is to be removed (e.g., >50%) variable retention harvesting provides numerous diverse choices in terms of the type and densities of structures to be conserved and the spatial patterns for this retention (e.g., evenly dispersed in the harvest unit or spatially aggregated) (Franklin et al. 1997). Most retention harvests will retain large living trees, snags, and logs. In designing regeneration harvest systems ecological forestry principles also call for recognizing and nurturing the diverse early successional communities that can develop following harvest and natural disturbances (Swanson, et al. submitted). This objective may result in different approaches to tree regeneration as well as the specifics of the retention harvest prescription, such as more reliance on natural regeneration and acceptance of competition from trees and shrubs.

In both Dry and Moist Forests, silvicultural activities would be designed to restore the spatial heterogeneity characteristic of late-successional forests; this refers to a non-uniform distribution of forest structural elements, such as trees, snags, and canopy density. Such spatial heterogeneity is characteristic of older forest stands and landscapes in both Moist and Dry Forest regions (Franklin et al. 2002; Franklin and Van Pelt 2004). The practitioner of ecological forestry will typically look to the heterogeneity inherent in stands and landscapes as a beginning point or guide in incorporating heterogeneity in treatments. Uniform silvicultural treatments which create homogeneous conditions will be uncommon at either the stand or landscape scale.

Recognition of Old Growth Forests and Trees

The term “old-growth” refers to the oldest successional stage in which a plant community is capable of existing on a site, given the frequency of natural disturbance events. Depending on the plant association, site conditions, and the frequency and intensity of disturbances, old-growth forests will have very different structures, species compositions, age distributions, and functional capacities than younger forests.

We realize that there is a continuing debate about the age at which old growth characteristics appear, what other stand characteristics need to be considered in designating old growth forests, and what needs to be done to conserve old growth forests.

We utilize age--of stands and of trees--as one of the defining limits on direction and action for several reasons:

- Society at large is interested in conserving older forests and trees. For example, Steel (2009) documents the interest of Oregonians in conserving old growth forests. Some believe that “old growth” has reached iconic status in the American mind (Spies, et al. 2009);
- Past activities have reduced their occurrence to levels far below historical levels. For many decades in the last century, older trees and forests were a focus of timber harvest in the Northwest, thus depleting this resource (Johnson and Swanson 2009, Haynes 2009);

- Alternative approaches fail to identify and protect some older trees. In Dry Forests, as an example, we often encounter older trees, including ponderosa pine and western larch, which are less than 21 inches dbh (the current size-based screen). As importantly, we often find situations where large but relatively young trees crowd the older trees. This greatly increases the risk that the old trees will die from either wildfire (because of the fuels) or insects (because of competition-induced stress). (See Appendix II for discussion.)
- Utilizing a more general or less precise definition of old growth has the potential for creating endless debate and delay. Simple rules, such as a 21" diameter limit on harvest or an 80-year limit on Moist Forest plantation thinning, have, in fact, facilitate recent management of Moist and Dry federal forests.

On Moist sites, we focus on conservation of *older forest stands*. We examine consequences of using three different ages to define "older stands": 80 years, 120 years and 160 years. These ages will be used to limit where various silvicultural actions can occur. In addition, we focus on conservation of individual trees that are beyond the threshold age in younger stands.

We use three ecological terms to describe the types of "older forest" being considered:

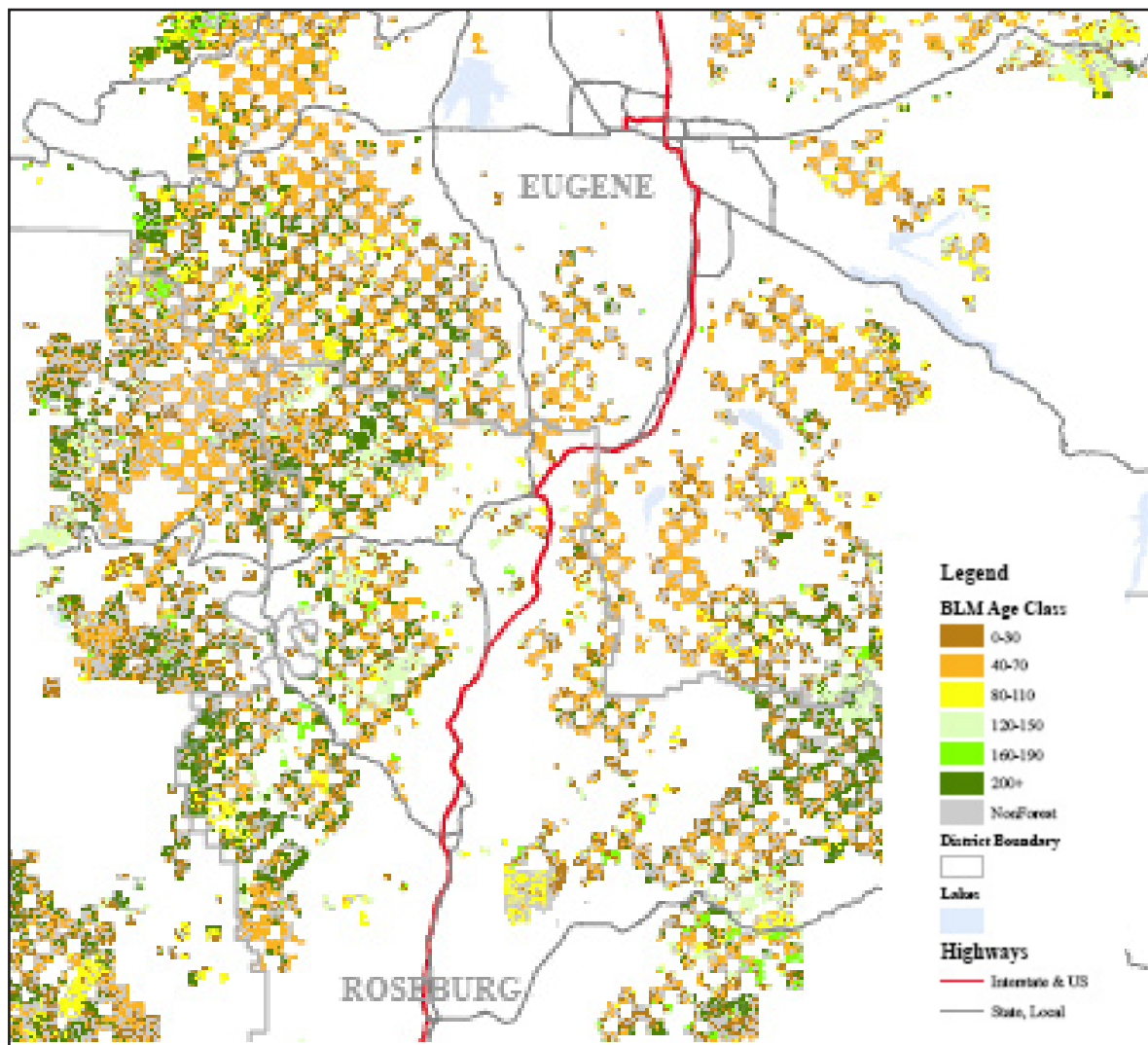
- 1) *Old-growth forests* on Moist sites will exhibit high levels of structural complexity, including spatial heterogeneity both vertically (e.g., multiple canopy layers) and horizontally (e.g., gaps and other forms of patchiness).
- 2) *Mature forests* are typically dominated by relatively even-aged and even-sized trees, which are still undergoing significant growth in height and have not developed the levels of decadence and structural complexity characteristic of old stands (Franklin et al. 2002).
- 3) *Late-successional forests* include all mature and old-growth stands; it is a category that was created by the Gang of Four (Johnson et al. 1991).

Stand ages 80 to 160 cover the range in threshold ages of stands being considered in most discussions of "old growth conservation." This range goes from including essentially all of the mature and old-growth forests (all late successional forests) at the threshold age 80 years, to including most mature and all old-growth forest at the threshold age 120, to including the most structurally advanced mature old-growth forest at threshold age 160 years.

On Dry sites, we focus on conservation of *older trees*, with those trees defined as being at least 150-160 years of age. We recognize that older stands (concentrations of old trees) can be found in Dry Forests but conserving the older trees within them typically requires active management within these stands. The choice of this age came from two sources: 1) trees in Dry Forests begin to exhibit the characteristics of old growth at these ages and 2) fire exclusion, through suppression of natural and Native American fires, and the introduction of livestock into these forests, began about 150 years ago. Thus, trees that need to be removed to restore the Dry Forests will be less than 150 years old.

This age-based approach has been incorporated into a number of Congressional proposals and, thus, the implications of such an approach are of some interest. Key questions about an age-based approach include: Aren't age-based rules "arbitrary?" Wouldn't it be better to use

Comprehensive ecological restoration will provide society with more and better management options 20 years into the future by providing more diverse and resilient forests and landscapes.



Map 6. Age class distribution for BLM lands in west central Oregon developed by the BLM as part of their recent plan revision.

Aging Moist Forests

- *Foresters have successfully aged forest stands in Moist Forests for generations; the federal agencies have shown they can successfully implement a program to reserve stands over a certain age.*
- *Most Moist Forest stands that would be harvested under a restoration strategy are even-aged plantations that are readily aged and contain few old trees that would be difficult to age.*
- *Protocols can be developed to address aging in the limited areas where multi-age stands occur.*

a definition that encompasses all the attributes of older forests? Will foresters have to bore every tree in a timber sale to determine age?

Moist Forests

Foresters have a long tradition of characterizing the age of even-aged stands that result from stand replacement disturbances. An even-aged stand is one in which most of the dominant trees regenerated after the same initiating disturbance and its age is determined by coring a sample of the dominant trees at breast height and adding some additional years to account for the growth from ground level to breast height (most commonly from tables developed from research and reflecting different site productivities). This process is easily applied to young and mature stands in Moist Forests. For example, McArdle et al. (1949) state, “As given in this bulletin the age of the stand is the average total age of the dominant and codominant trees. It is the number of years since the stand started from the seed...” A more recent example is from the BLM as that agency prepared its recent plan revision for Western Oregon (BLM 2008) (Map 6).

What about older trees in younger stands? Based on information on acres by age classes provided by the agencies, we can estimate the distribution of acres in Moist Forest age classes:

- 1) The vast majority of acres in Moist Forests on which timber harvest might occur are plantations with few trees over 80 years of age whether the age threshold is 80, 120, or 160 years.
- 2) Problems in aging would most likely come in Moist Forest stands between 80 and the threshold age for reservation. They would cover from 0-15% of the acres available for harvest depending on the threshold chosen. In those stands, we could encounter a number of problems in aging including trees near the age threshold, problems in aging trees such as the difficulty of seeing visible rings near the center, difficulty of seeing rings due to heart rot, difficulty of estimating years to breast height, and problems with small, suppressed, old trees which are not the target of the conservation effort. Also special procedures would be needed for hardwoods. How would we deal with these aging problems?

Where aging problems occur, we envision a process similar to that used for assessing wood quality in trees. Protocols for different trees and regions would be developed based on studies by scientists and forest managers and then field-tested. They would then be employed to age trees on timber sales, with information gathered along the way through sub-sampling the trees within the sale. This information would be pooled with other sales to see how the protocols are working. We envision that this sub-sampling would be applied to trees of commercial sawtimber size, i.e., trees over 11” dbh. Smaller trees might be sampled in post-sale monitoring but would not need to be bored.

Aging Dry Forests

- *Diameter limits have been useful as a first step to protect old growth trees; but we now need to move to age limits to directly address old growth conservation.*
- *Age limits allow both the protection of small old growth trees and removal of large young growth trees, such as grand and white fir, that threaten the future of old forests.*
- *Foresters have used visual characteristics to age ponderosa pine for over a century!*
- *Protocols for tree aging can be patterned on well-established methods of determining wood quality to enable tree aging with only moderate need for ring count.*

Then, post-sale monitoring by counting rings on cut stumps would also contribute information. As a result of the collection of this pre-sale and post-sale information, the agency would adjust the protocols as needed. Every five years or so, an independent team of experts (scientists and forest managers) would review the results and make suggestions.

Dry Forests

In Dry Forests, we focus on conservation of older trees, with those trees defined as being at least 150-160 years of age. In the 1920s, foresters developed a tree marking guide based on age and vigor called the Keen Classification to help them identify trees to mark. Thus, they have long experience with age-based criteria. In addition, the vast majority of trees that need removal as part of the restoration treatments are clearly much younger than 150 years. Recently visual guides for estimating ages of trees in Dry Forests of eastern Washington have been developed by Van Pelt (2008).

We could encounter aging problems similar to those discussed for Moist Forests. Also, estimating the age of small, old ponderosa pine and western larch can occasionally be troubling. Thus, we would envision a process similar to that described above for Moist Forests which combines protocols for aging with pre-sale and post-sale information to guide implementation and improvement of tree marking guides. These protocols should consider the approach taken by Van Pelt (2008) and earlier tree classifications (e.g., Dunning 1928 and Keen 1943).

We discuss aging issues in Appendix III. In summary, we find that: 1) age-based rules are not arbitrary (without reference to principle or logic), 2) a more general definition of old growth has the potential of endless debate and delay, and 3) federal forest management will be facilitated by simple rules that both limit and protect agency discretion. Furthermore, relatively few trees will need to be bored as part of timber sales, based on the process outlined above, and that process will accelerate learning to improve predictions over time.

Description of Proposed Silvicultural Activities

On Dry Forests

Current Situation

Our current understanding of the state of Dry Forests relative to their historical processes and structures has been summarized for western North America by Noss et al. (2006) and for the Pacific Northwest by Courtney et al. (2008) and Johnson et al. (2008). These authors drew on a large body of literature (e.g. Johnson et al. 1995, Youngblood, et al. 2004, Hessburg, et al. 2005, Fitzgerald 2005, and Spies, et al., 2006) as well as their own experience:

- Dry Forests experienced a variety of natural disturbance regimes prior to western settlement. One widespread circumstance were areas characteristically subjected to relatively frequent, low- and mixed-severity wildfire. In these landscapes pre-settlement fire regimes created shifting landscape mosaics dominated by fire-tolerant cover types and structures. Large areas, particularly in northeastern Washington and Oregon, were subject to mixed-severity wildfire regimes which resulted in significant percentages of forest that were denser and more even-structured. In both cases resilience to disturbances came from a shifting mosaic of conditions over space and time.
- In all areas, decades of fire suppression, grazing by domestic livestock, timber harvesting, and plantation establishment have altered the structure of the Dry Forests. Compared to historical conditions, current conditions generally have: 1) much lower population levels of old fire-resistant trees, such as ponderosa pine, 2) more forests with multiple canopy layers and high stem densities, 3) more continuously and densely forested landscapes with continuous and high surface and ladder fuel levels, and, consequently, 4) forests and landscapes that are highly susceptible to loss from stand-replacement wildfire or insect outbreaks.

These conditions are illustrated in a detailed analysis by Johnson, et al. (2008) of 525,000 acres of the Fremont-Winema National Forest that was once part of the Reservation of the Klamath Indian Tribes. Johnson, et al.(2008) divided this forest into plant association groups and they used historical information to help develop desired future conditions (DFC). They found the density of trees less than 21 inches dbh was much above historic levels and the density of trees greater than or equal to 21 inches and greater than or equal to 32 inches were below historical levels (Figure 3). In

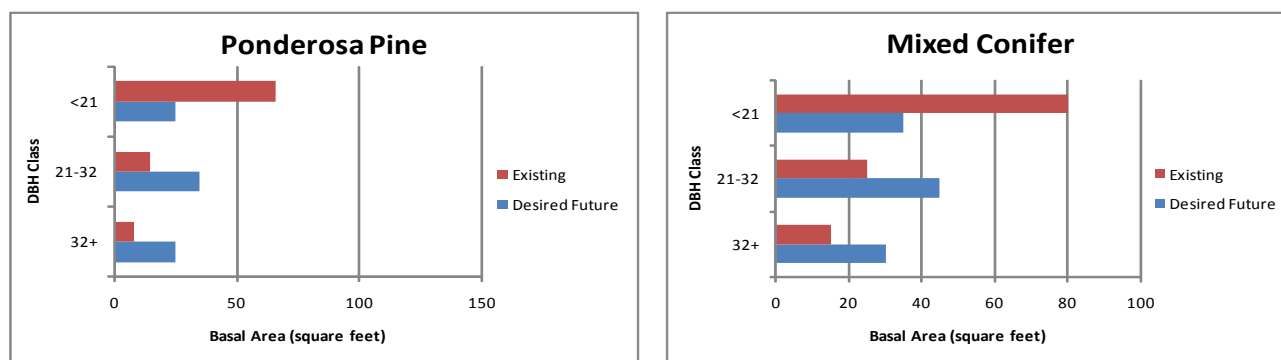


Figure 3. Comparison of desired future condition, based largely on historical conditions, with actual condition of the ponderosa pine and mixed conifer Dry Forests on the Winema National Forest from a study by Johnson, et al. 2008. Historically, we would have expected at least two-thirds of the basal area (a measure of density) would have been greater than 21 inches dbh; today more than two-thirds is less than 21 inches dbh.

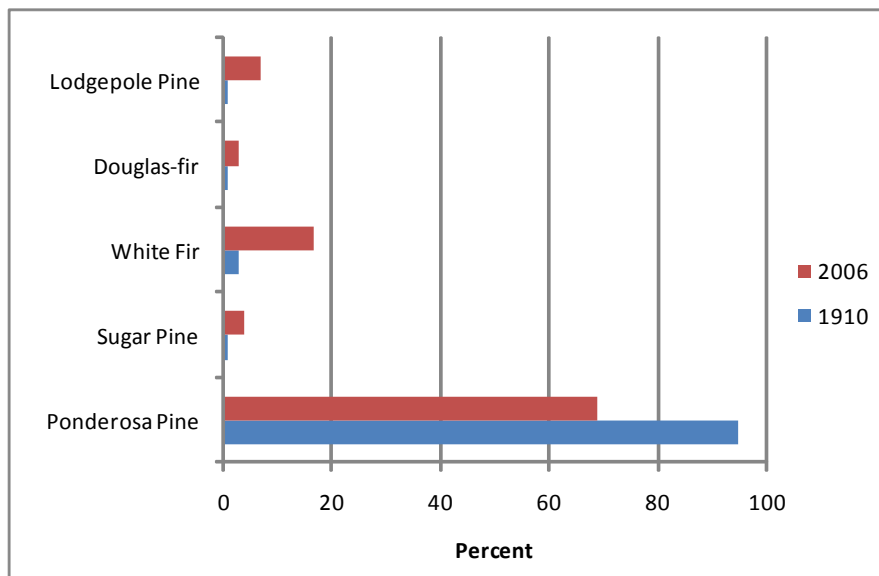


Figure 4. Historical and current proportionate distribution of major species in the Dry Forests of the Winema National Forest. Ponderosa pine has been significantly depleted through harvest while white fir and lodgepole pine, two species susceptible to fire, have shown a significant increase with the advent of effective fire suppression. (Source: Johnson, et al. 2008)

addition, levels of white fir and lodgepole pine were much above both historical and desired levels (Figure 4).

How extensive are these conditions across the Dry Forests of Oregon and Washington? A number of studies (Hardy et al. 1999, Schmidt et al. 2002, Noss et al. 2006), using imagery and related techniques found that much of the Intermountain West had a buildup of stand densities that threatened their sustainability.

Some studies (Donnegan et al. 2008), on the other hand, have found less fire hazard in current conditions based on recent inventory data and stand simulations, where that hazard is measured by the probability of active crown fire. We do not agree with their conclusion regarding the state of Dry Forests for several reasons: First, whether these fires are passive crown fires, active crown fires, or surface fires that cook the roots of the trees, they will kill many of the old trees due to the unprecedented increase in tree densities and fuel loadings in stands. Second, numerous analyses (some cited above) document the presence of under- and mid-stories in stands that are much denser than they were historically. These high tree densities increase competitive stresses that make the old trees vulnerable during the next cycle of drought and insect attack--a problem that is not addressed though treating only a small percentage of the landscape. Third, impacts of climate change must be factored into restoration projects; these are currently predicted to include hotter and drier summers and larger and more intense wildfires. These predictions (some of which have already been documented) strongly support a policy of reducing stand densities in Dry Forests. We conclude that in debating the merits of fuel treatments (or, preferably, restoration programs), it is essential to be specific about the ecological characteristics of areas being considered and specific management objectives, which certainly incorporate but extend beyond considerations of fuels and wildfire.

Fundamentally, reductions in understory densities around old-growth trees reduces the competitive stresses experienced by those trees. Two studies on western conifers have confirmed that stand density reductions do result in increased growth of individual old trees. Furthermore, these positive physiological responses to stand-density reductions have lasted for up to 15 years in old ponderosa pines or Douglas-firs (Latham and Tappeiner 2002; McDowell et al. 2003). Physiological

stresses created by abundant competitors can result in accelerated mortality of old-growth trees, a concern that is accentuated by the increasing summer moisture stress expected with climate change. We conclude that reductions in stand density are needed to reduce such stress and improve the vigor of these trees.

Restoration Silviculture

Given this situation, we propose that ecological restoration of Dry Forests involve silvicultural activities that:

- 1) Retain existing older trees (trees over 150 years of age), initiate restoration of ecologically sustainable stands and landscapes that incorporate characteristic stand structures and old tree populations, and provide significant wood harvest during the restoration process;
- 2) Maintain these sustainable conditions in perpetuity through active management, such as with prescribed fire and mechanical activities, which can include sustained wood harvest;
- 3) Incorporate ecologically appropriate spatial complexity, including both open and denser forest patches at both the stand and the landscape level;
- 4) Continue management activities on an ongoing basis to maintain a fire-resilient state; and
- 5) Restore riparian, meadow and hardwood communities.

Silvicultural activities should give high priority to: (1) Reducing risk to trees >150 years old from wildfire and competition, such as by removing fuels and competing vegetation; and (2) Restoring old tree populations to historical levels and then maintaining them there.

General objectives of silvicultural activities on Dry Forest sites should be to:

- 1) Reduce tree densities in overstocked stands;
- 2) Increase the mean diameter of stands;
- 3) Shift composition toward more fire- and drought-tolerant species, such as ponderosa pine, western larch, and sugar pine;
- 4) Restore and maintain historical levels of within-stand spatial heterogeneity;
- 5) Protect existing old trees and reduce fuels and competing vegetation around them; and
- 6) Provide for restoration and maintenance of historic old tree population levels by management of younger stand components.

With these objectives in mind, Johnson et al. (2008) urged prompt action over the majority of the 545,000 acres of the Fremont/Winema Forest they studied to restore the desired conditions with the prescriptions tailored to plant association groups. Density reductions in the ponderosa pine plant association groups concentrated entirely on trees under 21" dbh while density reductions in the mixed-conifer (white fir) plant associations also removed white fir over 21" dbh. Other restoration emphases were designed to restore hardwoods (aspen and willow) and wet meadows.

Courtney et al. (2008) in a review of the draft Northern Spotted Owl Recovery Plan, recommend a similar approach to restoring and conserving Northern Spotted Owl habitat in dry eastside forests within the NWFP area emphasizing measures focused on the Northern Spotted Owl. Specifically they recommend:

- Utilizing Agee and Skinner's (2005) summary of fuel treatment principles (reduce surface fuels, increase height to live crowns (including eliminating fuel ladders), decreasing crown density, and retaining old trees.

Restoration silviculture in Dry Forests should increase survivability of old trees by eliminating fuels and competition around them; just retaining old trees is not enough.

- Favoring fire-tolerant tree species during treatments, thereby steadily improving the fire tolerance of stands, especially where fires are typically low- or mixed-severity.
- Retaining the large and old fire tolerant trees: “These trees take 150 or more years to grow and are not easily replaced. They are key habitat features that can persist for centuries. Large trees of other species (e.g. grand fir and white fir) and younger, smaller trees (e.g. <20” dbh) of fire tolerant species may be removed outside critical owl habitat to reduce canopy fuels” (Courtney et al. 2008). The authors recommend that visual criteria-- including bark and canopy characteristics and other indicators--be developed to aid in field recognition of old trees regardless of diameter.
- Applying treatments unevenly within stands, effectively creating fine-scale patchworks within stands that provide a mosaic of open patches of large trees, denser patches with mid-canopy trees, and regeneration within a forest that generally meets fuel treatment principles.
- Varying treatments among stands--creating meso-scale landscape mosaics within regional landscapes.
- Developing management plans for entire landscapes (landscape silviculture) that integrate fuel reduction objectives with those for maintaining or improving habitat for Northern Spotted Owl prey habitat, habitat for other species, and restoration of Dry Forest ecological process and function.

Target levels for such variables as tree density, basal area, and old tree populations should be determined by individual plant associations, based upon historic conditions, and considering the landscape-level context. Published management guidelines focused on Stand Density Index (SDI) or basal area may be useful but must be applied with care in restoration forestry, since these were developed for young managed stands--not for stands dominated by a small population of large trees. Again, natural stands characteristically have significant fine-scale heterogeneity or “clumpiness” that needs to be maintained. For example, old trees are sometimes clustered in groups that contain two (common) to six (rare) individuals; such aggregations are natural and are probably mutually supportive rather than competitive. In any case, restoration silviculture needs to provide for such heterogeneity.

In restoration silviculture, potential shrub responses to reduction in stand densities must be considered. Some dry mixed-conifer plant associations have the potential to develop dense shrubby understories when light and moisture are made available by tree thinning; this is particularly the case in Dry Forests that exhibit more even-sized and dense structures. Such understories can provide significant ground fuels for wildfires, thereby negating some of the positive effects of thinning on fire behavior. The potential for development of shrubby understories can initially be assessed on the basis of plant association; i.e., plant associations vary significantly in potential understory responses. Current stand conditions provide another important measure. Hence, the potential for developing undesirable levels of understory fuels needs to be assessed on a stand-by-stand basis and prescriptions adjusted so as to reduce the risk of undesirable understory responses. Indeed, in some cases it may be desirable to maintain essentially full overstory cover, treating only ladder fuels, and leaving all dominant and co-dominant canopy trees in place rather than risk enhancing ground fuels (e.g., grasses or shrubs). This may also reduce the potential for invasive understory plants.

Conversely, restoration treatments must consider maintaining understories of desired species, including browse plants (such as bitterbrush) and other shrubs and herbs of special interest.

A Landscape Approach

Projects in the areas need to be planned and implemented at the landscape level to be effective and to insure that spatial complexity is incorporated at larger spatial scales. Landscape level consider-

ations include 1) what proportion of the landscape needs to be treated to achieve the goals, 2) what size of areas to treat at one time, and 3) the spatial heterogeneity desired within each size of landscape.

Scale of effort

Three recent studies have addressed the question of how much of the landscape needs to be treated to be an effective restoration strategy in Dry Forests; they all conclude that action needs to be taken on a substantial portion of the landscape.

Finney, et al. (2007) conducted a landscape simulation of three large areas in the West to explore how fuel treatments placed in topologically random and optimal spatial patterns affect the growth and behavior of large fires when implemented at different rates over the course of five decades. For different spatial treatment strategies, the results illustrated that the rate of fuel treatment (percentage of land area treated per decade) competes against the rates of fuel recovery to determine how fuel treatments contribute to multi-decade cumulative impacts on the response variables. Using fuel treatment prescriptions that simulate thinning and prescribed burning, fuel treatment arrangements that are optimal in disrupting the growth of large fires require at least 1 to 2% of the landscape to be treated each year. Randomly arranged units with the same treatment prescriptions require about twice that rate to produce the same fire growth reduction. The results also show that the topological fuel treatment optimization tends to balance maintenance of previous units with treatment of new units. For example, with 2% landscape treatment annually, fewer than 5% of the units received three or more treatments in five decades with most being treated only once or twice and 35% remaining untreated after five decades.

Considering actions over the first twenty years, we interpret the Finney, et al. (2007) results as follows: fuel treatments optimally placed to disrupt the growth of large fires require at least 20-40% of the landscape be treated and randomly placed treatments require at least 40-80% of the landscape be treated to achieve the same affect. Given the inevitable compromises over where treatments will occur, we average the two ranges to give an overall average of at least 45% of the landscape treated in the first 20 years. In addition, most units will be treated once or twice over the first fifty years as maintenance of previously treated units is balanced with treatment of new units. Also, perhaps one-third of the landscape will be left untreated.

Johnson, et al. (2008) focused on ecological restoration of a 600,000 acre portion of the Fremont-Winema National Forest (as described above). They argued for comprehensively treating the forests, meadows, and glades at a rate of approximately 3% per year for the first 20 years.

Courtney et al. (2008) focused on a strategy to conserve/restore Northern Spotted Owl habitat in dry eastside forests within the NWFP area but emphasize measures focused on the Northern Spotted Owl. Specifically they recommend managing the entire landscape to provide desired levels and sustainability of Northern Spotted Owl habitat by:

- Maintaining an area of owl habitat patches or patch clusters averaging 30-35% of overall landscape managed for Northern Spotted Owl habitat, with the percentage varying by forest type, i.e., managing for a lower percentage in landscapes dominated by the driest forest types and somewhat higher in landscapes dominated by the Moist Forest habitats;
- Providing high-quality Northern Spotted Owl habitat in patch clusters of several hundred acres

(+ or -) distributed across the landscape, especially in locations where fire refugia might be expected to occur;

Maintenance of large contiguous blocks of dense Dry Forest for Northern Spotted Owls and their prey is not a sustainable strategy.

- Embedding the high-quality Northern Spotted Owl habitat patches in a matrix that has been treated to reduce the potential for significant losses by stand replacement fires;
- Implementing restoration treatments on the majority of the landscape to reduce risks to high-quality Northern Spotted Owl habitat and achieve other management objectives;
- Starting risk reduction treatments around key Northern Spotted Owl habitat; and
- Undertaking follow up treatments at regular intervals to maintain fuels and desired levels.

The owl strategy calls for embedding the denser multi-storied forests required as Nesting-Roosting-Foraging (NRF) habitat by the owls and their primary prey species within a landscape matrix that has been treated to significantly reduce the potential for extensive contiguous intense wild-fires (Courtney et al. 2008). Approximately one-third of the landscapes within the range of the Northern Spotted Owl would be retained in NRF patches of at least 300 acres. These patches will typically be denser multi-storied mature or old stands which have a significant component of true firs (grand or white fir) or Douglas-fir or both; the objective will be to locate these patches on sites comparable to those where denser forests probably occurred in the past, including cool north-exposed slopes and cooler valley bottoms and riparian areas.

These designated owl NRF habitat patches would be embedded in a landscape that has been subjected to a restoration treatment to reduce overall stand densities, increase mean stand diameters, increase the proportion of fire- and drought-tolerant species, such as ponderosa pine, and, conversely reduce the proportion of fire- and drought-intolerant species, such as grand or white fir.

The owl strategy is illustrated by Johnson et al. 2008, although at slightly lower retention levels. This plan provides for 25% of the mixed-conifer forest in South Chiloquin (the area within the range of the NSO) to be maintained as owl NRF patches. The patches are located on north-facing slopes and in complex forest whenever possible. Much of the forest between the patches would be treated to substantially reduce stand densities (Map 7).

Collectively, these three landscape-level studies in wildfire control, ecological restoration, and spotted owl conservation all call for a substantial portion of the landscape to be treated on a continuing basis using prescribed fire and timber harvest to maintain desired stand structures and densities, including Northern Spotted Owl NRF habitat.

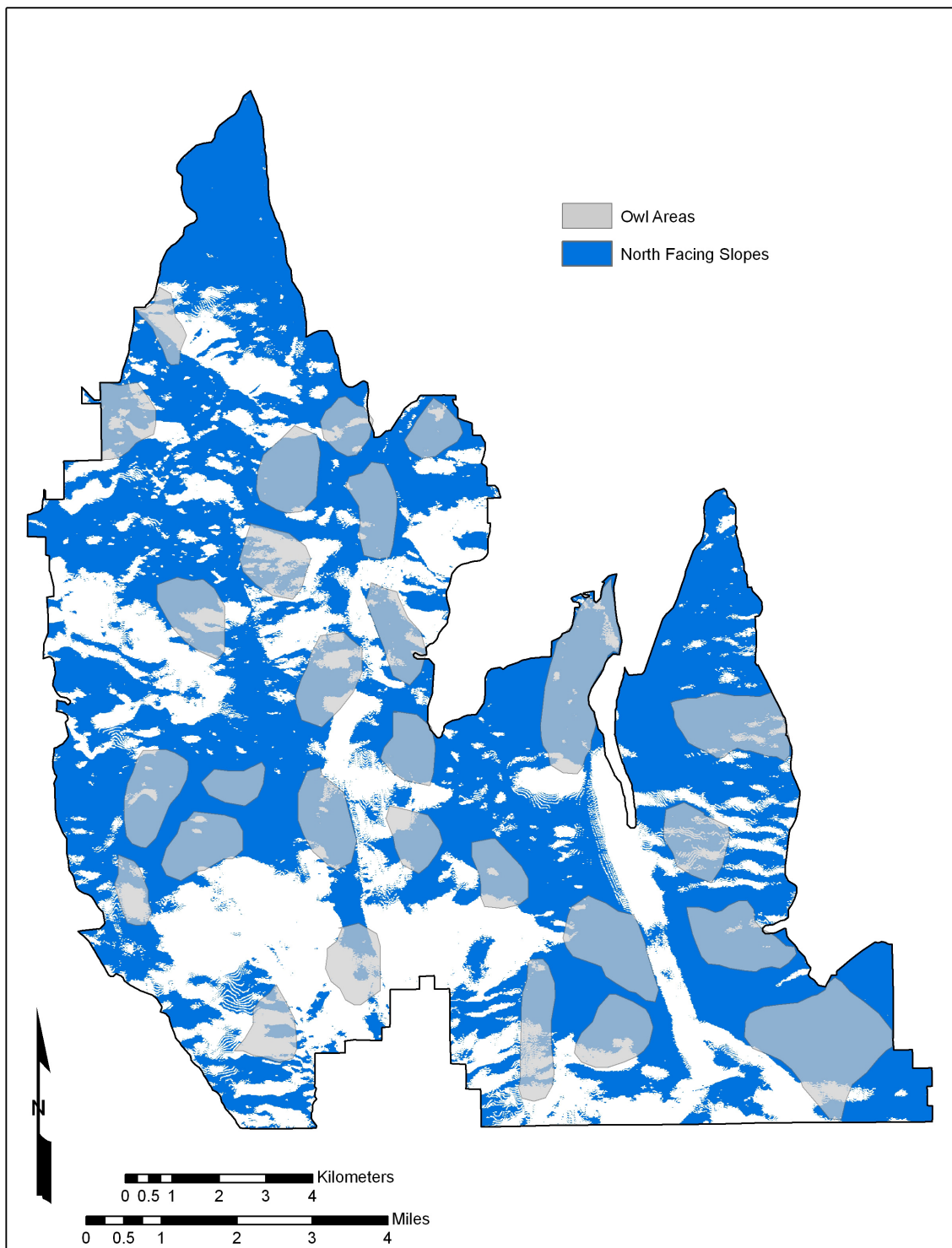
Size of project areas

Johnson, et al. (2008) urged that the forest being treated be divided into watersheds of 20,000-25,000 acres, with about one watershed tackled per year (Map 8). This would enable many of the cumulative effects of treatments to be considered and evaluated, such as the strategic placement of fuels reduction block, and would also help force consideration of all restoration needs at one time including road repair and closure, and meadow restoration. The expectation would be that the watershed would not be reentered, to a significant extent, until the next cycle through the forest.

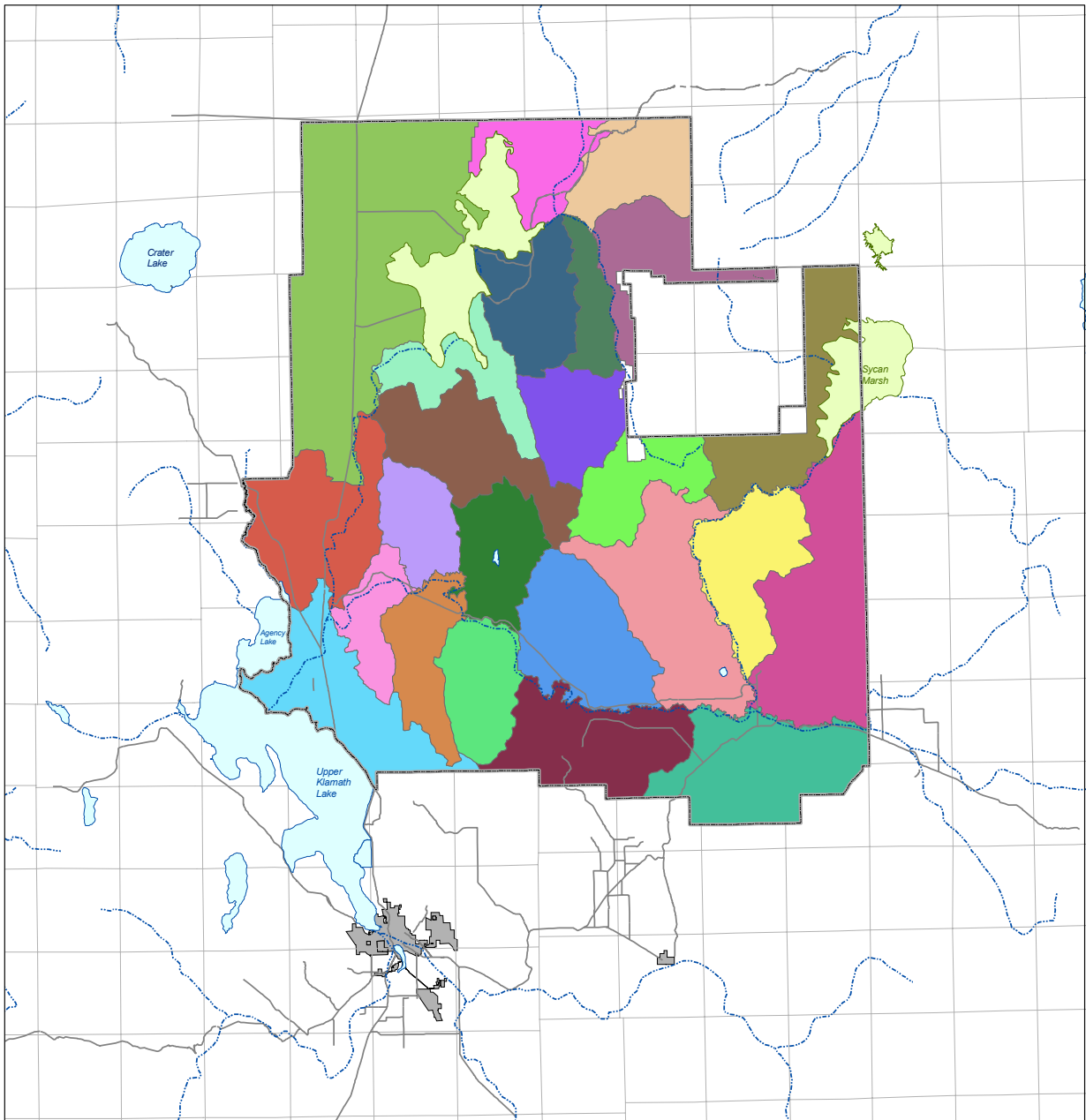
Landscape planning also needs to go on at much larger spatial scales to assure that objectives are met at subregional and regional levels.

The need for spatial heterogeneity

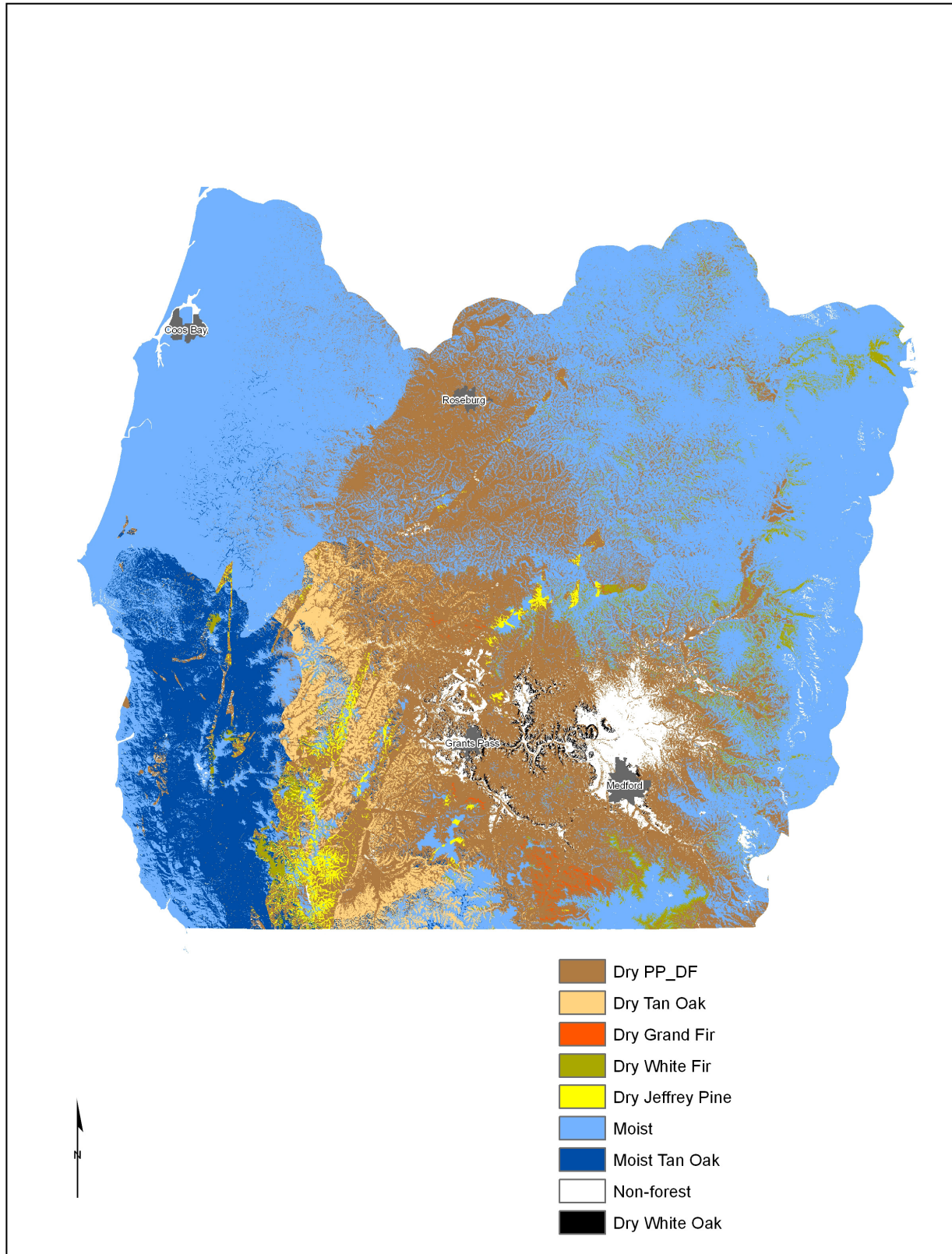
Spatial heterogeneity is an essential element in restoring and sustaining Dry Forests and landscapes. Restoration activities need to build upon and enhance existing residual spatial heterogeneity. Ecological restoration will rarely involve extensive areas of uniform treatments. A complex pattern of open and dense forest, meadows, and glades should result with:



Map 7. Spotted owl conservation areas suggested by Johnson et al. (2008) for the South Chiloquin area of the Fremont-Winema NF overlain on north facing slopes.



Map 8. Restoration units based on watershed boundaries suggested by Johnson et al. (2008) for a portion of the Fremont-Winema NF.



Map 9. Southwest Oregon plant association groupings.

- 1) Small dense patches of seedlings and saplings. Johnson et al. (2008) proposed at least 10% of these “skips”;
- 2) Medium-sized dense patches (300+ acres in size) scattered over the landscape to help provide habitat for species such as the Northern Spotted Owl and its prey; and
- 3) Variability in landscape-level forest and non-forest patches.

The Klamath Province: Complicated, Diverse Forests

Courtney, et al. (2008) note that “The Klamath Province contains highly variable environments, forests, and fire regimes.” Many areas in the western portion of the Klamath Province experience wildfire regimes like those in the Moist Forests farther north. On the other hand, the eastern portion of the Klamath Province exhibits forest types and fire regimes similar to Dry Forests on the eastern slopes of the Cascade Range. In addition to this broad environmental gradient local conditions vary greatly as a result of soils, climate, topography, and other influences. Fire behaviors are strongly influenced by topography and landscape context as well as plant association. Courtney et al. (2006) suggest that the current reserve approach for owl habitat is adequate for the short term, but that the area could be examined more closely to determine where fire and other disturbances behave more like the Dry Forests on the eastern slopes of the Cascade Range (Courtney et al. 2008). They recommend a province-scale analysis to tailor habitat management approaches to local conditions.

With these suggestions in mind, we can utilize a plant association map of Southwest Oregon, which contains much of the Klamath Province, to illustrate the use of plant associations to guide development of restoration prescriptions (see Map 9 for plant association groupings):

- The moist western portion and the high elevation portions of the Cascades experience high severity wildfire regimes like those of the moist farther north and are covered under the section on Moist Forests.
- The Tanoak plant associations of the Siskiyou Mountains have a robust shrub understory that may quickly develop when stands are opened up, potentially defeating the use of thinning to reduce fuel accumulation. Recent work by Thompson and Spies on fire behavior in the Biscuit fire area (personal communication) will greatly enrich our understanding of the Tanoak plant associations that dominate that area. In Oregon these plant associations occur largely within Wilderness and roadless areas on the Siskiyou NF. There is currently no scientific consensus on appropriate management approaches to dealing with wildfire issues in areas dominated by the Tanoak plant associations; development of this consensus should occur before any large-scale program is adopted, as was recommended by Courtney et al. (2008).
- The Dry Forests in the central and eastern portion of the Klamath Province contain plant associations that we would expect to exhibit forest types and fire regimes more like the eastern slopes of the Cascade Range, especially the ponderosa pine and Douglas-fir plant associations. The Dry Forest strategy described for the eastern slopes of the Cascade Range should be considered and we have conducted our analysis accordingly. The vast majority of Dry Forest plant associations on federal land in this province fall on BLM’s checkerboard ownership. Given the intermixed public and private ownership pattern, restoration treatments that reduce stand densities seem particularly appropriate.

- Finally, the grand fir and white fir plant associations probably historically exhibited a mixed severity fire regime. Thinning and shaded fuel breaks may be useful but potential shrub responses are one of several important considerations. There needs to be more of a scientific consensus on appropriate management treatments for these lands/plant associations before work is undertaken.

An important goal in forest restoration is to incorporate heterogeneity at all spatial scales—from logs to large landscapes.

In summary, plant associations are important in determining where and how silvicultural manipulations can be useful to ecological restoration and fuels reduction in the Klamath Province but that there must be strong consideration of topographic and other landscape conditions. A variation of the Dry Forest strategy proposed for the eastern slopes of the Cascade Range could be successfully applied to the Douglas-fir and Ponderosa pine plant associations, especially on the checkerboard lands of the BLM and the eastern portion of the Rogue River National Forest. Finally, the province-scale scientific analysis recommended by Courtney et al. (2008) should be conducted to be sure that the best available science is brought to bear; this analysis should utilize leading scientific and management expertise, including scientists from outside the federal and state governments.

Hardwood Restoration

The riparian and upland hardwood component of many Dry Forest landscapes are in a highly degraded condition as a result of the combined effect of fire suppression and grazing by ungulates and domestic livestock (Johnson, et al. 2008). Fire historically both revitalized hardwoods, like aspen and willow, and kept species like lodgepole at low levels. Also, the presence of predators, such as wolves, helped reduce ungulate pressure on aspen, cottonwoods, and willows (Ripple and Beschta 2003). Consequently, it is not surprising that hardwoods in Dry Forest landscapes have declined dramatically with fire exclusion, reduced populations of predators and the introduction of livestock. Reintroducing fire will help, as will increases in types and numbers of predators by reducing ungulate populations and altering ungulate behavior. Also, harvest may help remove invading conifers.

Wildfire, fish, and forest restoration

Chronic adverse impacts to native salmonids have resulted from developments in forested landscapes (Burton 2006 and Rieman et al. 1997). These include barriers, such as road culverts, dams, and water diversions, and introductions of exotic species and diseases. Many local populations have been fragmented and—in species with a propensity for migration—loss of life history stages.

Burton (2006) also makes some cautionary statements about treatments to reduce the extent and intensity of wildfires:

- 1) Expanding forest activities to reduce the risks of wildfire must not be done at the risk of creating chronic negative impacts on remaining high quality aquatic habitats (Rieman et al., 1997).
- 2) Over the long term, wildfires may improve and rejuvenate habitat for salmonids and potentially increase their abundance. Large fires trigger hydrologic events that remove fine sediments from stream channels and induce debris flows that transport beneficial coarse substrates to the channels. These processes may well provide the materials that maintain productive habitats for fish and other organisms over the long run.

- 3) Long-term effects of large, “uncharacteristic” wildfires may be beneficial to native salmonids even though short-term negative impacts may be significant, particularly if the habitat is already degraded or poorly connected to downstream reaches.

On Moist Forests

Silvicultural treatments are not needed to maintain existing old-growth forests on Moist sites. The composition and structure of intact existing old-growth forests has not been significantly affected by human activities, as has been the case in Dry Forests. These forests characteristically are structurally complex and massive (Franklin et al. 2002); by their very nature, they have large accumulations of potential wildfire fuels. Fortunately, wildfires historically occurred at intervals of centuries (Hemstrom and Franklin 1982; Agee 1993). However, when wildfires do occur, they are difficult to control and have the potential to be severe because of the large fuel accumulations. Efforts to alter either fuel loadings or potential fire behavior would involve drastic alterations of these ecosystems that would make them unnatural and incapable of completely fulfilling their natural functions, including as habitat for biological diversity.

Moist Forest ecosystems are adapted to severe, stand-replacement disturbance events, whether from wildfire, windstorm, or volcanoes. They are part of the natural forest life cycle in Moist Forest landscapes (Franklin et al. 2002). Such events typically leave behind extensive biological legacies which contribute to ecosystem recovery (Franklin, Mitchell and Palik 2007). These forests almost always produce significant landscape diversity with areas of low- and mixed-severity fire effects and unburned patches; in that regard almost all stand replacement fires are, effectively, “mixed-severity fire events.” Under natural conditions an extended period of dominance by an early successional or pre-forest community occurs which is rich in structural complexity, biological diversity, and important ecosystem processes (Swanson et al. submitted). After several decades a young, generally even-aged forest eventually resumes dominance of the site and undergoes an extensive period of development (approximately 175-250 years) before old-growth conditions are fully re-established.

On Moist Forest sites silviculture can help create the diverse early seral communities and accelerate the development of structural complexity and ecological diversity in plantations in Moist Forests (Carey 2009, Swanson et al. 2009, Tappeiner 2009). We suggest general treatment strategies for Moist Forests with the understanding that the prescription used should be keyed to plant association and landscape context.

The goals of silvicultural activities in Moist Forests are to:

- 1) Retain all older stands and as well as all older trees encountered as individuals or small groups within younger forests;
- 2) Restore large contiguous blocks of older forest;
- 3) Manage young forests in Matrix and Adaptive Management Areas for ecological and economic objectives, including regeneration harvests based on principles of ecological forestry; and
- 4) Provide for spatial heterogeneity at all spatial scales.

Appropriate silvicultural activities are expected to include spatially variable stand thinning regimes that enhance stand structural and compositional diversity as well as individual tree development. Silviculture to accelerate the development of structural complexity will include activities such as:

- Thinning, primarily using variable density prescriptions that contribute to development

A large acreage of plantations in Moist Forests would benefit from thinning to accentuate development of structural complexity and biological diversity.

of spatial heterogeneity within stands. Variable density thinning prescriptions should build on existing spatial heterogeneity within stands rather than imposing artificial patterns and generally incorporate unthinned areas. Thinning should also allow for at some modest levels of stem clustering. The objectives of thinning do include more rapid development of large trees and may include development of epicormic branch systems on dominant trees;

- Nurturing understory as well as overstory biota, including herb, shrub, and small tree components. Removal of dominant and co-dominant trees (“thinning from above”) will often be required to provide more open overstory conditions that favor understory plants and development of desirable healthy but suppressed trees in suppressed and intermediate crown classes;
- Creating heavily thinned patches and openings that are variable in size but generally small (<1 acre); and
- Creating and conserving existing decadence, which is often scarce in managed young forests. This could include creation of snags and down logs and introducing fungal infections to living trees.

Most Moist Forests at issue here occur within the area of the NWFP. Therefore, the land allocations and terminology of that plan are used in the discussion below.

Within **Late Successional Reserves** and **Riparian Reserves**, silvicultural activities must be designed to accelerate development of late-successional structural attributes. Highest priority should generally be given to plantations established following logging. Current standards allow silvicultural activities to be undertaken in stands until dominant trees reach 80 years in age at breast height. In this analysis we compare the effects of continuing to use 80 years as the limitation with effects of extending that maximum age to 120 years.

Within **Matrix** and **Adaptive Management Areas**, we consider regeneration harvest of forest stands dominated by trees less than a certain age (80, 120, and 160 years), based on ecological forestry principles. All older trees that are encountered would be retained and protected. Specifics of any regeneration harvest prescription should consider the plant association, existing stand conditions, and landscape context. In many stands it should be possible to make a gradual transition from the thinning regimes described earlier to prescriptions that provide for tree regeneration, such as by creation of larger openings; it is possible to successfully regenerate and grow even relatively shade-intolerant species, such as ponderosa pine and Douglas-fir, using openings of one or a few acres.

Regeneration harvest prescriptions should provide for:

- Significant structural retention on harvested units (we recommend and have modeled a minimum of 20% retention), including retention of both forest aggregates and individual structures (e.g., trees);
- Retained aggregates should vary in size and shape, reflecting the nature of the stand and the topography. Generally no entry or other treatments should intrude into retained aggregates. Retained aggregates should be located so as to build on the complexity and diversity already present within the stand, rather than imposing some arbitrary pattern;
- Protection of aquatic and semi-aquatic features in the project areas as well as other ecologically important areas (Lindenmayer and Franklin 2002); and
- Post-harvest treatments should consider the importance of the early successional (pre-forest) community (see below).

Early successional or pre-forest communities--the structurally, and biologically diverse communities that exist between a major natural disturbance event and re-establishment of dominance by a conifer forest canopy--are critically important components of the PNW forest landscape (Swanson et al. submitted). Natural disturbances to preserved mature and older forests can be expected to provide significant amounts of this habitat over time, provided that such areas are left unsalvaged

and allowed to regenerate naturally. These natural disturbances are highly episodic, however, and are not likely to provide desired amounts of these communities in time and space. Hence, a systematic silvicultural program to create early successional communities can insure an adequate distribution of such ecosystems in time and space. These activities will also provide opportunities for regeneration of cohorts of shade-intolerant tree species, such as Douglas-fir and western white and sugar pine, which is also desirable.

Considering Climate Change

Climatic fluctuations, including global warming, must be considered in developing and implementing long-term forest plans. Among the issues that require attention are the potential impacts of climate fluctuations on appropriate forest tree species composition and densities, potential behaviors of pests and pathogens, and occurrence of major disturbance events, such as wildfires and ocean-generated windstorms. Both the direct and indirect effects of climate fluctuations on forest ecosystems need to be considered (Franklin et al. 1991).

Global warming is a long-term directional change in climate that is affecting forests in the Pacific Northwest. There is a scientific consensus that such warming is underway, although the nature and intensity of the change in climate will vary with the region. The Pacific Northwest and its forests are highly susceptible to climate changes that are predicted for the region. This is primarily due to the summertime-dry climatic regime characteristic of the region, particularly the highly seasonal precipitation; rainfall is concentrated during the winter months precipitation. Consequently, summer drought is an important variable directly affecting tree vigor and growth as well as influencing frequency and intensity of fire and insect attack.

Any climatic change that increases either the length or intensity of the summer drought period has negative consequences for forest health (Franklin et al. 1991; Westerling et al. 2006). Climate warming within the region is projected to result in increased annual temperatures, including summer temperatures, and small increases in annual precipitation but little or no increase in summer precipitation. The net effect is that projected climatic changes in the Pacific Northwest are likely to result in longer and more intense (drier) summer droughts, on average.

If these predictions from the climate models are correct, the projected changes will have both direct and indirect effects on northwestern forests. Direct effects of warming will include increased plant moisture stress during the summer, which will, in turn, decrease annual growth and increase the physiological stress of trees. Increased populations of stressed trees will increase the potential for insect attack. The primary indirect effect of projected climate changes—longer and drier summer droughts—will be an increase in the frequency and intensity of wildfires.

There is already significant evidence for both direct and indirect effects of climate change in western North America. Mortality rates of trees in old-growth stands have been increasing during the last 40 years, a subtle but troubling change in these forests (Van Mantgem et al. 2009). Statistical evidence links fire size and severity with warming temperatures (Westerling et al. 2006). Major bark beetle outbreaks are underway as exemplified by the decimation of pinyon pine populations throughout the Colorado Plateau (Breshears et al.) as a consequence of drought and increased host susceptibility, and the immense outbreak of mountain pine beetle in lodgepole pine in British Columbia and adjacent Alberta as a consequence of warmer winter temperatures and improved reproductive success of the beetle (Bentz 2009).

The restoration approach for Dry Forests described above is well designed to accommodate climate change by increasing the forest's ability to resist both the direct and indirect effects of climate warming. It does this by:

- Reducing competition and the potential for drought-induced stress by reducing overall stand densities;
- Reducing the potential for intense wildfires by lowering overall fuel levels and maintaining them at low levels through prescribed burning programs;
- Favoring the most drought-tolerant and fire-resistant species, such as ponderosa pine over less drought- and fire-tolerant species, such as grand fir;
- Conserving old trees, which are most resistant to drought and to wildfire.

The strong emphasis in the restoration plan of conserving old trees from both fire and competition is precisely the strategy that is most appropriate for managing forests under a regime of increasing temperatures and summer moisture deficits. Ponderosa pine is among the most drought tolerant tree species (excepting only western juniper). Old-growth trees—freed of heavy competition from younger trees—are the most resistant to drought stress. They are also the ecological “backbone” of the drier forest ecosystem in terms of structure, function, and aesthetics—including provision of critical habitat elements to maintain characteristic species composition. They are most likely to survive wildfires and function as key elements of habitat in the recovery process.

Restoration approaches in Moist Forests also need to consider objectives that will increase both the resistance and resilience of these forests to climate change. Some examples include:

- aggressively seeking to increase tree species diversity within forest stands, including hardwoods, in thinning prescriptions and explicitly considering release of healthy trees of desired species present in subordinate positions in the canopy; and
- considering lower target densities than has been traditional, particularly on sites that are representative of marginal plant associations.

In summary, we believe that the approaches suggested in this analysis are appropriate responses to current predictions regarding climate change. Activities proposed will make the forest more resilient to both direct and indirect effects of a climate that is warmer, has a more intense summer drought, and has an increased frequency and intensity of wildfire.

Dry Forests: Acres available for Silvicultural Action and Potential Harvest Volume⁷

National Forests

We estimate that the national forests have a gross acreage of up to 8.8 million acres in Dry Forests that would be available for both timber harvest and prescribed fire to meet objectives. As discussed previously, this work comes from a Forest Service Analysis that excluded Wilderness, Inventoried Roadless Areas, and Forest Plan withdrawals, which we slightly modified for our estimate of Moist and Dry Forests. We then reduced this acreage by an additional 10% to allow for occasional Moist Forests and unstable slopes, areas adjacent to streams, and other resource conditions that would preclude timber harvest.

⁷ As described in previous footnotes, this analysis uses information from documents and data files provided by the Natural Resources Staff, USDA Forest Service Region 6, information from the recent BLM FEIS for plan revision and data bases provided by BLM State of Oregon staff, and data from the USDA Forest Service plan association classification. Throughout this report we used the log rules employed by the agencies—long logs for the Forest Service and short logs for BLM.

Timber harvest (other than post-fire salvage) occurred on less than 1% of these acres per year from 1996-2007 and less than .5% per year from 2001 to 2007 (Figure 5). Prescribed fire (outside of timber harvest units) occurred at a slightly higher rate (Figure 5). In addition mechanical hazard reduction which did not remove commercial volume also occurred, but it is often followed by prescribed fire so it is difficult to separate those acres. Thus, these numbers underestimate somewhat the total about acres that have had harvest, prescribed fire, or mechanical fuels reduction.

Estimating the board foot harvest volume associated with the ecological restoration proposed here is extremely difficult. It depends on the particular plant association, existing forest structure, long-term goals, and other objectives for the area. Some past efforts have estimated board foot levels associated with fuel treatments. Adams and Latta (2005) estimated that over four billion board feet could be removed from the national forests of Eastern Oregon through understory thinning. They also cautioned, though that significant investment would be needed. Barbour, et al. (2008) estimated that more than one billion board feet could be removed from the national forests of the Blue Mountains, again focused mostly on understory thinning but with some consideration of larger trees. They also emphasize the need for substantial investment.

With a goal of covering the national forests with needed ecological restoration treatments in 20 years, the acres harvested per year would increase substantially—perhaps even double. To make the harvest assessment associated that accelerated effort, we utilized a commercial thinning analysis done by Forest Service analysts in which they used CVS plot data to estimate possible harvest amounts from commercial thinning stands up to 160 years of age in the Dry national forests of Oregon and Washington. Key aspects of that analysis were that:

- These estimates come from an analysis of a CVS plot inventory taken in the mid 1990s in which plots with a sufficiently high stand density had 25% of the volume removed.
- The harvests were spread over 25 years. However, future growth was not included. Thus, the same volume could be removed over a shorter period of time if desired.
- The study did not consider harvest in stands over 160 years of age. Also, it did not consider harvest of trees over 21" in the Dry Forests outside the area of the NWFP.

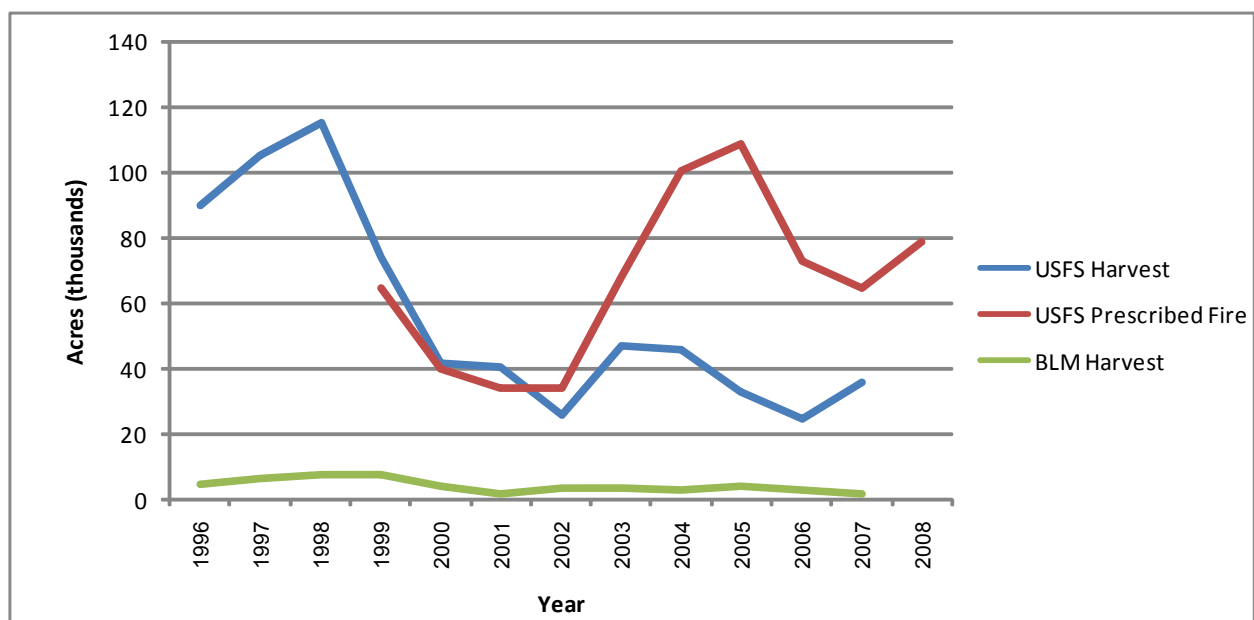


Figure 5. Acres of Dry Forest timber harvest and prescribed fire over time on the national forests along with acres of dry forest timber harvest on the BLM (BLM prescribed fire acres not obtained). For both agencies, timber harvest occurs on approximately one-half percent /year of the dry forest being considered for timber harvest in this analysis. About one percent/year is also burned with prescribed fire on the national forests; that burning can follow both commercial timber harvest and non-commercial hazardous fuel reduction or be done in areas not otherwise treated. We have attempted to exclude post-wildfire salvage from the harvest acres.

Using that analysis, we estimate that approximately eight billion board feet could be harvested by thinning approximately one third of 7.3 million Dry Forest acres of stands less than 160 years of age. That would produce at least 400 million board feet a year over the next 20 years as a valuable by-product of ecological restoration. Reducing this acreage by 10% as discussed above, we carry forward a conservative estimate of 360 million board feet/year.

Our restoration strategy also calls for entry into some stands over 160 years as needed to conserve the old trees within them. According to our analysis of Forest Service data, over 10% of the acres and more than 15% of the volume on Dry Forests is in stands classified as over 160 years of age. We did not count the harvest volume from those older forests in these estimates for two reasons. We think that many of those forests might be utilized for spotted owl habitat within the boundary of the NWFP. Even if harvests occur in some 160+ stands, as we recommend, this approach helps account for dense stands under 160 that will also be allocated to spotted owl habitat.

The R-6 commercial thinning study was done with CVS plots from the mid 1990s that were used without projection of growth or harvest. Since that time growth has greatly exceeded harvest but some forests have burned. While we believe that an estimate of 360 million board feet a year for 20 years is conservative; any estimate of Dry Forest harvest is inherently difficult to make.

Comparison to harvest estimates on the Fremont-Winema

To check the Forest Service analysis, we compared it to our own restoration analysis for the Fremont-Winema National Forest (Johnson, et al. 2008). The Region 6 commercial thinning study suggests that commercial thinning could produce approximately 953 million board feet over 25 years from 802,000 acres available for harvest on the Fremont-Winema NF. This averages 1.2 thousand board feet/acre. As discussed above, future growth was not included: the same volume could be removed over a shorter period of time if desired. These estimates come from an analysis of the CVS plots in which plots with a sufficiently high stand density had 25% of the volume removed. Based on these rules, the Forest Service would thin approximately 45% of the available acres on the Fremont-Winema (approximately 350,000 acres).

Johnson, et al. (2008) estimate that at least 800 million bd ft could be removed from a forest of 525,000 acres of the Winema NF over 20 years through implementation of an ecological restoration strategy similar to that discussed here. They considered only the portion of the Winema NF (and a little of the Fremont NF) that was within the boundaries of the former Klamath Indian Reservation and called for action on between half and two-thirds of the available acres. That strategy included leaving dense patches for Northern Spotted Owl in the part of the Forest within the range of the Northern Spotted Owl.

The total harvest over 20 years is equivalent to 1.52 thousand board feet/acre for the 525,000 acres. Thus, the Johnson, et al. estimates are 25% higher (1520 bd ft/acre vs. 1200 bd ft/acre) even though they reserved some stands for spotted owl conservation areas whereas the R-6 analysis did not do that. Three differences in the analyses can help explain that difference in volume estimates:

- 1) The Johnson, et al. (2008) estimates included significant harvest of shade tolerant trees (mostly white fir) over 21" dbh while the R-6 estimates do not count on that volume outside of the NWFP area, reflective of the Forest Service's general experience with implementation of the "eastside screens."
- 2) The Johnson, et al. (2008) estimates include harvest in stands that R-6 considered as over 160 years of age (as needed to meet ecological goals) while the R-6 estimates do not.

- 3) The Johnson et al. (2008) analysis includes a modest estimate of future growth while the R-6 analysis did not.

It should be noted that Johnson, et al. (2008) called for entry into half to two-thirds of the Dry Forest on the Fremont-Winema while the R-6 analysis estimated that slightly less than 50% of the stands would be entered. This difference is not surprising for two reasons:

- 1) Johnson, et al. (2008) call for entry, as needed, in “old growth” stands (stands over 160 years of age by the R-6 definition) to protect the old trees there and,
- 2) Johnson, et al. (2008) called for entry into dense stands that do not have commercial volume, with timber harvest and/or prescribed fire, which the R-6 analysis did not consider in their commercial thinning analysis.

In sum, the treatment rates and harvest levels modeled here seem very conservative--more activity will likely occur under the restoration strategy.

A Landscape Approach

Projects in the areas need to be planned and implemented at multiple landscape levels to be effective and to ensure that appropriate spatial complexity is incorporated at larger spatial scales as discussed above. This will include leaving some larger patches of dense forest in dominantly Dry Forest landscapes, such as may be required to provide habitat for the Northern Spotted Owl and its prey species.

Given the urgency of treating the Dry Forests to reduce risks of catastrophic loss of resource values, this strategy should be aggressively implemented in the Dry Forests on federal lands over the next 20 years with projects designed to take coordinated actions over relatively large areas, perhaps 10,000- to 15,000-acre geographical units, such as drainage basins of larger streams (see Map 8 for an example). Such an approach will maximize project effectiveness, enable landscape-level considerations to come into play, and help ensure that all needed actions in an area are considered at one time.

Once the activities are finished for a geographic unit, we would not expect to return to the area for another 20 years except for maintenance prescribed burning or if natural disturbances created the need for site restoration and recovery. Within the project area, we would generally expect about one-half and no more than two-thirds of the area to be entered for activities of some kind, although more detailed project analysis would be needed in particular stands for treatment.

What would happen after all candidate landscapes are treated, assuming that they are all treated after 20 years? A second restoration cycle could be initiated, going back through the restoration units in approximately the same order, unless other circumstances arose. In the second cycle some stands that were not treated the first time would be considered for treatment, as would those that had been previously entered.

Project landscape units of this scope also need to be planned in the context of larger spatial scales, at perhaps one order of magnitude larger (100,000 to 150,000 acres and larger). This is important to deal with larger scale environmental gradients and appropriate connections with adjacent project areas.

Meaningful ecological restoration will not be achieved just by removing small trees; restoration treatments will also remove some large trees.

BLM

We estimate that the BLM administers approximately 800 thousand acres of Dry Forest in south-west Oregon (Map 4), with 40% of the Roseburg District in Dry Forest along with 75% of the Medford District. Approximately two-thirds of the BLM is either in Late Successional Reserves (LSRs) or Riparian Reserves (RR).

These Dry Forests have experienced a general increase in stand densities during the last half-century in an area that has both intense summer drought and is in a zone known as “lightning alley.” Not surprisingly, our estimates of Dry Forests are close to the percentage of high and very high fire hazard estimated by the BLM in the FEIS for the forest plan revision (BLM 2008, page 404-407)--45% for Roseburg District, 65% for the northern part of the Medford District, and 80% for the southern part of the Medford District.

We estimate that BLM has harvested less than .5% of these acres per year (Figure 5).

What rate of entry and volume of timber harvest would occur if the previously described ecological restoration strategy was applied to these Dry BLM forests? In the recent FEIS, BLM applied an uneven-aged management strategy to 180,000 acres of the Timber Management Area (what we call Matrix) in the Medford District and Klamath Falls Resource Area of the Lakeview District. That strategy seems similar to our ecological restoration approach. It calls for a combination of thinning, single tree selection, and group selection and for retention of the overstory component to provide shade, reduce wind speed, and promote overall fire resiliency in the stand. Much of BLM’s future older forest in its Timber Management Areas comes from this management.

This BLM strategy might yield an average of 28 million board feet/year in the first decade as part of its allowable cut from entering approximately 23% of the 180,000 acres. Most of the remaining acres would be entered for harvest in later decades. In the long run, this strategy might yield a harvest of perhaps 25 million board feet/year.

We would propose applying the Dry Forest strategy to Matrix and LSRs in Dry Forest over a larger gross area of 800,000 acres. Some of that area has been administratively withdrawn. One-third of the area (potentially including much of the administratively withdrawn area) would be left in dense patches as part of the NSO strategy in Dry Forests and some forest immediately adjacent to streams would not be entered. Thus, timber harvest might be considered for approximately half the estimated area of Dry Forest (about 400,000 acres) or approximately double the area to which the BLM applies its unevenaged strategy.

Why do we suggest that the Dry Forest strategy would be applied to a larger area than proposed by the BLM? Two reasons explain much of the difference: 1) we applied the Dry Forest strategy on parts of the Roseburg District; BLM did not do that; and 2) we applied the strategy to both Matrix and LSRs within the Dry Forest.

The ecological restoration approach taken here would probably result in a lower per acre removal than suggested in the BLM analysis in order to retain the bulk of the overstory trees. Given the urgency of addressing the buildup in stand densities, we modeled entry into 40% of the area that might be considered for timber harvest over the next 20 years (20% of the entire Dry BLM forest). Thus, we conclude that the Dry Forest strategy might provide 40 million feet/year over the next 20 years. We advocate this cautious approach due to the uncertainties about ecological restoration of this complex landscape. Much adaptive learning will be needed from the initial entries.

Moist Forests: Acres Available for Silvicultural Action and Potential Harvest Volume⁸

Commercial harvest is the main silvicultural action in Moist Forests, whether it be for ecological restoration or commercial timber production. Little prescribed fire or other mechanical treatment has been used, and will be used to achieve goals.

National Forest Land Base

We estimate a total of 4.1 million acres of Moist Forest in western Oregon and Washington outside of Wilderness, other withdrawals, and Inventoried Roadless Areas (Figure 6a). The amount of Late Successional Reserves (LSR) and Matrix (including Riparian Reserves) and the break into age classes comes from the CVS plot analysis by the Forest Service slightly modified to account for our estimate of Moist Forests. The division between Matrix and Riparian Reserve (RR) is based on estimates by national forest in Johnson, et al. (1994). (Note: Adaptive Management Areas are included in Matrix)

This information comes from plots taken in the mid 1990s. It has not been updated. However, little regeneration harvest or wildfire has occurred in these Moist Forests since then. Thus, we think it gives an accurate picture of the age class distribution, albeit with the stands about 15 years older.

By these estimates, the Moist Forest considered here contained about 1.2 million acres beyond 160 years of age and almost an equal acreage of forest less than 40 years of age when the inventory was taken (about 1995). Approximately 65% of the acres are in reserves. LSR and Matrix show a fairly similar age class distribution, with LSRs having slightly more old forest and slightly less young forest.

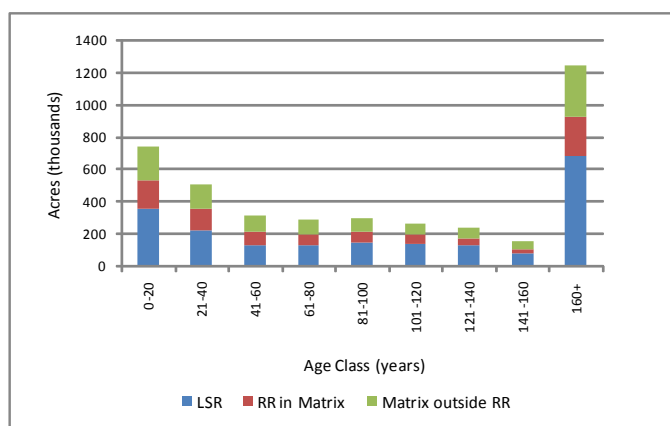
These acres cover only a part of the LSRs--the part outside of Inventoried Roadless Areas and Forest Plan Withdrawals. Looking at the Cascade Range national forests, over two million acres of forest fell into these two allocations and much of this acreage went into the LSR system. The portion of the LSRs considered here is the part where regularly scheduled timber harvest generally could have occurred in the past.

Only acres less than 80 years of age in the reserves can be considered for harvest. Also, the Forest Service has largely given up trying to harvest stands over 160 years of age in Matrix even though that action was permitted in the NWFP, due to litigation and public pressure. Thus, the acres available for harvest are strongly slanted toward the younger age classes (Figure 6b). In addition, the number of acres on which regeneration harvest can occur are smaller still (Figure 6c).

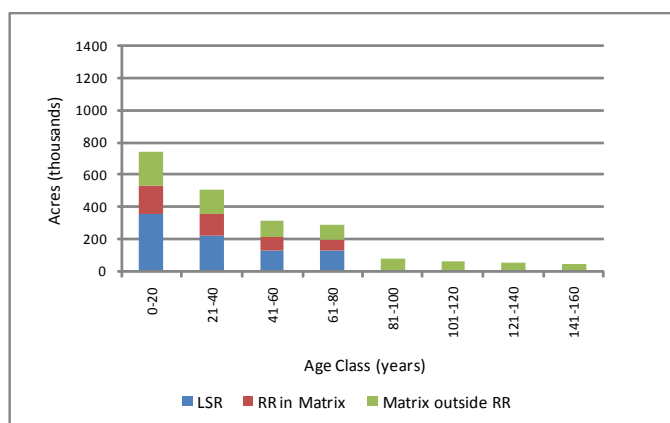
BLM Land Base

We estimate that approximately 75% of the Moist Forest on BLM lands is either in Late Successional Reserves (LSR) or Riparian Reserves (RR) (Figure 7a), with the percentage in reserves generally increasing across age classes. Over half of the Moist Forested acres are less than 80 years of age. Almost all remaining forest over 200 years is in reserves under the NWFP.

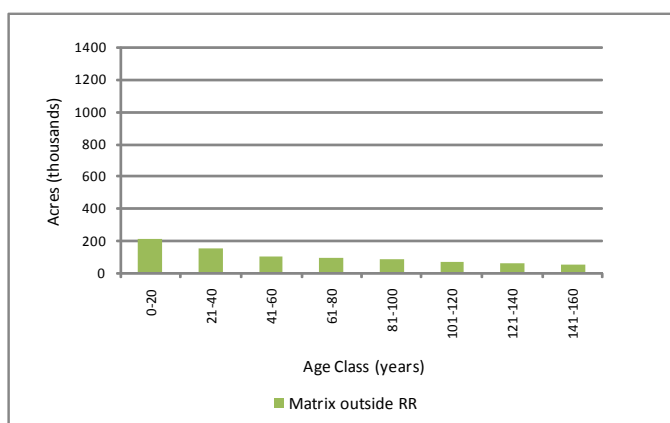
⁸ As described in previous footnotes, this analysis uses information from documents and data files provided by the Natural Resources Staff, USDA Forest Service Region 6, information from the recent BLM FEIS for plan revision and databases provided by BLM State of Oregon staff, and data from the USDA Forest Service plan association classification. Throughout the report, we used the log rules employed by the agencies--long logs for the Forest Service and short logs for BLM.



a) Moist national forest outside of Wilderness, Inventoried Roadless Areas, withdrawals in Forest Plans classified into LSR, RR, and Matrix—the starting point in our analysis (note this does not show the total acres in LSRs since many LSR acres are in the roadless and plan withdrawal acres).



b) Moist national forest under 160 years old potentially available for thinning under the NWFP. Harvest is generally not permitted in LSR/RR stands over 80 years of age under the NWFP. Attempts to harvest stands over 160 years of age in Matrix on the national forests have generally ceased; thus, we exclude them here.



c) Moist national forest Matrix under 160 years old potentially available for thinning and regeneration harvest under the NWFP. Note: regeneration harvest is allowed only in Matrix in the NWFP.

Figure 6. Distribution of Moist Forest by age class and allocation on national forests within the area of the Northwest Forest Plan This information comes from plots taken in the mid 1990s. Thus, stands on these acres would be generally be 15 years older. Note: Adaptive Management Areas are included in Matrix.

As with the Forest Service, acres over 80 years of age in the reserves cannot be considered for harvest. The BLM has also been largely unsuccessful harvesting stands over 160 years of age in Matrix even though that action was permitted in the NWFP, due to litigation and public pressure. Thus, the acres we modeled as available for harvest are strongly slanted toward the younger age classes (Figure 7b). In addition, the number of acres on which regeneration harvest can occur are smaller still (Figure 7c).

Moist Forest Thinning

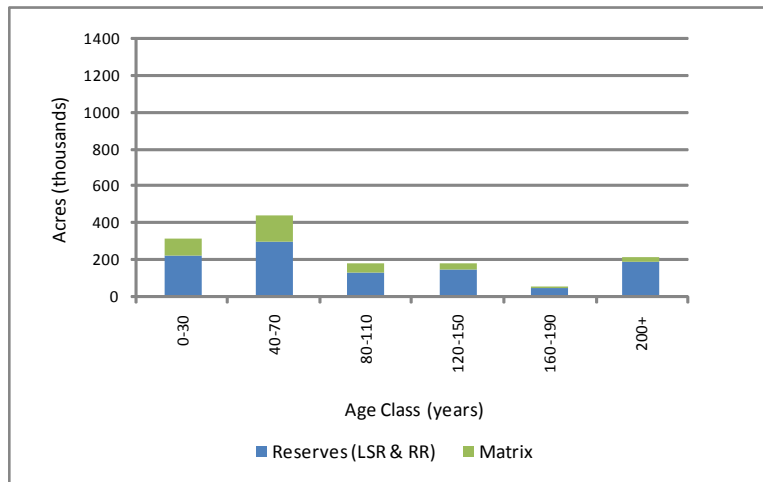
National Forests

We utilized the commercial thinning analysis done by the Forest Service to estimate potential thinning volumes on Moist Forests. That analysis allowed thinning up to age 160 in Matrix and Riparian Reserves and up to 80 years in LSRs. We limited our use of Forest Service analysis to ages 0-80 for all land allocations for two reasons: 1) almost half of the gross Matrix lands that would be the source of the estimated thinning volume from ages 80-160 lay within Riparian Reserves which have similar structural goals as the LSRs and 2) the volumes over 80 in Matrix will be counted in the regeneration harvest volume (see below) or are beyond the age at which harvest will be permitted under the different scenarios examined. Thus, we derive a harvest volume estimate from thinning on Moist Forests in the national forests of 5.0 billion board feet over 20-25 years on approximately 650,000 acres for an average of 295 million board feet per year over 20 years or 236 million board feet over 25 years (Figure 8). We recognize that it would be difficult to thin all of these acres—although thinning occurs in Riparian Reserves, some acres will be too close to streams to harvest. Thus, we reduced the estimated volume harvested by 15% (the equivalent of reducing thinning in Riparian Reserves by about one-third), carrying forward an estimate of 250 million board feet/year over 20 years.

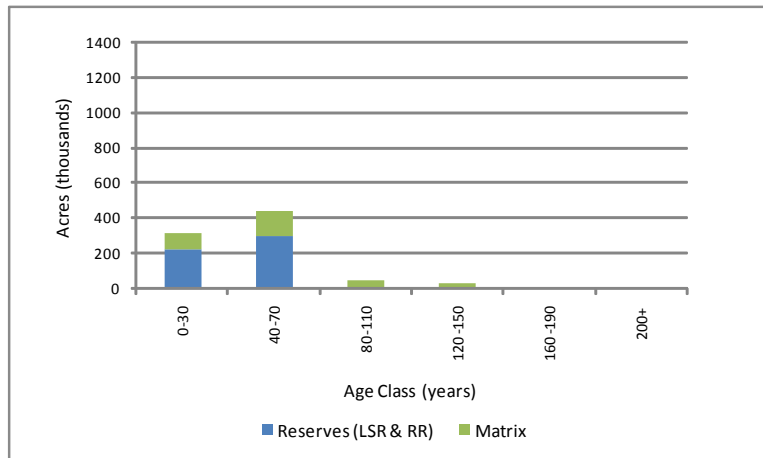
As mentioned above, the thinning analysis done by Region 6 comes from inventory plots taken in the mid 1990s. It does not include growth or harvest that has occurred since then. Thus, the information comes from inventories that are almost 15 years old. Not many fires occurred in Moist Forests during that period and little regeneration harvest occurred. Thus, most acres moved up 15 years in age. Some thinning occurred in these forests over the last 15 years, but that harvest was been significantly less than the growth that occurred as we will discuss further below. Compared to the volumes in Figure 8, we would expect considerably more harvest volume in the next 20 years from the large acreage shown in the 0-20 class and less from the acres shown as 61-80 as these latter acres move beyond thinnable age. With the large number of acres in the young classes that would become eligible to thin, a thinning harvest volume of 250 million board feet/year is a useful starting estimate of likely harvest under the strategies suggested here. The actual harvest level could be higher.

This strategy calls for thinning close to one third of the acres less than 80 years of age and removing an average of approximately nine thousand board feet/acre. Over the first 20 years, approximately 15% of the Moist Forest outside of Wilderness, other withdrawals, and Inventoried Roadless Areas would be thinned.

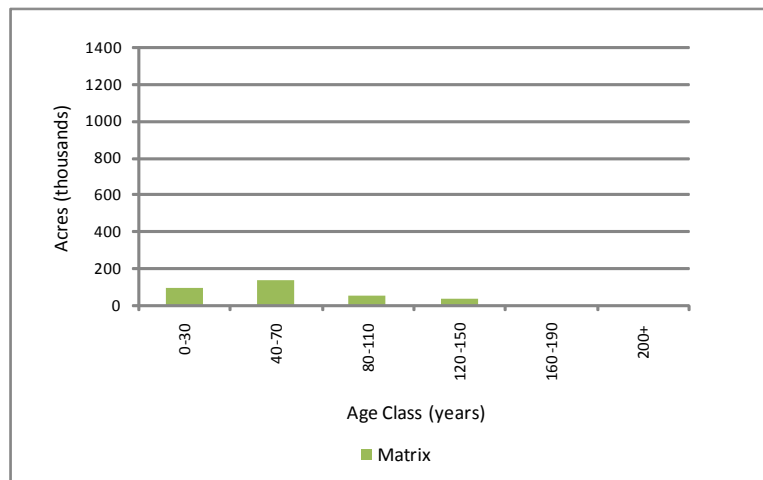
A maximum thinning age of 80 years was used here. Extending the maximum thinning age to 120 years in the LSRs will primarily affect the thinning volume produced beyond 20 years from now, as described below for BLM.



a) Moist BLM forested acres by land allocation and age class—the starting point in our analysis.



b) Moist BLM forested acres under 160 years old potentially available for thinning under the NWFP. Harvest is generally not permitted in LSR/RR stands over 80 years of age under the NWFP. Attempts by BLM to harvest stands over 160 years of age have generally not been successful. Thus, we exclude them here.



c) Moist BLM Matrix under 160 years old potentially available for thinning and regeneration harvest under the NWFP. Note: regeneration harvest is allowed only in Matrix in the NWFP.

Figure 7. Distribution of Moist Forest by age class and allocation on the BLM lands within the area of the Northwest Forest Plan. Note: Adaptive Management Areas are included in Matrix.

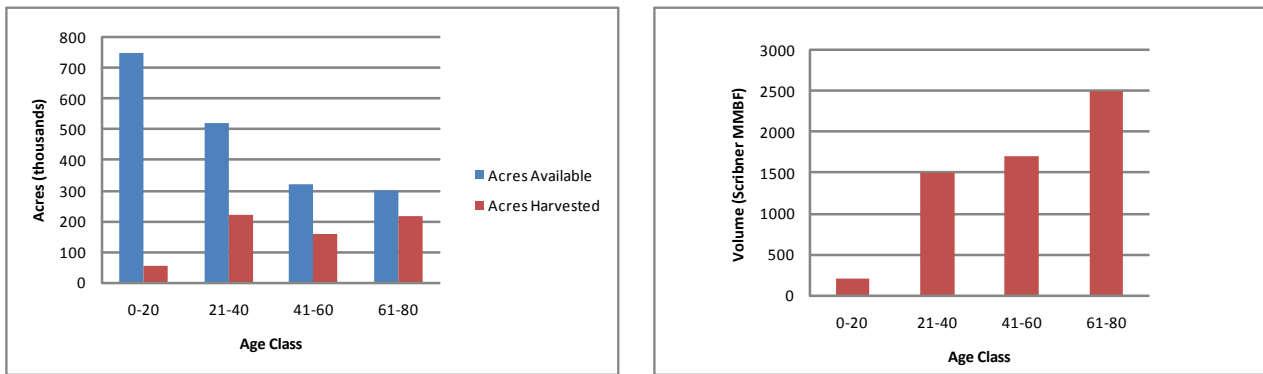


Figure 8. Restoration thinning on the national forests: Estimate of the acres available for restoration thinning, the portion of that acreage that might be thinned, and the volume from that thinning on the Moist Forests of the national forests over the next 20 years. This estimate utilizes information that is 10-15 years old. We still think it is a useful, somewhat conservative estimate. The large acreage in the 0-20 class, from which little thinning is assumed here, will shift into higher age classes over the next 20 years, providing a large source of volume.

BLM

BLM (2008) estimated that thinning in reserves of the NWFP (LSR and RR) in stands less than 80 years of age could yield an “overall” volume per year over the next five decades that starts at 85 million board feet/year and declines to 45 million board feet/year by the fifth decade in the future (Figure 9). Based on the distribution of potential thinning acres and volume among different Districts, we estimate that approximately 85-90% of that thinning would occur within plantations in Moist Forests. Thus, we used an estimate of 65 million board feet/year for the first 20 years.

According to BLM’s analysis (BLM 2008), approximately 40 million board feet per year could be thinned in Matrix over the next 10 years in Western Oregon under the NWFP. In the thinning analysis for its proposed plan, however, the BLM utilizes a heavier thinning harvest in the young stands in Matrix than it shows for the NWFP. We believe that heavier thinning in Matrix is appropriate as the BLM attempt’s to reintroduce spatial heterogeneity into these stands. Using the heavier thinning, the BLM might achieve 55 million board feet/year in the Matrix under the NWFP over the next decade and perhaps 45 million board feet/year in the decade after that. After removing the relatively small amount of Matrix thinning in Dry Forests, we estimate that 50 million board feet per year could be harvested over the next 10 years and that a somewhat lower level can be continued into the second decade. Therefore, we will estimate that an average of 45 million board feet/year could be thinned from Matrix over the first 20 years.

In addition, BLM did a comparative analysis of thinning on all of its lands with age limits of 80 years and 120 years without any operational constraints or limits (such as avoiding unstable slopes) or concerns that the thinning matched the objectives of particular land allocations:

This BLM analysis showed little immediate increase in volume from increasing the maximum thinning age in the first few decades, but a slight increase by decade three and a significant increase for decades four to seven, somewhat offsetting the decline over time described above. Raising the maximum thinning age allows the thinning of existing mature stands (80-120 years of age) and also the thinning of existing younger stands after they reach 120. Most of the impact comes from the repeated thinning of young plantations after they reach age 80. Also, thinning in stands currently over 80 years of age in the reserves would be controversial. Thus we conclude that raising the reserve thinning age in the plantations from 80 to 120 could have a significant effect on plantation thinning in later decades. It also could have a slightly negative effect on thinning volume in

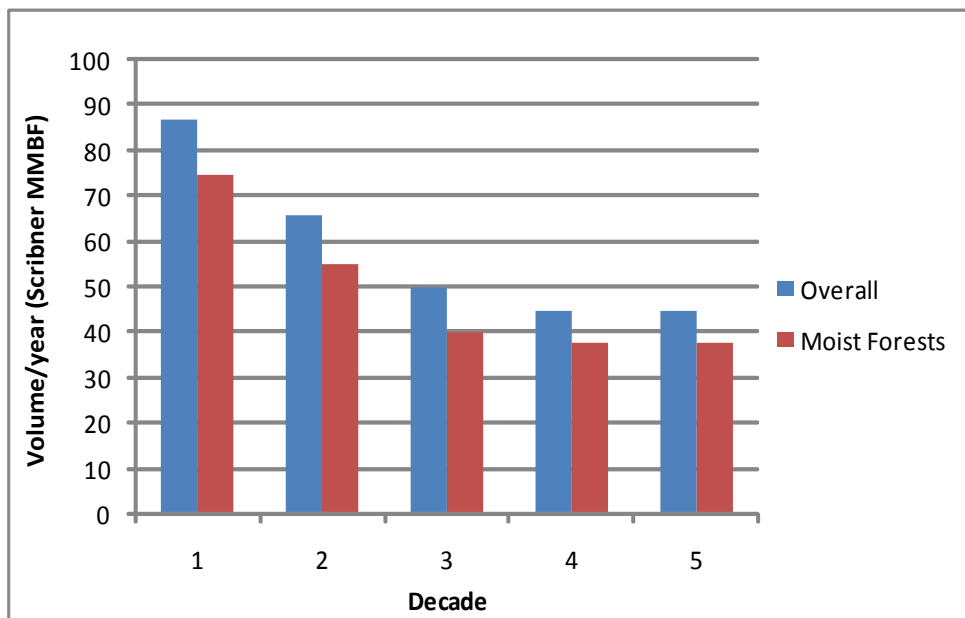


Figure 9. Restoration thinning on BLM lands in Reserves (total and Moist Forest Portion). Thinning occurs in plantations in Late Successional Reserves and Riparian Reserves to increase structural diversity. It is limited to stands less than 80 years of age; thus it is projected to decline substantially after a few decades.

the near term as silviculturists have more time to move the stands to desired conditions. Identifying the actual shape of the resulting yield stream would require additional quantitative analysis.

Evaluating the Ecological Justification for an Increase of the Maximum LSR Thinning Age from 80 Years to 120 Years

Guidelines for management of Late Successional Reserves (LSRs) under the Northwest Forest Plan (NWFP) direct that harvest be limited to stands <80 years of age west of the Cascades, where “west of the Cascades is defined as all physiographic provinces in western Oregon and Washington except the Oregon Klamath Province.” Harvest in older stands (>80 years old) requires specific justification and approval. Thinning (precommercial and commercial) may occur in stands up to 80 years old regardless of the origin of the stands (e.g., plantations planted after logging or stands naturally regenerated after fire or blowdown). The purpose of these silvicultural treatments is to “... benefit the creation and maintenance of late-successional forest conditions.”

Procedures for exception to the rule do exist. They require an appeal to the Interagency Team that oversees implementation of the NWFP. Relatively few appeals have been proposed or granted.

The emergence and first consideration of forests greater than 80 years of age, as a grouping of forest conditions, occurred during the work of the Scientific Panel on Late Successional Forest Ecosystems, also known as the “Gang of Four” (Johnson et al. 1991). This group was paneled by two Congressional committees to map and characterize the “old-growth forests” of the Pacific Northwest. During initial discussions of this task, several forest ecologists identified naturally regenerated mid-aged forests as potentially important habitat for many late-successional species. These stands had originated following wildfire and windstorm during the 19th and very early 20th centuries, some from single burns and some from multiple burns. These stands often had substantial structural complexity as a result of legacies of live trees and snags and logs that persisted following the disturbance. They were typically dominated by maturing Douglas-fir and often had a developing understory of shade-tolerant tree species.

Ultimately the 1991 scientific panel developed a category of “Late Successional/Old Growth” (LS/OG) that incorporated all stands >80 years of age. Subsequent science and management panels continued to recognize the larger category of LS/OG forests in considering the structurally-complex forest population important to late-successional species, including the use of 80 years as an initial point for consideration (FEMAT 1993).

Discussions with agency personnel suggested that the vast majority of stands that might benefit from thinning to accelerate late-successional structure were currently less than 80 years old, and of human origin--mostly plantations that were established after harvest in the last 50 years. These stands are the major focus of silviculture within the LSRs. While these stands currently can be thinned without restriction, because they are less than 80-years old, many young stands will soon exceed 80 years of age and fall under the restrictions of the 80-year rule. Thus, the 80-year rule creates a dilemma for the post-clearcut plantations that have been the focus of thinning in LSRs: The 80 year rule, which was intended to limit actions in wild stands, may inadvertently alter treatment schedules for plantations.

Allowing field discretion in decisions on silvicultural treatments in young managed stands (plantations) after they reach 80 years of age could influence future activities in these stands currently less than 80 years of age, most of which originated from clearcuts. If silviculturists know that they can count on further entries in these stands they can plan treatment sequences that go beyond 80 years. A program of multiple entries might better achieve the LSR objective of moving these stands more rapidly toward desired structurally complex conditions than one that required all entries to be completed by 80 years. Therefore, we believe that the “80 year rule” for plantations on federal Moist Forests that are now the focus of federal thinning should be reconsidered. As discussed above, such an increase in maximum thinning age would mainly affect silvicultural activities 20-60 years from now. See Appendix IV for more discussion.

Moist Forest Regeneration Harvest

There is an understandable interest in “thinning” in the federal forests of the Northwest, given the ecological usefulness and social acceptability of this silviculture. The thinning would produce a pulse of timber harvest over the next 20 years and more modest supplies of wood after that.

A long-term timber supply strategy from these forests would include regeneration harvest, which would primarily involve heavier partial cuttings designed to result in regeneration of new tree cohorts. While that type of silviculture is largely integrated into the “thinning prescription” on the Dry Forests, regeneration harvest would contrast more markedly with thinning in Moist Forests. In Moist Forests, thinning and regeneration harvest require somewhat different silvicultural manipulations, with regeneration harvest reducing stand density more substantially than thinning to open up the stand enough to enable regeneration of relatively shade-intolerant species, such as Douglas-fir.

The NWFP called for regeneration harvest of mature and old growth stands in Matrix to provide the lions-share of the harvest in the first thirty years of the plan. That did not happen. The agencies’ proposals to harvest mature and old growth forests were consistently appealed through their administrative/legal process and, most fundamentally, there was little public support for cutting large and old trees (Thomas, et al. 2007). It should be noted that the proposed regeneration harvest in the NWFP followed ecological forestry principles to a modest degree, such as by requiring a minimum of 15% retention, but resistance to cutting mature and old growth stands was still too great. Even innovative silvicultural approaches to regen-

Regeneration harvest in the Moist Matrix using principles of ecological forestry can provide diverse early successional-communities and a continuous source of wood volume.

eration harvest, such as the Blue River Strategy--a landscape-level ecological forestry experiment and demonstration project (Cissel, Swanson, and Weisberg 1999)-- was resisted by some groups because it involved harvest of mature forest and some older trees.

Thus, in recent years, the federal agencies have generally been unsuccessful in implementing regeneration harvests in the Moist Forest Matrix lands (Figures 10 and 11). They have shifted to “thinning”--partial cutting that makes an ecological contribution or, at any rate, is more socially acceptable. A long-term timber supply cannot be assured without regeneration harvests on these forests, however. As the stands age, it gets harder and harder to justify thinning them from an ecological perspective.

Also, post-disturbance forest openings, and the structurally diverse early successional communities they support, are increasingly recognized as being important for forest biodiversity. Wildfires can help provide those conditions (if unsalvaged), but most recent fires have been in the Dry Forests and the contribution of wildfire to early successional communities is inherently irregular in time and space, even if the disturbed areas are allowed to recover naturally without salvage logging and dense plantings of commercial tree species.

So how do we provide for ecologically sound and socially acceptable regeneration harvest? We took a three-phase approach to Moist Forest regeneration harvest here: 1) Utilize an approach to regeneration harvest that makes an ecological contribution--we define a regeneration harvest prescription with significant structural retention to provide for the structurally complex and diverse early successional communities, and which will then contribute cohorts to help maintain the age class structure of these forests through time; 2) Identify stands outside of reserves and other special or controversial areas and below the threshold age for old forest--in this case we identified the Moist Forest Matrix outside of Wilderness, Inventoried Roadless Areas, and other forest plan withdrawals or special allocations and below a specified age; and 3) Fit the approach within the agency's other laws and mandates (especially the Forest Service) such as the requirements from the National Forest Management Act that stands not be cut before they reach culmination of mean annual increment and that they be regenerated within five years after harvest.

(Note: In the discussion that follows, regeneration harvests are considered for the “young” forest within Matrix and Adaptive Management Areas of the NWFP, not within Late Successional Reserves or Riparian Reserves.)

Given all these considerations, we settled on a long-term average rotation age between 120 and 160 years. Much younger rotations do not allow for a long enough period to develop key structures and processes and surpass culmination of mean annual increment. On the other end, as stands age beyond 160 years, we begin to have an old growth structure which the agencies would be unlikely to harvest on continuing basis.

What will be the land base? We examined three potential land bases for Matrix lands, outside of Inventoried Roadless Areas, on which regeneration harvest might occur. They are based on the acres that would be available under different maximum ages of existing stands (minimum existing age for old forest reserves in Matrix). We looked at three threshold ages: 80 years, 120 years, or 160 years. We then divided each acreage base by 140 to estimate the average number of acres that would be harvested per year (Figure 12).

What will be the average regeneration harvest per acre? We examined the average volume per acre in existing Moist Forests aged 100-140 on the national forests and BLM lands, which largely came in on their own, as the best example of what future stands managed under this strategy might provide. Based on that analysis, we assume a standing inventory of 35 thousand board feet per acre on the national forests and 45 thousand board feet per acre on BLM lands (BLM uses a somewhat

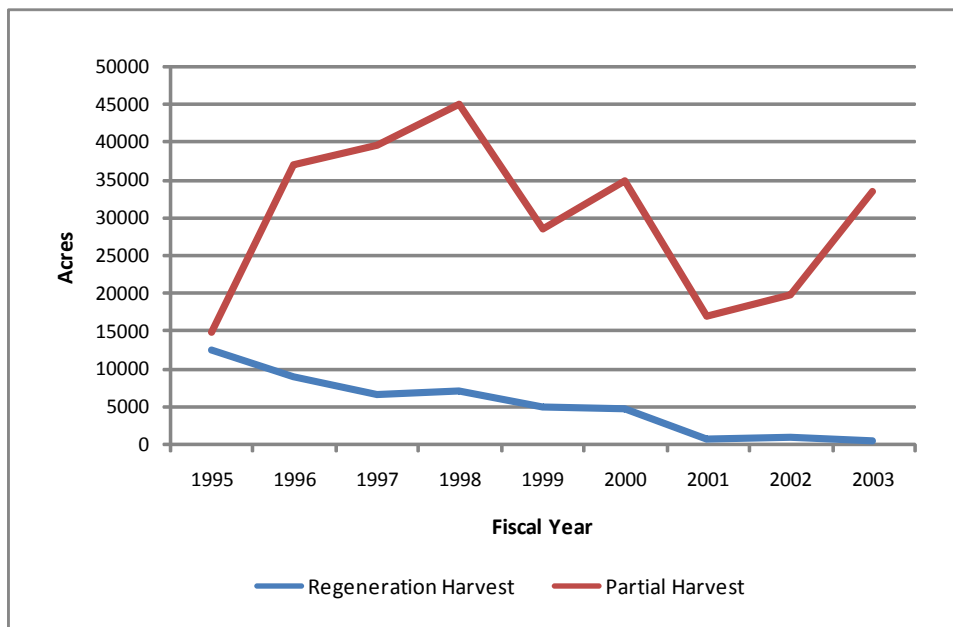


Figure 10. Thinning acres and regeneration harvest acres on Forest Service and BLM lands within the area of the Northwest Forest Plan from 1995-2003. The Northwest Forest Plan called for regeneration harvest in mature and old growth forests to provide much of the harvest in the first 30 years. That did not happen due to a combination of litigation and public pressure. The agencies have been much more successful in restoration thinning. (Source: Baker et al. 2006)

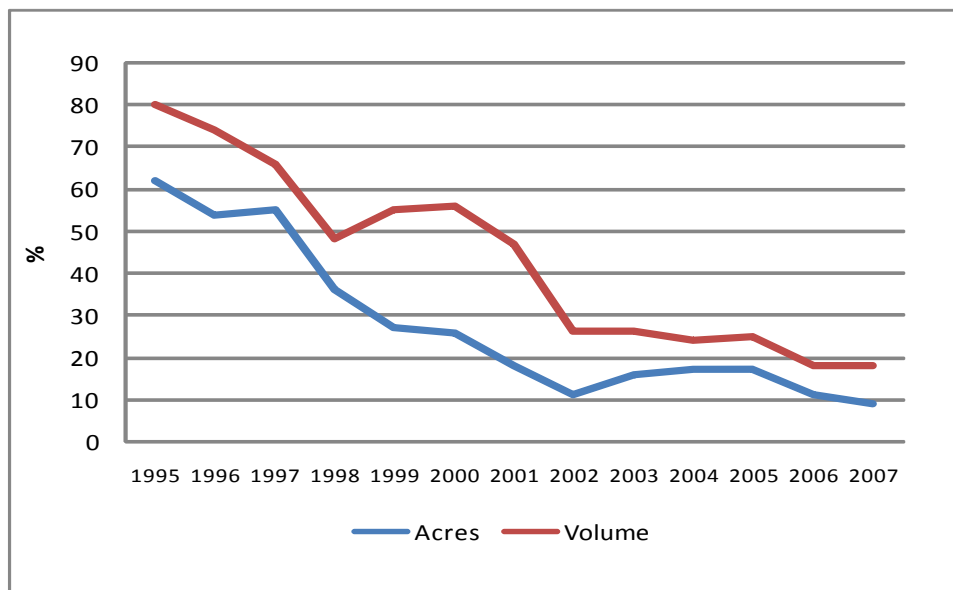


Figure 11. The percentage of volume and acres from regeneration harvest from in Moist Forests on BLM lands from 1995-2007. Regeneration harvest has played a steadily decreasing role in BLM harvest actions over time as a result of litigation and public pressure. Almost all BLM recent harvest in Moist Forests comes from restoration thinning in young stands.

different utilization standard which explains much of the difference between the two estimates.) Further, we assumed that 20% of the stand volume would be left as a legacy to provide for structural diversity under an ecological forestry prescription. While the NWFP requires 15%, we feel that a higher minimum level of retention would be desirable and, in fact, federal foresters often leave more than the minimums required under the NWFP. Using 20% retention gives us an average volume harvested of 28 thousand board feet acre on the national forests and 36 thousand board feet per acre on BLM lands. Multiplying these volumes times the acres harvested/year gives the expected total harvest volume from Moist Forest regeneration harvest both in the next 20 years and in

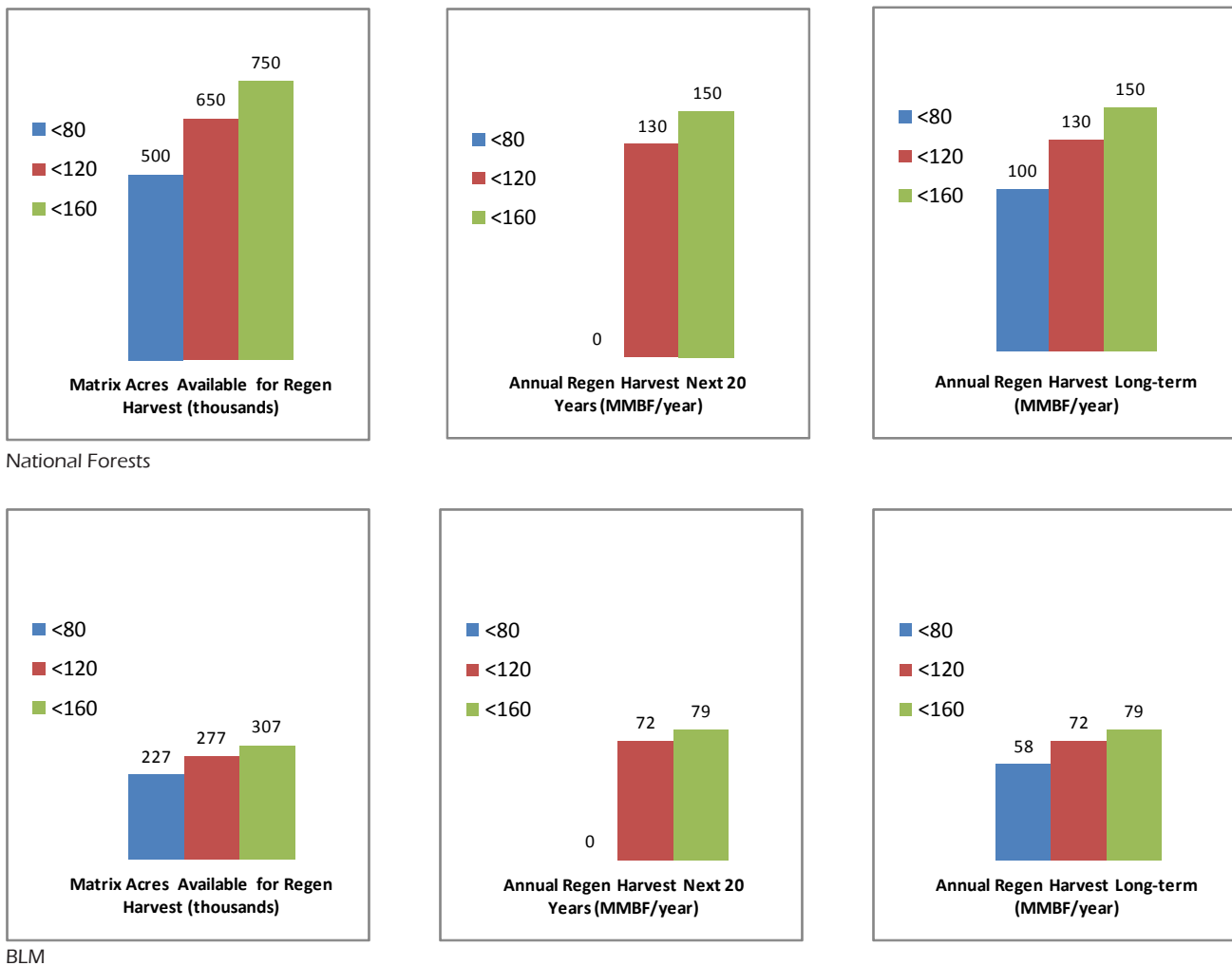


Figure 12. Potential regeneration harvest in Moist Forests. Different amounts of Matrix acres would be available for regeneration harvest depending on whether the threshold age for reserving Moist Forest existing stands was 80 years, 120 years, and 160 years. The short-term and long-term estimates were the same for threshold ages of 120 and 160 as they have sufficient acres available to provide regeneration harvest over the next 20 years; in the case of 80 years, however, stands would not be old enough to immediately undertake regeneration harvest (MMBF = millions of board feet).⁹

the long-run (Figure 12). As an example, an upper limit of 120 years for the age of existing stands that could be regeneration harvested could produce an average of 72 million bd ft/year from the BLM lands in both the short-run and the long-run.

What would be the source of the regeneration harvest in the first 20 years? We presume that the oldest stands available would be harvested and that stands less than age 80 are really too young to be regeneration harvested and might not have reached culmination of mean annual increment. In the case of the 160-year maximum, most acres would come from the 120-160 year age class and the rest from the 100-120 age class. In the case of the 120-age maximum, the acres would come from the 80-120 age classes. In the case of the 80-year age maximum, implementation of the regeneration harvest strategy would have to wait for a few decades as stands currently available would not be old enough to harvest.

⁹We used the acreage by age class from Figures 6 and 7 as the starting point in our analysis. We then adjusted the national forest acreage estimates to update that inventory to the present.

Some key points about the results:

- 1) Short-run and long-run harvest levels would be the same if there are currently sufficient stands to harvest from 80-120 years of age (with a 120 threshold) or 80-160 years of age (with a 160 threshold). The relative lack of stands in these age classes in the Moist Forest Matrix (Figures 6 and 7) make achieving the short-run regeneration harvest rates somewhat problematic.
- 2) Whether the threshold stand reservation age is 120 or 160 does not have much impact on the regeneration harvest level due to the small number of stands between 120 and 160 in the Moist Forest Matrix. Dropping the reservation age to 80 years has a large impact in the short-run and a lessor impact in the long run.
- 3) The long-run estimates assume that the existing growth and yield relationships continue far into the future. Coming climate change will alter these relationships and make these long-term estimates very speculative.

What proportion of the 80-160 year age class might be regeneration harvested under this scenario? In aggregate, up to 25% of those age classes would be available for regeneration harvest over time, depending on the age threshold used, outside of Wilderness, Inventoried Roadless, and other areas withdrawn from timber harvest.

The national forests have about 4.1 million acres of Moist Forest outside of Wilderness, Inventoried Roadless Areas and forest plan withdrawals, and BLM has about 1.4 million acres of Moist Forest outside of Wilderness. The regeneration harvest rates discussed above would harvest approximately 1% of these acres *per decade* on the national forests and 1.5% of those acres on BLM lands.

In addition, perhaps one-half million acres of plantations from 0-80 years of age are in Late Successional Reserves in Moist Forests away from riparian areas. Creating forest openings and early successional communities from those stands could be useful but we have not included this in any of our calculations. Also, a reconfiguration of the LSRs could potentially shift some of these young stands into Matrix. These are issues that should be considered by a scientific review group who will have the benefit of seeing how early examples of regeneration harvests work out.

Finally, we do believe that the issue of prompt restocking--specifically the requirement that lands will be "...adequately restocked within five years after harvest" on the national forests--needs to be reconsidered. First, all of our experience with credible retention harvesting indicates that there is adequate natural regeneration. Second, prompt uniform regeneration on harvested sites is probably not desirable where the creation of fully functional early successional or preforest communities is a goal. These communities require several decades to develop and mature, if they are to fulfill functions such as habitat for early successional animal specialists. The meaning of "adequately restocked" needs reevaluation in light of this new understanding of the early successional ecosystem (Swanson et al. submitted).

Overall Potential Harvest Levels, Current Harvest, and Current Growth

Potential Harvest Levels over the Next 20 Years

Summarizing the previous sections, we can estimate total potential harvest (millions of board feet/year) for the next 20 years from these restoration strategies (Figure 13).

The potential annual harvest shown here for BLM of slightly more than 200 million board feet/year, for a threshold age of 120 years or above, is only slightly less than the quantity estimated for BLM under the NWFP. How can that be, given that stands and trees over 120 years have been reserved and we employ a lower management intensity than utilized in the NWFP? First, the NWFP estimate included only Matrix (and Adaptive Area) harvest and this estimate includes harvest from Matrix (and Adaptive Areas) and reserves. Second, the BLM has raised its estimate of harvest under the NWFP in its recent FEIS (BLM 2008). Considering both Matrix and reserve harvest, BLM now estimates an annual harvest for the next decade of approximately 350 million board feet. Thus, we estimate a lower potential harvest under this proposal than BLM's latest estimate of what it would obtain under the NWFP, primarily due to the reservation of old forest in the Matrix.

Long-term Sustainable Harvest Levels

It is difficult to discuss harvest levels in detail beyond the first 20 years. They depend on markets and social dynamics, on how climate change affects these forests, on new knowledge that will develop on how forests function, and

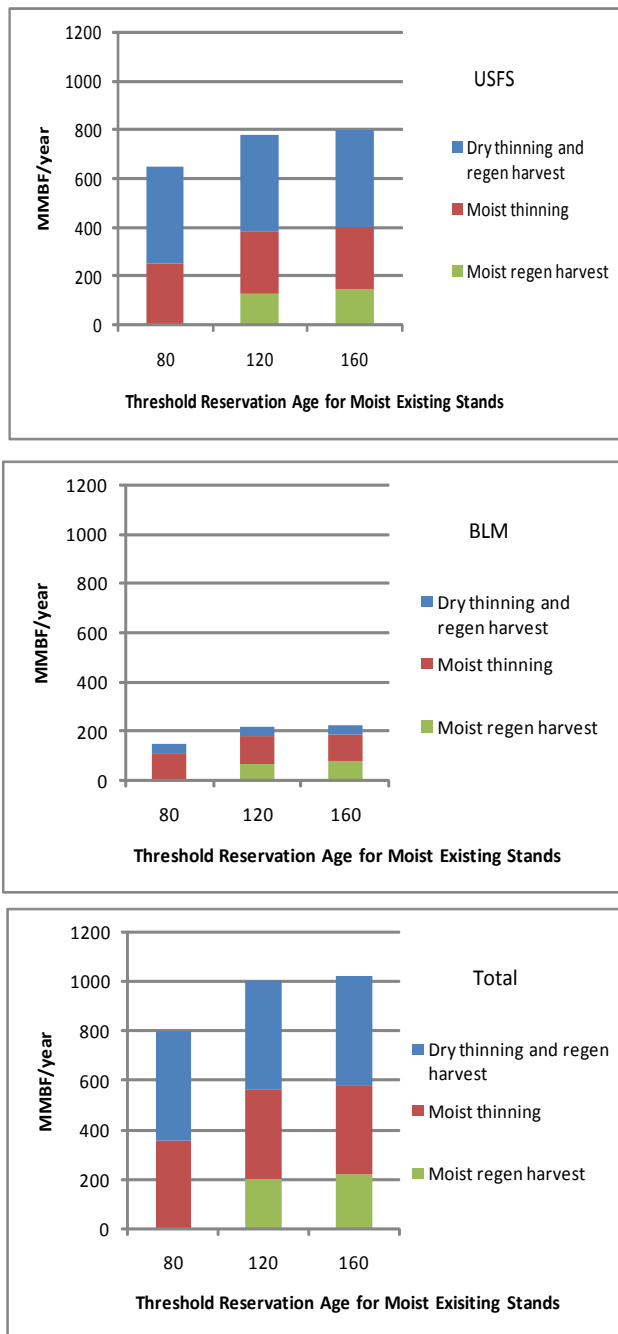


Figure 13. Potential total restoration harvest. Summing the Moist and Dry harvest for both agencies shows a total harvest that ranges from 800 million to one billion board feet per year for the next 20 years (MMBF = millions of board feet).

on many other factors. In this second 20-year period, the harvest contribution from Moist Forest thinning in Late Successional Reserves and Riparian Reserves would most probably decline on the national forests similarly to that shown for BLM (Figure 9). Raising the maximum thinning age for those allocations from 80 to 120 for stands currently less than 80 years of age could offset some of those declines but eventually the stands will be too old to thin in those allocations. Regeneration harvest in the Moist Forest would continue. In addition, we envision a second cycle of density reduction in the Dry Forests which would contribute volume, although probably at reduced levels compared to the restoration activities during the first cycle.

Both the Forest Service and the Bureau of Land Management share a commitment to sustained yield. Recently, that commitment has been subsumed by other concerns about sustainability. Also, in a world in which change and uncertainty seems to dominate, the notion of sustained yield of wood products may seem archaic. Still, many people are interested in an estimate of the long-term sustained yield that might flow from a strategy or plan.

Federal harvest declined in the late 1990s and has since rebounded as agencies concentrated more on restoration thinning.

It is especially difficult to estimate the sustained yield of wood products that might be associated by the density reduction strategy for Dry Forests. Repeated entry will be needed to maintain desired stand conditions but the mixture of harvest and fire as tools to achieve those goals is difficult to assess at this time.

The potential sustained yield for Moist Forests is easier to estimate under the management strategies discussed above than that for Dry Forests, although estimating its likely level in the face of climate change is difficult. Moist Forest sustained yield can be approximated by the projected regeneration harvest level in the Matrix (which might actually come in a combination of thinning and regeneration harvest). Those levels are approximately 100-150 million board feet/year for the national forests and 58-79 million board feet/year for the BLM Western Oregon Lands depending on the age threshold for defining old forest (Figure 12). Whether these levels would hold up under climate change cannot be determined at this point.

Comparison to Current Harvest

A summary of harvests from the two agencies from 1995-2007 (Figure 14) shows a similar pattern: harvest declined in the late 1990s as additional stipulations of the Northwest Forest Plan took effect (Survey and Manage) and various lawsuits challenged agency implementation of the NWFP. The harvest gradually rebounded as the agencies learned to focus on those actions, mainly restoration thinning, that had the broad public support as providing both ecological and social benefits. Recently total federal harvest has approached 600 million board feet/year.

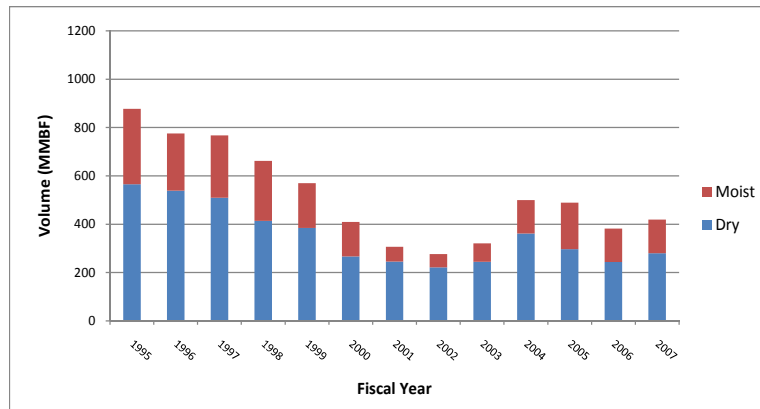
Also, as shown in Figures 10 and 11, harvests have increasingly come from thinnings rather than regeneration harvest. In fact, regeneration harvest has shrunk to a very small percentage of total harvest.

Forest Service analysts suggest that potential future harvest under any strategy should be compared to what they offered for sale, or what was sold, rather than what was harvested (Figure 15). Sometimes operators did not want the timber, other times lawsuits prevented sales or harvest, and still other times poor markets caused buyers not to harvest. In the last few years, a poor timber market has existed, so operators may be holding some sales for better times. For perspective, we compare our potential harvest estimates to sales and harvest.

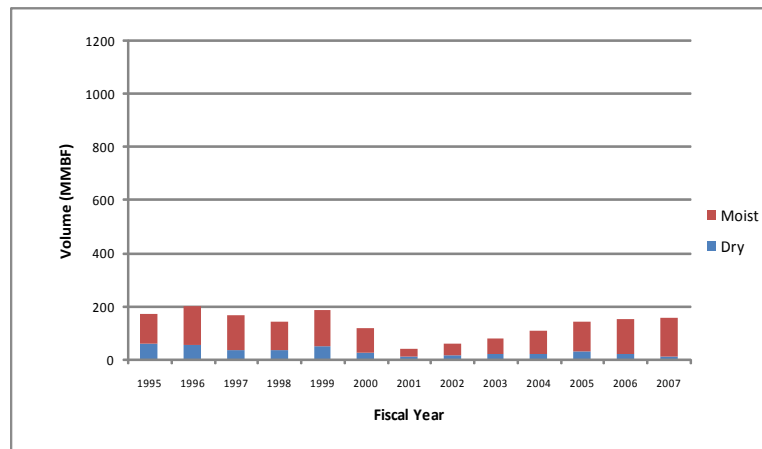
We compare total agency potential harvest to how much was sold and how much was harvested both in the short-run and in the long-run (Figures 16 and 17). Generally our estimate of potential harvest for the next 20 years is greater than recent harvest and sales, although some of that increase is due to a reinitiation of regeneration harvest. For the long-term potential harvest, we

only have estimates for Moist Forests. In the long-term, harvest comes only from the Matrix and is lower than both recent sales and recent harvest.

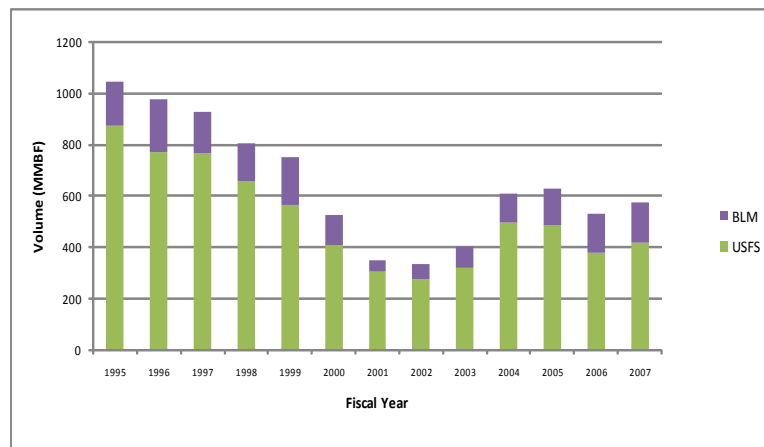
A long-term supply of timber can be provided by the Moist Forest Matrix and continued restoration and maintenance of Dry Forests.



a) Moist and Dry Forest harvest from the national forests

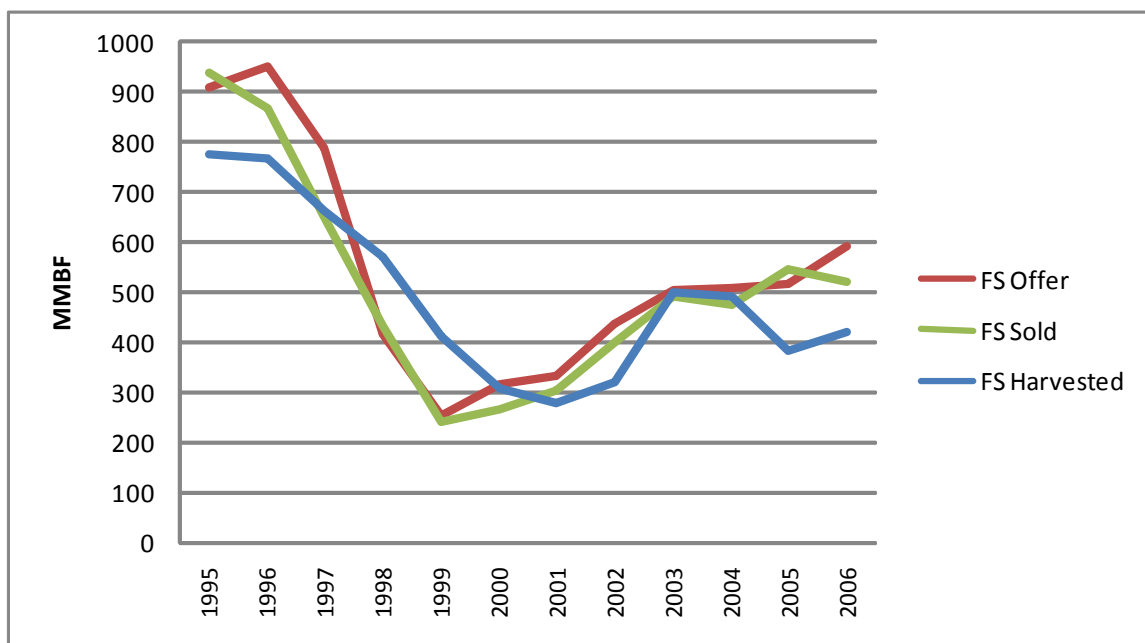


b) Moist and Dry Forest harvest from the BLM

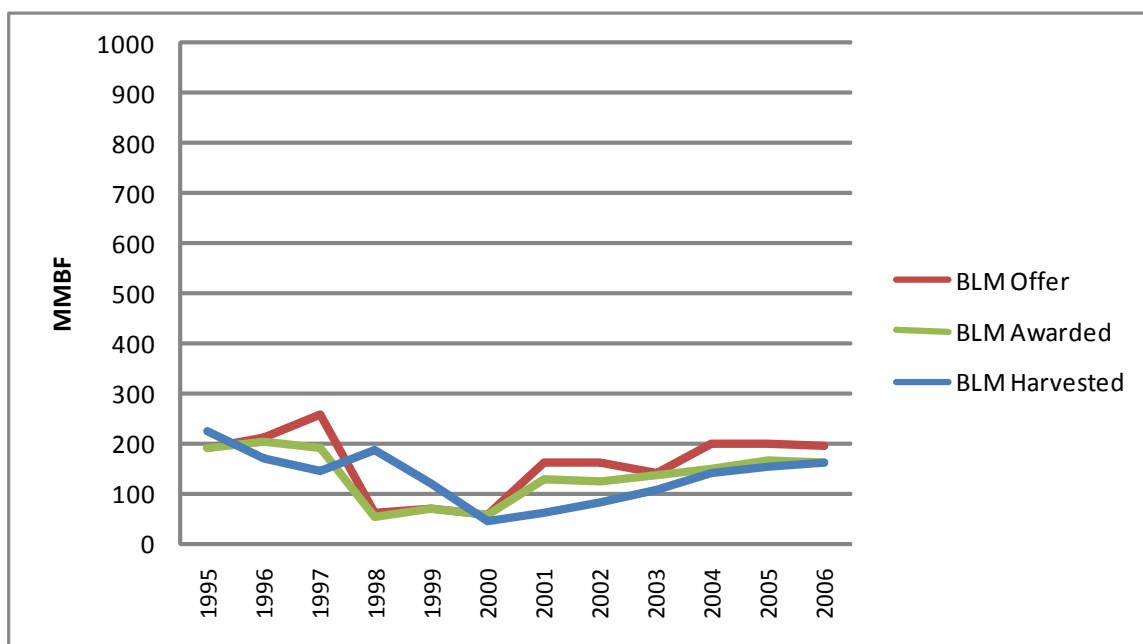


c) Total harvest from national forest and BLM

Figure 14. Federal timber harvest from 1995-2007 in Oregon and Washington. Timber harvest in all cases followed a similar pattern: harvest declined in the last 1990s as additional stipulations of the Northwest Forest Plan took effect (Survey and Manage) and various lawsuits challenged agency implementation of the NWFP. The harvest then gradually rebounded as the agencies focused on those actions, mainly restoration thinning, that had broad public support as providing both ecological and social benefits.



a)



b)

Figure 15. Timber volume offered, sold (awarded), and harvested from 1995-2006 on the a) national forests and b) BLM forests. Offered means means the agency has developed a timber sale and advertised it. Sold (awarded) means that the contract has been awarded to the purchaser. Harvested means that the trees have been cut and removed. Sold on the national forests is similar to awarded on BLM lands. After sales, purchasers have a number of years to harvest the timber; thus, sometimes harvest is above sales and sometimes below them. Appeals and litigation can also cause sold to be greater than harvest and offering to be greater than sold.

Thus, compared to recent harvest levels, the restoration strategy here shows an increase in harvest for both the Forest Service and the BLM. Why do we believe that? These strategies build on what the FS and BLM have been successful in doing--thinning young stands in Moist Forests and undertaking density reductions in Dry Forests. They add to those FS actions in four ways 1) speeding up and expanding forest health treatments in Dry Forests, 2) allowing removal of some young trees over 21" dbh and entry into areas with concentrations of old growth trees in Dry Forests to protect old growth and reduce stand densities. 3) accelerating Moist Forest thinning in the young stands approaching thinnable age, 4) undertaking regeneration harvest in the Moist Forest Matrix over time, using ecological forestry principles, in stands now younger than 120 years of age. These four features of the proposal should each enable an increase in harvest over the next 20 years compared to recent harvest levels. Taken together that increase could be substantial. These strategies complement the BLM successes in thinning and density reduction primarily through arguing for acceleration in stand density reduction in southwest Oregon, compared to the recent past, and undertaking regeneration harvest in the Moist Forest Matrix. Considerable uncertainty surrounds the BLM harvest that would occur in Southwest Oregon—it might be considerably higher.

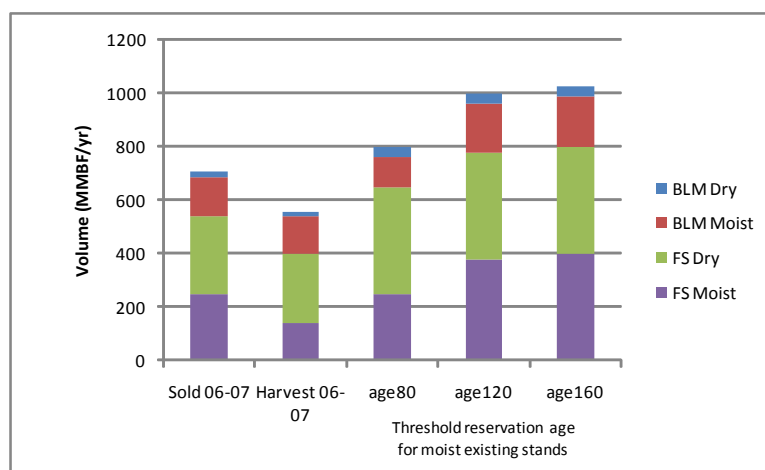


Figure 16. Recent sales (06-07), recent harvest (06-07), **and potential harvest from Moist and Dry federal forests for the next 20 years** under threshold ages for reserving old Moist Forest stands of 80 years, 120 years, and 160 years. Potential annual harvest for the next 20 years is greater than recent sales and harvest under all three threshold reservation ages.

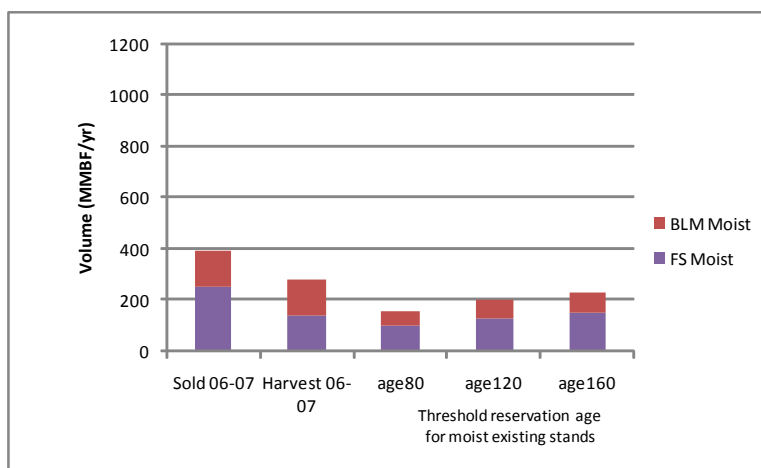


Figure 17. Recent sales (06-07), recent harvest (06-07), and potential **long-term harvest from Moist federal forests** under threshold ages for reserving old Moist Forest stands of 80 years, 120 years, and 160 years. Potential annual long-term Moist Forest harvest is less than recent sales and harvest under all three threshold reservation ages.

Comparison to Current Growth

On the national forests, the annual harvest volumes described above are significantly less than current growth in board feet (Figure 18). We do not have growth estimates for the BLM lands but expect a similar harvest/growth relationship.

On the Dry Forests, some growth will be consumed by prescribed fire and by continued wildfire. If wildfires held to moderate levels, total board foot volume should increase with future growth shifted toward the larger, older, more drought-resistant and fire-resistant trees. Total biomass, on the other hand, should decrease.

On the Moist Forests, the growth will help rebuild late-successional forests and provide a significant carbon sink.

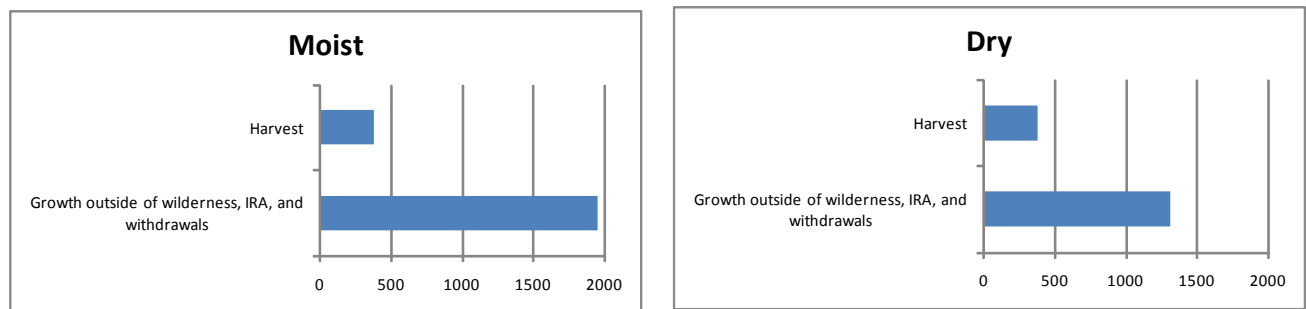


Figure 18. Comparison of potential restoration harvest to growth on the Moist Forests and Dry Forests of the national forests. By almost any comparison, growth is significantly greater than harvest. (IRA = Inventoried Roadless Areas)

Challenges

There are several challenges to implementation of this restoration strategy:

- Investment will be needed. While timber harvest values can help defray costs, they will not be sufficient to cover all the needed actions and the associated infrastructure and planning. This conclusion is consistent with conclusions from other studies (Adams and Latta 2005, Barbour, et al. 2008).
- The strategy is an integrated approach that softens the division of the landscape into Reserves and Matrix that could be controversial.
- Restoring forests while simultaneously conserving and restoring the watersheds within which they are located will create both opportunities and tensions. The partial cutting strategy outlined here will require maintenance, use, and repair of the existing road system which carries with it the potential for impacts on aquatic systems.
- Successfully pursuing a pathway that nourishes all the resources of value on these lands will require professional management of the highest level and, hence, a restoration of the Forest Service to a critical mass of professionals.
- Finding ways to utilize the biomass (slash and small trees) left after harvest, rather than burning it, will remain a significant issue. A recent analysis (Biomass Project Team 2006) documents that significant biomass would be available under strategies for Dry Forests similar to those suggested here and the potential to use these materials for power generation.

Carbon Storage Effects

The restoration approach suggested here will have differing effects on carbon stocks in Moist and Dry Forests. In Moist Forests, growth will go toward rebuilding the carbon stocks that have been greatly depleted during the last 100 years of western settlement and use of some of the most productive lands in the United States (Mitchell et al. 2009; Hudiburg et al. 2009).

In Dry Forests, density reduction will reduce overall carbon stocks initially with eventual recovery. To understand carbon effects of restoration treatments, we examined the average ponderosa pine and mixed conifer stand in Johnson et al. (2008). We then estimated the carbon amounts per acre before and after treatment and compared those levels to species/stand structures from Munger (1917). Munger (1917) measured both ponderosa pine and mixed conifer stands in areas northeast of Klamath Falls and Johnson, et al. (2008) used these stands to help craft a desired future condition. These historical stands have a much higher proportion of their biomass in large diameter trees than existing stands. We utilized the biomass equations of Jenkins, et al. (2006) for ponderosa pine, white fir, and Douglas-fir to estimate carbon amounts as a function of diameter class for these three species (Figure 19).

Even with a doubling of harvest from federal forests, board foot growth would still far exceed removals.

In both cases, the carbon per acre drops sharply as treatment occurs and then recovers as the desired species and stand structure is achieved (Figure 20). Since a goal of the treatments is to reduce biomass levels, especially in small to medium sized material, post-treatment carbon levels are much below pre-treatment carbon levels. The historical stands of Munger (1917) contain a much higher proportion of large trees, resulting in a higher carbon content per acre than in current stands (Figure 20). This higher level in the historical stand compared to the existing stands, is somewhat moderated in mixed conifer by the higher proportion of ponderosa pine, a tree that contains less carbon than white fir of the same size (Figure 19).

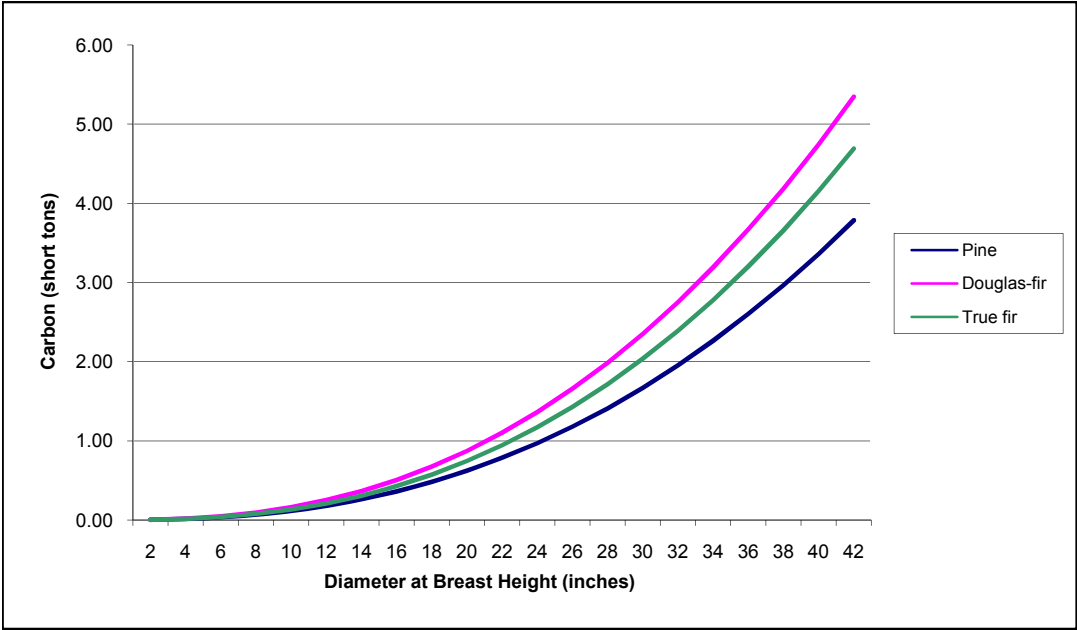


Figure 19. Carbon content by species and size. Because ponderosa pine has more taper than other species, it has less carbon content for any sized-tree.

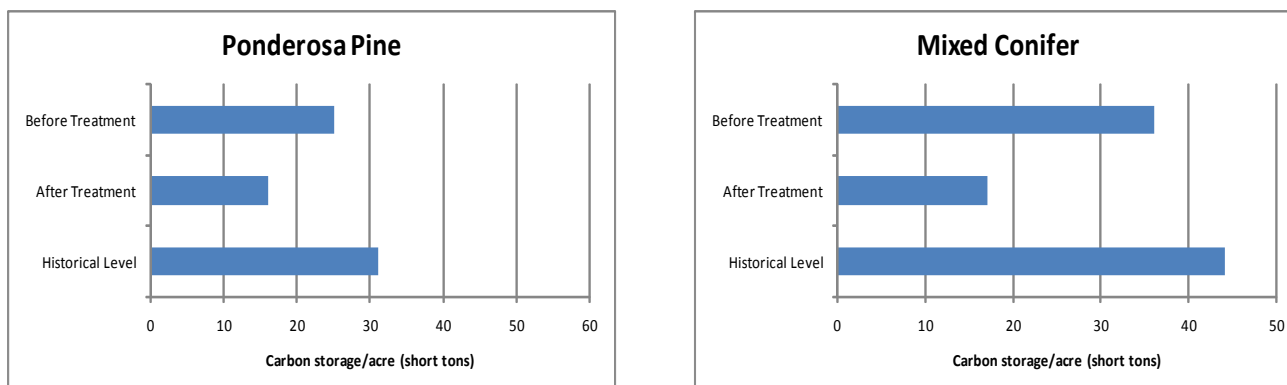


Figure 20. Carbon storage before treatment, after treatment, and associated with historical levels in the ponderosa pine and mixed conifer Dry Forests of the Winema National Forest. One effect of density reduction treatments is to reduce the amount of carbon on the site. As the forest then moves toward the long-term goal, and shifts the biomass toward larger, more fire resistant trees, rebuilding of carbon will occur on the site.

North, et al. (2009) also found that the historical mixed conifer forest in the Sierra Nevada contained more carbon than the current forest. In sum, targets based on historical conditions could eventually result in increased carbon sequestration.

Using the data from Johnson et al. (2008), we estimate that a significant proportion of the biomass harvested during a treatment will be left on site. While these products may provide long-term carbon storage, the logging debris is often burned on site. Utilization of this biomass for energy or other purposes would help reduce short-term emissions associated with restoration.

The net effect of Dry Forest restoration on the overall carbon balance remains controversial. While it has been argued that reducing stand densities will reduce carbon emissions during wildfire, others (Mitchell, et al. 2009) have argued that such savings do not make up for carbon lost during treatments.

Forest Restoration: Approaches after Stand-Replacement Disturbances

Wildfire and other natural stand-replacement disturbances will be an inevitable part of the future of both Moist and Dry Forests on federal lands. Some of these disturbances will be high-severity, stand-replacement events and they will continue to challenge society's capability to manage wildfire to meet its goals.

Carbon

- *Dry forests cannot sustain the carbon (fuel) levels that currently exist in many stands.*
- *Ecological restoration in Dry Forests will initially result in reductions in carbon storage, but stored carbon levels will recover as growth is transferred to larger, more resilient trees.*
- *Productive uses for the biomass residues from restoration activities are needed—burning these residues results in significant, immediate emissions.*
- *The contribution of restoration treatments in Dry Forests to limiting future emissions from wildfire is controversial and unresolved.*

What should be done after such events? Should salvage occur? If so, which trees should be removed? What other activities should be undertaken? We provide one answer to these ques-

Restoring the viability of the federal resource management agencies is imperative to achieve restoration goals and—most importantly—to meet the challenge of climate change.

tions in the context of this paper—strategies to restore federal forests and the benefits that flow from them. Our approach is simple: *we develop guidance for Moist and Dry Forests after a disturbance based on their management direction before the disturbance.*

Background

Treatment of areas following occurrence of major disturbances is a complex and controversial topic. Complexities include the trade-offs among various resource management goals, such as between management of fuels and provision of wildlife habitat in the case of wildfires. Conflicts often exist between economic and ecological objectives as timber salvage is generally about recovering economic values rather than enhancing ecological recovery.

A further complication is that science of post-disturbance management activities has only recently begun to receive serious attention. The authors of a recent book on this subject (Lindenmayer et al. 2008) propose that post-fire treatments should be guided by two general principles: (1) avoiding additional harm to resource values following a major disturbance; and (2) using pre-disturbance management goals as a starting point in determining appropriate actions.

One of the most contentious post-disturbance management activities is whether or not to remove dead and surviving live trees following major disturbances, a debate driven by the fact that live and dead wood has both ecological and economic value. Removal (“salvage”) of dead wood, damaged living trees expected to die, and even other merchantable living trees is inevitably economically motivated, although these economic objectives may include generation of funds to carry out other post-disturbance restoration activities.

Concerns with the removal of standing dead and down trees, collectively known as coarse wood, include the numerous ecological roles that it plays in forest ecosystems (Harmon et al. 1986, Maser et al. 1988) including roles as:

- Long-term sources of energy and nutrients;
- Aggregated sources of soil organic matter, which form important parts of soil matrices;
- Structural elements of the landscape that influence hydrologic and geomorphic processes within aquatic and terrestrial ecosystems;
- Significant modifiers of microclimatic regimes in the post-disturbance ecosystem; and, most profoundly
- Habitat for a large array of animals, including the majority of vertebrate and large numbers of invertebrate species.

Large snags and logs are generated by natural mortality processes in living forests that include mature and old trees, continually replenishing this important resource. This process is disrupted by a stand-replacement disturbance. Such disturbances do generate a large pulse of dying, dead and down material. However, that pulse of large wood after the stand-replacement disturbance is all of the large wood that the recovering ecosystem is going to get for many decades or even a century—i.e., until trees of large size are once again a part of the stand and undergoing mortality. Some of the dead wood legacy from the stand-replacement disturbance will persist and fulfill important functional roles in the recovering forest for many decades and, in the case of the largest and most decay resistant material, for well over a century (Figure 21).

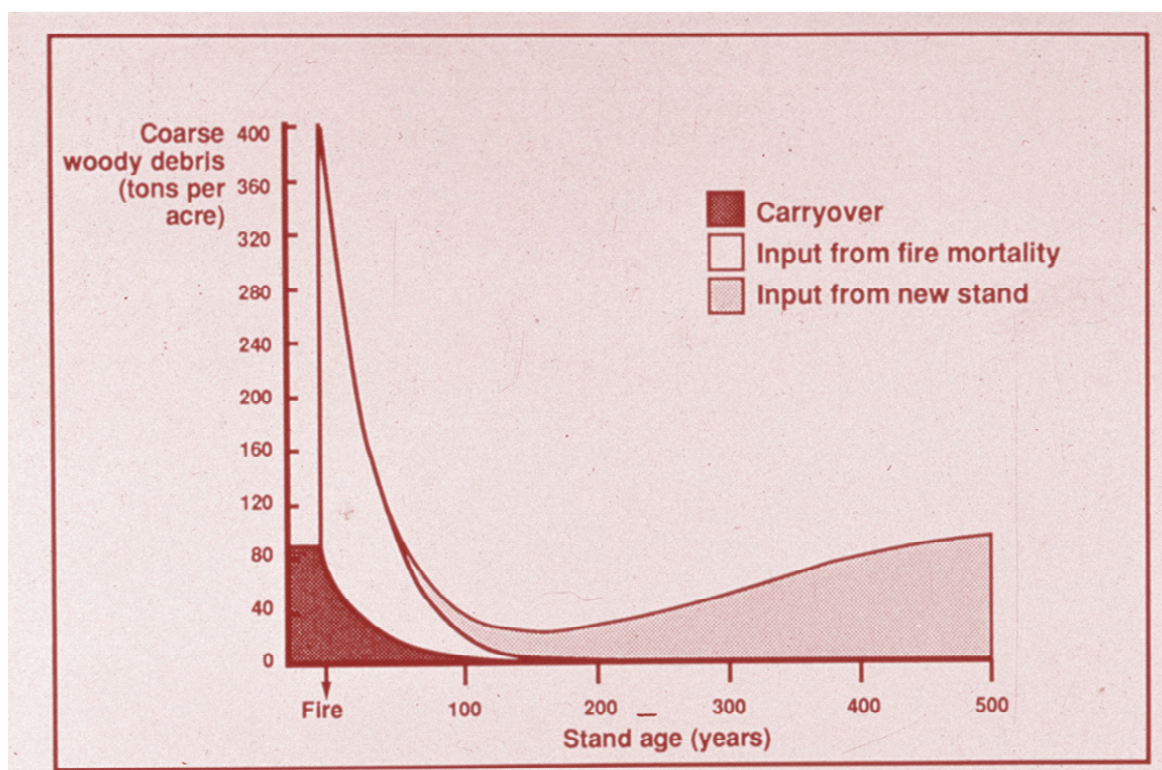


Figure 21. The dynamics of coarse wood after disturbance. Standing dead and down trees, collectively known as coarse wood play numerous ecological roles. Large snags and logs are generated by natural mortality processes, continually replenishing this resource. Disturbances disrupt this process, generating a large pulse of this wood. However, the pulse of large wood after a stand-replacement disturbance is the major source of this wood for many decades, until trees of large size are once again part of the stand. Source: Maser, et al. 1988

Overall fuel levels, though, could be an important consideration in at least some ecosystems. Excessive fuel loadings could potentially, increase the intensity of a subsequent fire or make reintroduction of prescribed burning difficult. This is primarily an issue where fuel buildups in the disrupted forest had exceeded historical levels.

General Post-Disturbance Restoration Guidance

We feel that there several principles should guide any decisions regarding restoration or other management activities following a major disturbance event:

- 1) Do no significant additional ecological damage to the biota and functional capabilities of the post-disturbance ecosystem, with particular consideration of soil and aquatic resources;
- 2) Consider the merit of potential activities in the context of the primary management objectives for the site (e.g., maintenance of biological diversity, watershed protection, or wood production). For example, salvage would appear to be inappropriate in areas that have been allocated primarily to maintenance of native biodiversity and functions and natural forest ecosystems (including old growth); and
- 3) Give full consideration to the ecological roles played by biological legacies from the pre-disturbance ecosystem including their importance and duration.

Post-disturbance Restoration Guidance for Dry Forests

As we proposed at the outset, post-disturbance actions should help achieve the pre-disturbance management objectives for the forest, unless the society (in the case of public lands) chooses to change those objectives. If these forests have an overall restoration objective, as suggested in this paper, then any post-disturbance actions should further that objective.

Salvage

Given that restoration of these forests is focused on reducing stand densities, post-disturbance salvage, if it were to occur, should result in similar outcomes. Of course, any actions on the post-disturbance landscape would only occur after an environmental review that considers the often fragile state of watersheds after fire, for example.

Generally, silvicultural manipulation of Dry Forests after disturbance would utilize the same limits as existed before the fire: limit any salvage to those trees that were excess to (were not associated with) achieving the desired future condition before the disturbance. We believe that similar target stand structures considering before and after wildfire for Dry Forests has several advantages such as: 1) Utilizing the same ecological template in both cases; 2) Eliminating debates over whether damaged trees will die—controversies that can increase the difficulty of post-fire strategies; and 3) Utilizing prescriptions that will be well-known to foresters who work on these sites.

Occurrence of wildfire in Dry Forests would cause reevaluation of the priorities for action among the different landscape units: restoration actions could shift to those that experience wildfire, undertaking prescribed treatments on the burned and unburned portions of the area.

Reforestation

The need for artificial reforestation would be carefully evaluated, especially in areas that have been subject to uncharacteristic wildfire. This evaluation would consider such issues as the availability of surviving seed trees, the potential for sprouting brush species to occupy uncharacteristically large areas of the burn, and characteristic tree densities and spatial distribution on the site. When a decision is made to artificially reforest, the guideline would be to set the stage for attainment of the desired future condition. In the case of ponderosa pine/bitterbrush plant associations, as an example, that desired condition would often be a mature pine stand with 12-20 trees per acre over 21+” dbh and with some intervening denser patches. Hence, reforestation goals should avoid establishing dense, uncharacteristic, “fully stocked” forests, thereby perpetuating the potential for uncharacteristic fire.

Once desired planting levels have been determined, a distributional guide for planting would be to create an irregular or variable density pattern rather than a uniform pattern of seedlings. The desired pattern could be described as a low density of seedlings planted on an irregular pattern over the majority of the area with occasional densely planted patches. This approach provides the opportunity for planters to seek out more favorable locations for tree seedlings than is possible under a systematic grid. Also, areas with greater forest growth potential can be selected as sites for denser plantings.

The decision to reforest the site need not be tied to the decision to remove trees. Some sites where tree removal occurs might best be left to naturally reforest and some sites where removal does not occur might best be planted. It must be recognized, though, that reforestation under burned trees must occur within a few years after the fire to meet safety concerns.

Post-disturbance Restoration Guidance for Moist Forests

As with the Dry Forests, we believe that the management goals and restoration strategy for the Moist Forests generally should reflect the management goals prior to the disturbance. Thus, *a forest within Moist Forest LSRs and stands reserved in the Moist Forest Matrix would not be salvaged. Salvage, though, would be considered for stands in the Matrix that have timber production as one of the primary objectives.*

Post-disturbance Guidance for Reserves in Moist Forests

The LSR network was designed to accommodate large, intense natural disturbances and allow for natural recovery processes (Franklin 2005). This is one reason that the NWFP provides for conservative direction with regards to salvage in LSRs and directs that activities should enhance or at least not interfere with natural recovery processes.

Salvage logging of large snags and down boles does not contribute to recovery of late-successional forest habitat. Large snags and logs of decay resistant species, such as Douglas-fir and cedars, are critical as early and late successional wildlife habitat as well as for sustaining key ecological processes associated with nutrient, hydrologic, and energy cycles.

Stand-replacement disturbances in Moist Forests provide large pulses of coarse woody debris (CWD) (snags and logs), which lifeboat dependent species and processes until the regenerating forest begins to produce large dead wood structures, which is typically not for a century. Retention of large snags and logs are specifically relevant to Northern Spotted Owl since these structures provide the habitat that sustains most of the owl's forest-based prey species. In summary, general salvage of large snags and logs is antithetical to rapid recovery of late-successional forest habitat.

Slow re-establishment of forest cover is common following natural stand-replacement disturbances in the Pacific Northwest. This circumstance provides valuable habitat for early-successional species, particularly animals that require snags and logs and diverse plant resources, and for many ecosystem processes. In fact, naturally disturbed habitat that is undergoing slow natural reforestation—without salvage or planting—is among the rarest of the forest habitat conditions in the Pacific Northwest. Yet, it is increasingly evident from research, such as at Mount St. Helens and many other locations (Lindenmayer, et al., 2008), that such large, slowly reforesting disturbed areas are important hotspots of regional biodiversity.

Planting may be appropriate within the LSRs to establish tree seed sources for specific species and locations but this should not be done using traditional approaches, which are designed to create uniformly stocked forest stands over large areas, even at low densities. Planting, if done, should create irregular patterns and variable densities to duplicate the spatial heterogeneity that is characteristic of natural regeneration.

Post-Disturbance Guidance for Matrix in Moist Forests

Matrix lands are managed to provide a continuing supply of wood products and other goods along with a variety of services and values. Wildfire or other stand-replacement disturbances should not change the management objectives here which include wood production.

Salvage

Prompt salvage in Matrix would be considered using the principles of ecological

Restoration programs need regular third-party oversight—including public accountability—to regain and sustain societal trust. “Trust, but verify!”

forestry. Special analyses are required to assess whether harvest can be done, given the fragile nature of many sites after wildfire. Where harvest after fire will not cause unacceptable damage to the post-fire landscape, we would expect that the same prescriptions and retention levels suggested for the unburned landscape would be considered for the burned landscape consistent with any additional standards that are needed.

Reforestation

Regeneration would be considered in the context of the goal of nurturing the development of structurally-complex, early-successional communities. The need for artificial reforestation would be carefully evaluated. This evaluation would consider such issues as the availability of surviving seed trees, the potential for sprouting brush species to occupy uncharacteristically large areas of the burn, and characteristic tree densities and spatial distribution on the site.

Appendix I: Ecological Forestry

General Principles

Ecological forestry encompasses forest practices (silvicultural activities) that are based on principles of natural stand development, including the role of natural disturbances in the initiation, development, and maintenance of forest ecosystems, and operating on temporal scales consistent with recovery of desired structures and processes (Franklin, Mitchell, and Palik 2007). These elements include: (1) retention of structural and compositional elements of a forest (biological legacies) at the time of a regeneration harvest; (2) manipulations of established stands to direct their development to desired structural and compositional conditions, such as by variable-density thinning, creation of dead tree structures, and prescribed burning; and (3) determination of return intervals for silvicultural activities based upon recovery periods for key structures and processes. These three elements have analogies in the traditional forestry concepts of regeneration harvests, intermediate stand treatments (e.g., thinning), and rotation interval.

Ecological forestry also incorporates spatial considerations at multiple spatial scales. Ecological forestry will typically incorporate natural spatial heterogeneity at all spatial scales, from centimeters (logs) to meters (stands) to kilometers (landscapes). The practitioner of ecological forestry will look to the heterogeneity inherent in stands and landscapes as a beginning point or guide in implementing heterogeneous activities. Uniform silvicultural treatments in either stands or landscapes, which create homogeneity, will be unusual in the practice of ecological forestry.

Ecological forestry is planned, implemented, and evaluated at the landscape scale, incorporating knowledge developed from the study of pattern and ecological function in natural landscapes. This includes issues associated with natural patch size and distribution, connectivity, and appropriate management consideration of landscape components of exceptional ecological and cultural significance, such as aquatic features and early-successional and other non-forested communities within forest landscapes.

Some Applications to Northwest Forestry

Ecological forestry incorporates natural stand development processes in manipulating young simplified forest stands toward greater complexity. Thinning is probably the most important single activity used in directing stand development under ecological forestry. However, in ecological forestry, thinning has a much broader range of objectives than traditional pre-commercial and commercial thinning programs, which have rapid growth of selected crop trees as their primary goal and primarily utilize thinning from below (the smaller trees) to create a spatially uniform stand is the generic form of commercial thinning. A primary goal in ecological forestry is to create structural complexity and spatial heterogeneity. Stimulating the creation of “decadence”—such as snags and logs and other woody debris on the forest floor, and wood decay in living trees—is also a common objective of silvicultural activities in ecological forestry. Thinnings using ecological forestry principles also may involve removal of some larger dominant or co-dominant trees in order to nurture components of the understory or mid-story community.

In ecological forestry, variable density thinning will be a dominant form of silvicultural activity with many objectives including: (1) development of some large trees; (2) stimulation of desirable suppressed understory herbs, shrubs, and trees in mid-story canopy positions; (3) creation of decadence, including CWD; (4) stimulation of spatial heterogeneity in structure, building on existing patterns of spatial diversity when possible; and, often, (5) commercial wood harvest. As noted,

activities will typically involve some thinning from above (i.e., removal of some dominant and co-dominant trees) as well as from below and spatial variability in type and intensity of activities.

Moist Forests

Long-term management of mature Matrix forests on Moist sites for ecological values and timber in the Pacific Northwest can be based on principles of ecological forestry (EF), particularly the concepts of biological legacies and rotations keyed to recovery of ecological values. Variable retention harvesting is the primary EF approach to regeneration harvesting on Moist Forest sites; by retention we mean leaving significant structural elements (e.g., live trees, snags, and logs) of the harvested stand behind, so as to structurally enrich and increase the diversity of biota and ecological processes in the post-harvest ecosystem (Franklin et al. 1997). With regards to sustaining desired levels of ecological function in the stand, there are potential trade-offs between the level of retention of live trees and rotation period; i.e., where rotations are short, ecological impacts can be mitigated by higher levels of live tree retention and, conversely, lower levels of retention (higher levels of harvest) can produce similar ecological outcomes when longer rotations are utilized. Interestingly, this inverse relationship between rotation and retention has a natural model in the inverse relationship that exists between natural disturbance interval and levels of live tree legacies—the shorter the interval between disturbance the greater the legacy; the Blue River Strategy is designed around this relationship, for example (Cissel, Swanson, and Weisberg 1999).

Moist Forest sites in Matrix lands can be managed for the sustained production of both economic (wood) and ecologic values. Intermediate stand level activities would be similar to those used in restoration treatments – e.g., variable density thinning. Regeneration harvests will utilize variable retention prescriptions and nurture early successional communities. Rotation ages can be highly variable in length (e.g., from 60 to 240 years) and utilize retention levels that are appropriate for integrated (ecological and economic) objectives.

Dry Forests

Long-term management of Dry Forest sites in the Pacific Northwest can also be based on principles of ecological forestry. Initial silvicultural activities would be designed to restore ecological conditions that are both sustainable and provide for a full array of ecological values. These are sometimes referred to as “restoration” and include the following considerations:

- 1) retention of all old trees and focused silvicultural activities around these trees to enhance their potential for survival by reduction of fuels and competing trees and other vegetation in their immediate vicinity;
- 2) silvicultural activity in the remainder of the stand to a) reduce stand densities to levels that are appropriate for that site (plant association), b) increase the mean stand diameter, and c) shift composition to more drought- and fire-tolerant species, such as pines and larch;
- 3) silvicultural activity in harvest areas build upon and enhance the spatial heterogeneity (fine scale, low contrast structural mosaic) that is characteristic of the Dry Forest types, including provision for denser untreated patches;
- 4) silvicultural prescriptions incorporate the objective of managing a portion of the stand to restore and maintain a population of large, old trees historically characteristic of the site (i.e., keyed to plant association); and
- 5) planning and implementation of activities are planned and implemented at the landscape level and incorporate heterogeneity in conditions essential to sustain all elements of the biota (e.g., Northern Spotted Owls and their prey species).

Sustainable, desirable ecological conditions are maintained on restored sites and landscapes by a continuing program of active management that may include use of prescribed fire, managed natural fire, and silvicultural manipulations, including periodic timber harvest.

Appendix II Shifting from Diameter to Age to Identify Older Trees in Dry Forests

A Brief History of the 21" Rule

Historically, the Forest Service in the Dry Forests of Oregon and Washington has used a partial cutting strategy that focused on harvest of the big, old ponderosa pine trees. As a result, their numbers were sharply depleted by the middle of the 1980s. It was clear that that approach was not sustainable but the FS plans of the mid 1980s did little to change things.

In response to the threat of litigation, the Regional Forester in the mid 1990s adopted interim direction for the national forests that included a requirement that these national forests limit harvest to trees less than 21" dbh (with some exceptions permitted). Also, these "eastside screens" called for a number of other conservation measures including more substantial stream buffers. The screens were put in place without an EA or EIS (an EA was written later) and were to last approximately 18 months. They still are in place today.

The "21-inch rule" has been fundamentally important in shifting management of eastside forests and conserving the remaining large, old trees. It helped midwife changes that redirected Forest Service management of these national forests.

Shifting from Diameter to Age for Identifying Old-Growth Trees in Dry Forests

When we began developing a plan for the former Klamath Reservation Forest (now a part of the Fremont-Winema National Forest) at the request of the Klamath Tribes, we utilized the 21" rule to limit the harvest of old growth trees and to identify areas of high concentrations of old growth trees (Johnson, et al. 2008). Our fundamental strategy for these forests (restore structural complexity as rapidly as possible) came from a previous assessment that had employed the 21" rule. Also, we used the old growth mapping results from the Audubon mapping project to make an initial spatial identification of "old growth stands." That project utilized a criterion of at least 10 trees/acre over 21".

As we developed the Plan, we used the 21" rule as the limit for harvesting most species. We made a partial exception for white fir, allowing it to be cut up to 24" because many young but large white fir were crowding old pines, providing fuel ladders and intense competition. We presented a draft of this approach to the Tribes and the Forest Service, defending our use of the 21" rule.

As we further developed the Plan, though, doubts began to surface about the usefulness of the rule. First, we found areas where significant number of old growth ponderosa pine trees (older than 150-160 years) were less than 21" dbh. In some places most of the remaining old growth trees are less than 21" dbh. While this is a localized phenomena, we have also found it on the Deschutes NF. (As an example, the pine forests along Highway 20 near Black Butte Ranch have significant numbers of old growth trees less than 21" dbh.) Because of their economic value, you can be sure they will be harvested in density treatments if allowed. Thus, the 21" rule would allow the harvest of old growth pine trees. Similarly, one of us (Franklin) has encountered a stand of very old western larch on trust lands in Washington State, in which most of the larches were under 21 inches.

Second, we became convinced that harvest of large, young growth white fir was an essential part of restoring old growth ponderosa pine forests. This harvest is now permitted as an exception to the rule but the Forest Service is somewhat reluctant to push this harvest. As an example, the harvest

analysis provided the Region 6 that we used in this paper excludes volume over 21". We became concerned that this crucial component of restoration would not occur in the magnitude that is needed.

Third, we began to see the conservation effort more as one of maintaining all the old trees across the landscape than the identification of old growth groves per se that would be reserved. As such, we wanted to be sure we used a rule that catches all the old growth trees that now exist.

Fourth, we find more resistance to the diameter rule than the old growth rule among foresters. They seem to feel that the rule restricts them more than need be.

Fifth, we think that a long-term permanent solution should focus directly on the resource values being sought. The 21" rule has been very useful in interim conservation of old growth trees, but we feel that it is now time to shift to conserving old growth trees directly

It is true that measuring dbh is somewhat easier to do than estimating age. Being able to determine whether a tree is "old growth", though, is certainly something every forester should be able to do. We believe that anything that pushes professionals to improve their ability to conserve forests is a good thing.

Appendix III: Age-based Rules

In this paper, we evaluate the implications for federal forest management of instituting restrictions on silvicultural activities based on tree age or stand age, with the goal of preventing the harvest of old trees and stands while allowing activities needed to achieve ecological and social goals. Key questions about an age-based approach include: Aren't age-based rules "arbitrary?" Wouldn't it be better to use a definition that encompasses all the attributes of older forests? Will foresters have to bore every tree in a timber sale to determine age?

Are Age-based Rules Arbitrary?

A Google search of the Web for a definition of arbitrary turns up a number of definitions as widely accessed including "based on or subject to individual discretion or preference or sometimes impulse or caprice" (wordnet.princeton.edu/perl/webown) and "choices and actions which are considered to be done not by means of any underlying principle or logic, but by whim or some decidedly illogical formula" (en.wikipedia.org/wiki/Arbitrary).

The second definition seems most applicable here: "choices and actions which are considered to be done not by means of any underlying principle or logic." Is an age-based definition of older forest or older trees arbitrary by this definition? Age of dominant trees is one of the criteria for old-growth on Moist Forest sites (Spies and Franklin 1988; Franklin and Spies 1991, and Franklin et al. 2002) and one of the defining attributes of old growth forests, so it is difficult to argue that reserving stands dominated by trees over some age is arbitrary by this definition. Certainly such an approach can be seen as overly-simplified or unsophisticated because of the other criteria for defining older forests or old trees but that is different from being "arbitrary." This approach is no different from selecting a drinking age or a driving age or the many other simple rules that society uses to limit actions and choices.

We focus on identifying older trees on Dry Forest sites and, once again, it is well known that trees undergo systematic changes in their structural and physiological characteristics as they age. In fact, a generalized scheme for classification of trees based upon tree age and condition was a primary basis for management of ponderosa pine forests for much of the 20th century (Keen 1943). This was widely used and readily applied by professional foresters throughout the western United States so, again, it is difficult to argue that such schemes are either arbitrary or difficult to use. It is true that the age selected needs to reflect some judgment about how to achieve the goals. Here, as an example, we think that we can safely say that reserving trees and stands in our commercial Moist Forests over 120 years would capture essentially all trees and stands that would be called "old growth." In addition, such a definition would capture some "late-successional" trees and stands that would be called "mature growth" by ecologists and foresters rather than old growth. On the other hand, reserving all trees and stands over 160 years might capture somewhat less old growth forest and significantly less mature forest. In the end, policy makers need to consider those outcomes and make a decision. We also need to understand both intended and unintended outcomes of different age breaks. In this paper, we have tried to describe some of those implications.

Are Age-based Rules Useful?

Some proposals for identifying old growth trees and stands utilize the full suite of old growth characteristics--number of old trees, presence of multiple stories, presence of dead wood. And it must be argued that such an approach would be more accurate. Some approaches using continuous scales based on multiple stand attributes have been proposed (e.g., Franklin and Spies 1991).

Then why not use that more comprehensive approach? Or one that stake-holders can all agree to? To understand why, we need to look at the recent forest management history on the federal forests in the context of the goals they we discuss in this paper. First, those goals, put simply, are to reserve old-growth trees and forests while simultaneously allowing activities to go forward that achieve ecological and social goals. Full implementation of the NWFP has often been stymied where the harvest of trees is involved (Thomas et al. 2007). It is not too much to say that the harvest that has occurred on federal forests in the Northwest has largely been made possible by two simple rules: 1) the 80-year limit on thinning in LSRs in Moist Forests and 2) the 21" limit on thinning in Dry Forests. Those rules not only limit activities that agencies can undertake, they also protect the discretion of agencies to act by giving clear rules on when and where activities are permitted.

Would agencies have a better chance of moving forward if these simple rules were replaced with either a more fully developed set of guidelines for action or a decision process that called for groups to agree on old-growth definitions? We now have twenty years of experience to challenge this view—without simple straightforward rules for action that both limit and protect agency discretion, we will be continuously embroiled in debated, appeals, and lawsuits. If there is a need for action, as we have here, such an approach will not suffice.

Can Age-based Rules be Implemented?

If these very simple rules, such as the diameter-limit rule are working, at least to some degree, why suggest augmenting or replacing them with an age-based rule which, admittedly, will take more thought. As we describe in the body of the paper, we think such a rule will help direct and limit agency discretion in ways that will enable an increase in needed activities and also reassure people that care about older forests. So can it be done?

Most commonly, people question whether an age-based approach can be implemented. It often takes the form of the following: Will foresters have to bore every tree in a timber sale to establish the age of each one? We suggest that very few trees will actually need to be bored as part of timber sales, based on the process outlined below. This discussion relates to aging of *conifers* in Moist and Dry Forests. At the end of this section, we will discuss special issues surrounding the aging of *hardwoods*.

Moist Forests

Older Conifer Stands

We suggest that the agencies determine which stands meet the age definition (over a certain age) with review by an expert panel of scientists and managers. Since the agencies, such as BLM (2008) have shown they can age their stands, this should not be impossible. The proposed expert panel would not have decision-making authority on which stands meet the age definition but would provide advice as needed and file a report on the adequacy of the approach taken.

Older Conifers within Younger Stands Available for Harvest

Based on information on acres by age classes provided by the agencies, we can estimate the distribution of acres in Moist Forest age classes below the chosen threshold on which timber harvest might occur: from 85-100% of those acres would be less than 80 years depending on whether the threshold was 80, 120, or 160 years. Most of the acres less than 80 years were created through clearcutting in mature or old growth stands. On those acres almost all of the trees would be obviously less than the age threshold (probably more than 95% of the trees) or obviously greater the

threshold (a few percent of the trees). Thus we expect relatively few aging problems in “plantations.”

Problems in aging would most likely come in Moist Forest stands between 80 and the threshold age. They would cover from 0-15% of the acres available for harvest depending on the threshold chosen. In those stands, we could encounter a number of problems in aging including trees near the age threshold, problems in aging trees such as difficulty of seeing visible rings near center, difficulty of seeing rings due to heart rot, difficulty of estimating years to breast height, and problems with small, suppressed, old trees which are not the target of the conservation effort. How would we deal with these aging problems?

Actually drawing conclusions about the internal characteristics of a tree from its surface characteristics is not a new problem in forestry. For decades foresters have had to estimate the grade of trees for lumber. This grade depends both on surface characteristics and hidden conditions within the tree like rot, check, and ring count. One time-tested approach is as follows: Protocols are developed for different trees, and perhaps different regions, based on experience, coring, and examining felled trees. The protocols are then employed to grade trees in a sale, with a sub-sample of trees, perhaps every 50th tree (designated to cut), carefully examined to gather evidence on how the protocols are working.

We would envision a similar process here. Protocols for different trees and regions would be developed based on studies by scientists and forest managers and then field-tested. They would then be employed to age trees on timber sales, with information gathered along the way through sub-sampling the trees within the sale. This information would be pooled with other sales to see how the protocols are working. We envision that this sub-sampling would be applied to trees of commercial sawtimber size, i.e., trees over 11” dbh. Smaller trees might be sampled in post-sale monitoring but would not need to be bored.

Post sale monitoring by counting rings on cut stumps would also contribute information. This would seem an excellent vehicle to involve community members and local conservation groups in addition to the agency itself, after the development of some standards approaches to measurement. As a result of the collection of this pre-sale and post-sale information, the agency would adjust the protocols as needed. Every five years or so, an independent team of experts (scientists and forest managers) team would review the results and make suggestions.

Dry Forests

In Dry Forests, we focus on conservation of older trees, with those trees defined as being at least 150-160 years of age. In the 1920s, foresters developed a tree marking guide based on age and vigor called the Keen Classification to help them identify trees to mark. Thus, they have long experience here with age-based criterion. While we feel that the vast majority of trees that need removal as part of the restoration treatments are clearly much younger than 150 years, Recently visual guides for estimating ages of trees in Dry Forests of eastern Washington have been developed by Van Pelt (2008).

We could encounter aging problems similar to those discussed for Moist Forests. Also, estimating the age of small, old ponderosa pine can occasionally be troubling. Thus, we would envision a process similar to that described above for Moist Forests which combines protocols for aging with pre-sale and post-sale information to guide implementation and improvement of tree marking guides.

These protocols should consider the approach taken by Van Pelt (2008) and earlier tree classifications (e.g., Dunning 1928 and Keen 1943).

Hardwoods

Hardwoods make exceedingly valuable contribution to the functioning of forest ecosystems. Great difficulties, though, can be encountered in attempting to age them, including difficulty in determining xylem rings. Thus, we would expect some special procedures would be developed for them

Appendix IV: Thinning in Late-Successional Reserves: Is the “80-year” Rule Too Restrictive?

Guidelines for management of Late Successional Reserves (LSRs) under the Northwest Forest Plan (NWFP) direct that harvest be limited to stands <80 years of age west of the Cascades, where “west of the Cascades is defined as all physiographic provinces in western Oregon and Washington except the Oregon Klamath Province.” Harvest in older stands (>80 years old) requires specific justification and approval. The usefulness of this 80-year limitation in achieving LSR goals has been the subject of frequent debate.

On November 2-4, 2005, we joined a small group of scientists and agency specialists who traveled to federal forests in southwestern Washington and the central Coast Range and Cascades of Oregon. Our goal was to better understand the rationale and consequences of the 80-year limit on stand treatments in LSRs. During the trip we were joined by professional colleagues, many of whom were involved in forest management on the Forest Service and Bureau of Land Management (BLM) lands that we visited.

The actual rule governing harvest in stands in LSRs in the Standards and Guidelines for the NWFP is as follows (page C-12 for West of the Cascades except for the Oregon Klamath Province from USDA & USDI 1994): “There is no harvest allowed in stands over 80 years old (110 years in the Northern Coast Adaptive Management Area). Thinning (precommercial and commercial) may occur in stands up to 80 years old regardless of the origin of the stands (e.g., plantations planted after logging or stands naturally regenerated after fire or blowdown). The purpose of these silvicultural treatments is to benefit the creation and maintenance of late-successional forest conditions.” Procedures for exception to the rule do exist. They require an appeal to the Interagency Team that oversees implementation of the NWFP. Relatively few appeals have been made or granted.

Origin of the 80-Year Rule

The emergence and first consideration of forests greater than 80 years of age, as a grouping of forest conditions, occurred during the work of the Scientific Panel on Late Successional Forest Ecosystems, also known as the “Gang of Four” (Johnson et al. 1991). This group was paneled by two congressional committees to map and characterize the “old-growth forests” of the Pacific Northwest.

During initial discussions of this task, several forest ecologists identified naturally regenerated mid-aged forests as potentially important habitat for many late-successional species. These stands had originated following wildfire and windstorm during the 19th and very early 20th centuries, some from single burns and some from multiple burns. These stands often had substantial structural complexity as a result of legacies of live trees and snags and logs that persisted following the disturbance. They were typically dominated by maturing Douglas-fir and often had a developing understory of shade-tolerant tree species.

Ultimately the 1991 scientific panel developed a category of “Late Successional/Old Growth” (LS/OG) that incorporated all stands >80 years of age. The 80-year parameter was chosen so that stands that originated in the 1902 wildfires were included in the analysis; field work by Jerry Franklin and Tom Spies in the 1902 Yacolt and Siouxon Burns had shown that many of these stands had significant structural complexity and potential habitat value.

Subsequent science and management panels continued to recognize the larger category of LS/OG forests in considering the structurally- complex forest population important to late-successional

species, including the use of 80 years as an initial point for consideration (FEMAT 1993). Forest stands that had reached that stage in development were viewed as likely to have achieved significant structural complexity, often including disturbance legacies, and much less likely to benefit from silvicultural treatments than young stands.

Subsequent research has significantly improved our understanding of coniferous forest stand development in the Douglas-fir region (Franklin et al. 2002). Stands typically begin to transition from a youthful stage of rapid growth and competitive mortality to maturity at 80 to 100 years of age. Over the next 100 or so years, stands gradually take on more and more late-successional attributes before attaining the structural complexity of old-growth forests. Today most ecologists refer to these stands as “mature” or “mid-successional” rather than “late-successional.”

Current Functioning of the 80-year Rule

Based on our field-trip discussions with field managers, we conclude that the 80-year rule both restricts and protects agency discretion.

The rule channels agency actions toward younger stands, especially plantations where a case can easily be made for actions to increase structural diversity. Currently, federal forest managers generally limit harvesting in LSRs to stands less than 80 years of age in the West Cascades. Requests for exceptions have been relatively rare in Oregon and Washington, at least in part because of the need for an exception to be granted.

The rule also protects agency discretion. Increasingly agencies are attempting to develop watershed-level environmental assessments that cover multiple thinning projects. This reduces unit costs and insures that projects incorporate a watershed perspective. Such an approach is premised on the belief that none of the individual projects will be successfully challenged so as to halt the entire effort. The 80-year-rule helps to clarify what agencies can include in these projects with the expectation that they will be successfully implemented. Changing from the age criterion to a structural criterion, which theoretically might be desirable, could open all stands, including plantations, to challenges as to whether they meet the criteria, through appeal of the NEPA project analyses and resulting lawsuits, negating the efficiencies gained by the watershed approach.

The agencies' management personnel consistently indicated that their highest priority is thinning plantations 20 to 60 years of age. This is where their activity is likely to have the most impact on stand development. The 80-rule is not preventing that action. Rather, the agencies lack sufficient budgets to do all the work that is needed.

Why Allow Harvest in Stands Over 80 Years of Age in LSRs?

The primary objective of the LSR system is to provide for a viable network of late-successional forest ecosystems. Within this larger objective, one LSR management goal is restoration and maintenance of larger contiguous blocks of late-successional forests in landscapes that were previously fragmented by logging. Hence, the NWFP provided for silvicultural treatment of young stands to accelerate their structural development, particularly of dense plantations.

Most existing stands over 80 years of age are of natural origin. These stands vary widely in their degree of compositional and structural development for many reasons, including site productivity, composition and density of initial stand, subsequent disturbance, availability of shade-tolerant trees, and the nature of the non-arboreal understory. In any case, some natural stands are significantly slower than average in developing attributes of mature and old-growth forests. The deficien-

cies may involve one or many attributes that characterize old-growth forests, including large-diameter trees and a significant component of shade-tolerant tree species.

Consequently, silvicultural treatments have been proposed for stands that exhibit slow rates of structural development. A variety of different prescriptive approaches have been suggested including uniform thinning from below, variable density thinning, and tree-focused thinning to stimulate development of very large trees. Many of these proposals for treatment of natural stands >80 years old have been very controversial. Objections include: (1) probability that the stand will develop adequately on its own; (2) potential for interference with natural stand development processes; and (3) “pristine” nature of these stands (little evidence of the impact of humans).

It is also true that post-clearcut plantations that have been the focus of thinning in LSRs will increasingly approach 80 years of age. Thus, the 80 year rule, which was intended to limit actions in wild stands, may inadvertently alter treatment schedules for plantations.

Discussions with agency personnel suggest that the vast majority of stands that might benefit from thinning to accelerate late-successional structure were less than 80 years old, and of human origin--mostly plantations that were established after harvest in the last 50 years. These stands are the major focus of silviculture within the LSRs. While these stands currently can be thinned without restriction, because they are less than 80-years old, many young stands will soon exceed 80 years of age and fall under the restrictions of the 80-year rule.

Allowing field discretion in decisions on silvicultural treatments in stands of in young managed stand (plantations) after they reach 80 years of age could influence future activities in these stands currently less than 80 years of age, most of which originated from clearcuts. If silviculturists know that they can count on further entries in these stands they can plan treatment sequences that go beyond 80 years. A program of multiple entries might better achieve the LSR objective of moving these stands more rapidly toward desired structurally complex conditions than one that required all entries to be completed by 80 years. Therefore, we believe that the “80 year rule” for the plantations in LSRs on federal

Dry Forests that are now the focus of federal thinning should be reconsidered, perhaps allowing thinning in those stands up to 120 years of age. As discussed above, such an increase in maximum thinning age would mainly affect silvicultural activities 20-60 years from now.

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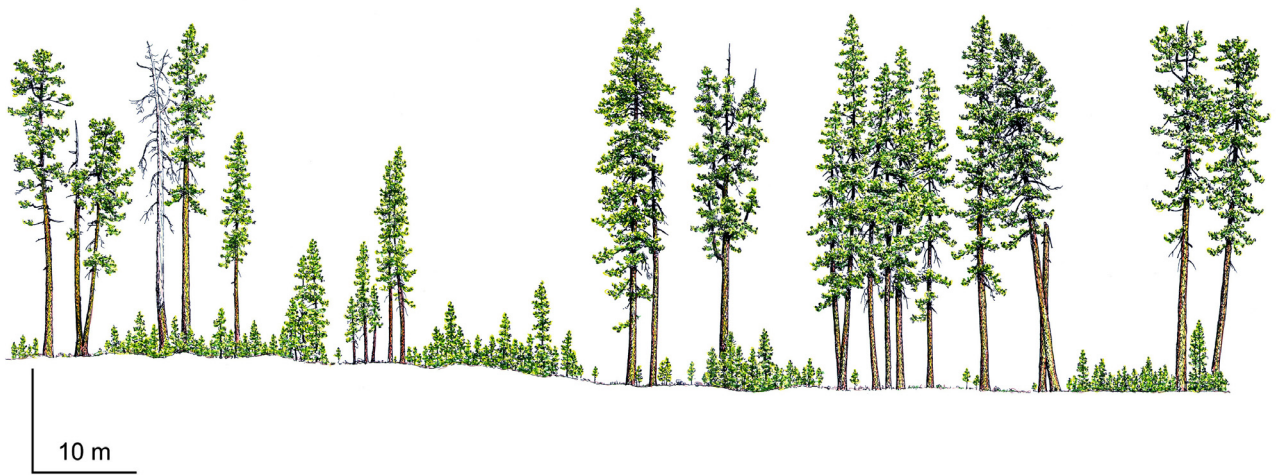
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OLD-GROWTH FORESTS

Dry



Moist



Structural cross sections illustrate the structural heterogeneity of different forests: (top) Dry Forest: old growth ponderosa pine stand in southeastern Oregon (Blue Jay Springs Research Natural Area, Winema National Forest); (bottom) Moist Forest: old growth, 650-year old stand of Douglas-fir, western redcedar, and western hemlock in the southern Washington Cascade Range (Cedar Flats Research Natural Areas, Gifford Pinchot National Forest). Old growth forests typically have complex structures, including heterogeneous spatial arrangements as well as diversity of individual structures. Two aspects of this spatial complexity are: 1) vertical distribution of foliage, often apparent as multiple layers and 2) horizontal heterogeneity, often evident as canopy gaps and dense reproduction patches. Shifts in mortality processes from competitive-based mortality in young stands to agent-based mortality (i.e., insects, diseases, wind) in older stands play an important part in the development of structural heterogeneity. Old temperate forests can be viewed as fine-scale mosaics in which all stand development processes are simultaneously present within the stand (Franklin and Van Pelt 2004). (Drawings used with permission of Bob Van Pelt.)

DRY FORESTS

Eastern Oregon and Eastern Washington



Many ponderosa pine forests consisted of fine-scale structural mosaics and were dominated by 10 to 20 large, old trees/acre; this ponderosa pine stand illustrates some of that diversity including the dominance of the old pines and an opening that is dominated by reproduction of ponderosa pine (Yakama Indian Reservation, Washington).



Old-growth ponderosa pine stand illustrating the historically characteristic open structure of these forests, dominance of large old trees, and relatively low levels of smaller diameter trees. This stand, which is on a site characterized by the Ponderosa pine/Bitterbrush plant association, also has a dense understory of the important deer and elk browse species, bitterbrush; restoration and maintenance of ecologically desirable understory conditions is an important objective in restoring these Dry Forest sites. The primary need in this forest is restoration of low-severity fire but it needs to be accomplished with care for the fire-sensitive bitterbrush, which generally does not sprout when burned (Winema National Forest, Oregon).

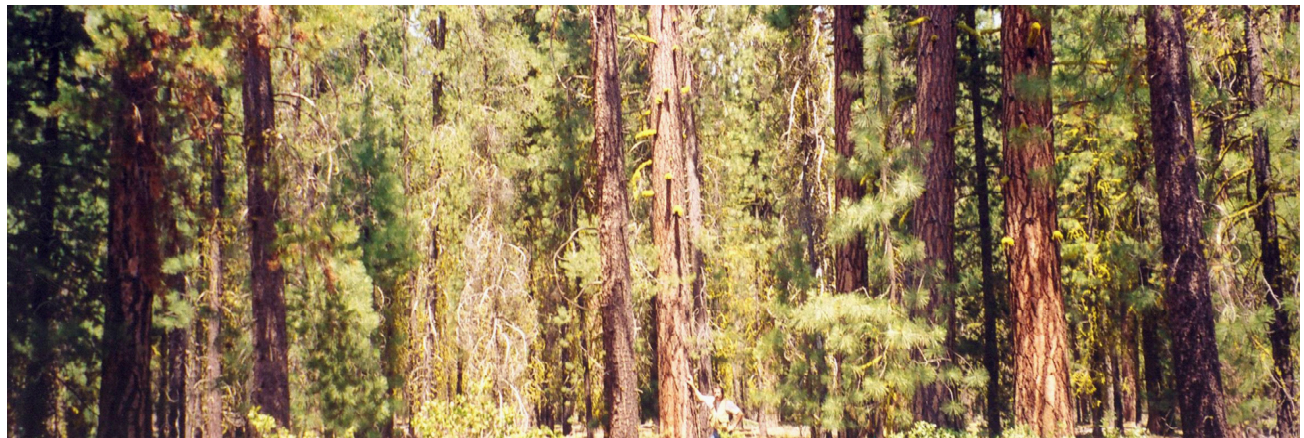
DRY FORESTS

Complex ponderosa pine

Eastern Oregon



One important reason for using age-based rather than size-based criteria for retention of trees in Dry Forest is that many old ponderosa pine and western larch trees are less than 21 inches in diameter at breast height (dbh) and, therefore, vulnerable to timber harvest under current rules; in this stand pictured here more than half of the old-growth ponderosa pine are less than 21 inches dbh (stand on Winema National Forest).



Many Dry Forests currently have dense accumulations of surface, ladder, and crown fuels that put these forests and the remnant old trees that they contain at high risk. A pure ponderosa pine stand on Ponderosa pine/Bitterbrush site approximately 90 years after partial cutting and after over a century of fire exclusion. The human figure at the lower front of both pictures provides the scale. Restoration of such sites begins with removal of ground and ladder fuels and completing vegetation from the vicinity of the old ponderosa pines (Winema National Forest, Oregon).

DRY FORESTS

Simplified ponderosa pine

Eastern Oregon



Many Dry Forest stands have been converted to dense young forests with highly simplified structures and high potential to carry crown fires; these have been created both by so-called “overstory removal” (where the overstory of old trees was removed) and purposeful creation of dense plantations following harvest (Winema National Forest).

DRY FORESTS

Ponderosa pine/Douglas-fir

Eastern Washington



Contrasting forest conditions on Meeks table Research Natural Area, a small plateau that was never subject to grazing by domestic livestock. Top: Classic open ponderosa pine stand with pinegrass understory. Bottom: Dense patch of pine and Douglas-fir with concentration of live and dead fuels. (Wenatchee National Forest, Washington).

DRY FORESTS

Mixed Conifer

Eastern Oregon



Human activities during the last 150 years – including fire exclusion – have grossly modified many of the Dry Forests on the eastern slopes of the Cascade Range in the Pacific Northwest; growth of the fire-sensitive white fir in this stand has created dense ladder fuels and intense competition around the veteran ponderosa pine trees that are still present. The old-growth pine, which are the structural backbone of the Dry Forest, are at greatly increased risk of death from both high-severity fire (due to the fuels) and bark beetle attack (due to the competition). Ecological restoration of this site should begin with elimination of the fuels and competition provided by these young (<150 year) white firs. (Winema NF, (top) and Ochoco NF (bottom)). Similar photos of stand conditions in the national forests of the Blue Mountains can be found in Johnson et al. 1995.

DRY FORESTS

Western Larch

Eastern Washington

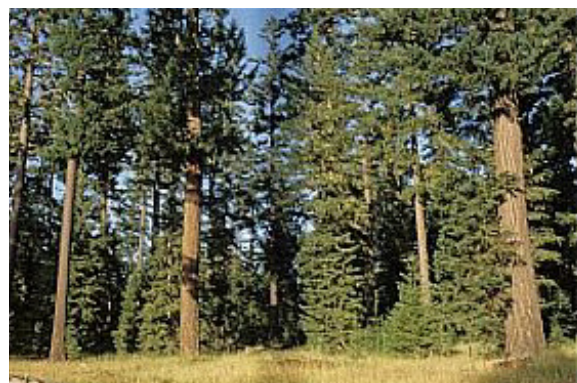


Western larch is a deciduous conifer similar to ponderosa pine in its resistance to wildfire. Two portions of an old-growth western larch stand are illustrated here. Top: stand that was historically dominated by large, old trees at low density (bare trees in photo) but is now overgrown by a dense stand of Engelmann spruce and grand fir as a result of fire suppression. Bottom: stand exhibiting historic structure of open, larch-dominated stand (trust land managed by the Washington Department of Natural Resources near Ellensburg).

DRY FORESTS

Ponderosa pine

Southwest Oregon



Threats to old growth in the dry forests of southwest Oregon—Old growth trees are threatened by a build-up of understories in the dry forests of Southwest Oregon (upper right and left). Large old pines and Douglas-fir historically dominated many sites near Medford and Grants Pass but now face competition from dense understories. BLM did an “understory removal” 20-30 years ago in these types of stands (lower left and right). Work by Latham and Tappeiner (2002) on those sites showed that the big, old (over 200 –300 yr) Douglas-fir and ponderosa pine increased their basal area growth after logging. Thus, we might conclude that the understory was competing with the old trees—potentially a serious effect in time of drought. Additional treatment will be needed in the next few decades to keep the understory in check. (Source: John Tappeiner, Judd Lehman, and James Johnston.)

DRY FORESTS

Hardwoods

Eastern Oregon



Restoration of hardwood trees and shrubs is also an important objective in Dry Forests. Aspen stands have been invaded and suppressed by ponderosa pine and lodgepole pine (upper left) as have willow communities (upper right). Silvicultural treatments (prescribed fire/harvest) can substantially replicate the effects of wildfire in restoring aspen (lower left) and willow (lower right) as well as other shrubs and hardwood trees as long as ungulate grazing (especially elk and cattle) is controlled. (Winema National Forest, Oregon).

DRY FORESTS

Wildfire/Insect Outbreaks

Eastern Oregon and Eastern Washington



Maintaining large contiguous blocks of suitable Northern Spotted Owl (NSO) nesting, roosting and foraging habitat does not appear to be a sustainable strategy in Dry Forest landscapes due to risks of extensive high-severity wildfires and insect outbreaks: (top) The B&B Fire Complex in the central Oregon Cascade Range consumed nearly 100,000 acres of suitable habitat in a single event and followed many years of Spruce Budworm defoliation (Deschutes National Forest, Oregon); (bottom) Heavy defoliation and mortality caused by Spruce Budworm in dense grand fir-dominated stand (Okanogan National Forest, Washington).

DRY FORESTS

Wildfire

Eastern Oregon



Abundant ladder and ground fuels resulted in death of all trees including old-growth ponderosa pine in a wildfire event; restoration treatments in such stands can dramatically reduce the risk of fire behavior that kills large, old pines. (Toolbox fire; Winema NF).

DRY FORESTS

Wildfire

Eastern Oregon

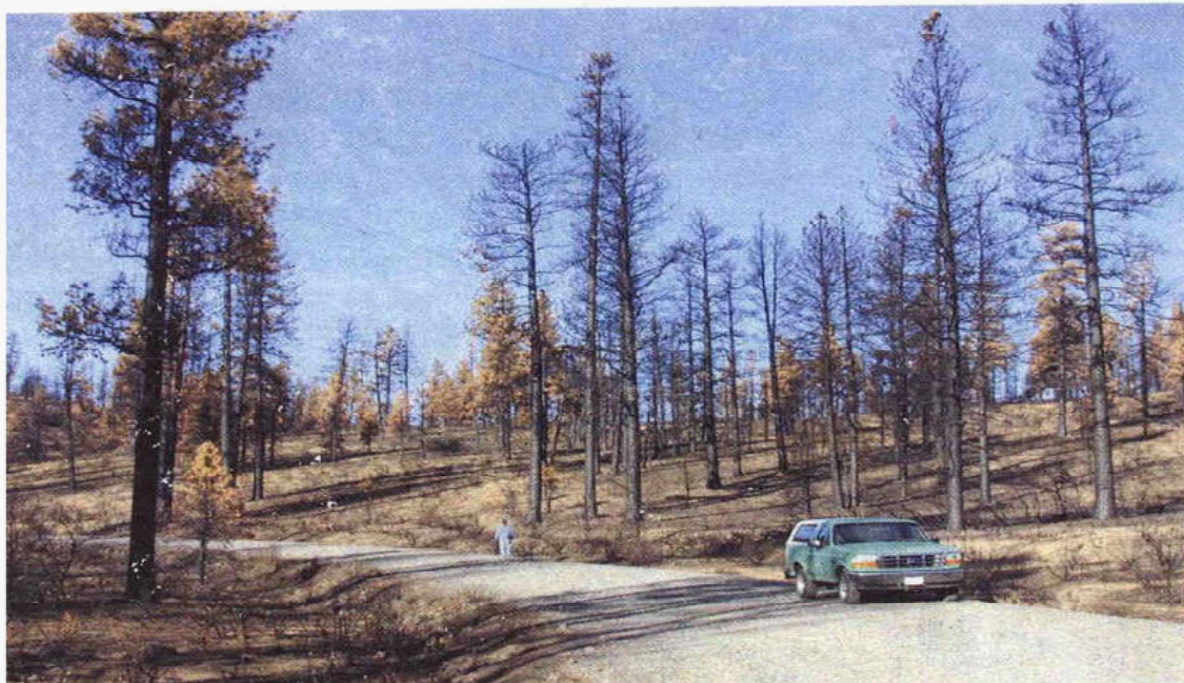


photo: U.S. Forest Service, Skunk Fire Environmental Assessment

Shrubs (surface fuels) left to grow for decades without fire can create long flame heights when they do burn. This can torch and kill over-story trees even in low-density stands. These phenomena argue both for the careful consideration of the effect of silvicultural treatments on shrubs and for the reintroduction of fire, on a regular basis, so that these conditions do not develop. (Skunk Fire, 2002.)

DRY FORESTS

Mixed Conifer

Sierra Nevada, California, and Eastern Oregon



Many ecologically-diverse mixed-conifer old-growth forests have been clearcut and regenerated with dense pine plantations; establishing dense plantations on Dry Forest sites creates the potential for future stand-replacement fires and ensures that structurally complex stands will require a century or more to redevelop; Jeffrey pine plantation established following clearcutting (Sierra Nevada Range, California).



Sometimes all the pines were removed leaving only the white fir understory. This understory will grow into dense stands susceptible to wildfire and insects.

DRY FORESTS

Treatments

Eastern Oregon



Prescribed burning is an important element in restoration and long-term management strategies for the Dry Forest stands; in some cases, prescribed burning may be a sufficient treatment in itself when initiating efforts to restore more sustainable structure and composition but, more often, it will be necessary to reduce fuel loadings that include activity fuels created by silvicultural treatments. Great care is required in restoring fire to forest stands that have been free of fire for many decades or even a century or more, particularly where old trees are a part of the stand. Protective measures around old trees—such as raking and/or creation of protective fire trails around trees—will often be needed to prevent significant mortality in the old trees. Top: Prescribed fire at Black Butte, Deschutes NF (Source Brett Cole (left) and James Johnston (right)). Bottom: A stand after prescribed fire at Black Butte (left) and old tree mortality after prescribed fire at Blue Jay Springs, Winema NF (right).

DRY FORESTS

Treatments

Southwest Oregon



Hazardous fuels reduction in the Applegate Watershed of southwest Oregon. Both the Forest and the Bureau of Land Management are using a variety of tools to reduce stand densities in southwest Oregon—prescribed fire (upper photos), commercial harvest (bottom left), and mechanical reduction of understory fuels (bottom right). Both types of mechanical treatments produce “activity fuels” that are often piled and burned; prescribed fire often follows mechanical treatment. Treatments will need to be repeated in the future as fuels build up again. (Photo source: Ed Burns and Jack Shipley)

DRY FORESTS

Treatments

Eastern Oregon



Thinning to restore forests can also provide sawlogs, pulpwood, and biomass. Often whole tree logging is utilized with the top and branches cut off at the landing. Without a pulp and biomass market, piles of tops and branches are often burned on site.
(Photo source: Loren Kellogg)

DRY FORESTS

Eastern Washington



Restoration of Dry Forests has to be planned and carried out at landscape spatial scales in order to be effective; it cannot be accomplished by treating individual forest patches in isolation or by the use of fuel breaks, although these can contribute to restoration efforts if planned and implemented as part of a more holistic landscape design. An exemplary Dry Forest landscape is illustrated here on trust forest lands managed by the Ellensburg WA office of the Washington Department of Natural Resources.

Western Washington



Old-growth stands on Moist Forest sites exhibit high levels of structural complexity and provide many ecosystem functions better than young forests, such as in influencing snow hydrology, including rain-on-snow storm events. Trees visible in this canopy photo are predominantly old Douglas-firs (heavily branched with large intercepted snow load) and western redcedar (more finely branched co-dominant trees) (Wind River Experimental Forest, Gifford Pinchot National Forest, Washington).

Western Washington



Coarse wood in the form of downed boles are important structural elements of all natural forest stands, including the old-growth Douglas-fir—western hemlock stand shown here; such logs will typically persist for several centuries as they undergo gradual decay and serve numerous functions, including critical habitat for the majority of animal species (Ashael Curtis Nature Trail, Mt. Baker Snoqualmie National Forest, Washington).



Old-growth forest ecosystems demonstrate high levels of spatial heterogeneity in structure, including levels of canopy closure and understory development; old-growth Sitka spruce—western hemlock forest in the South Fork of the Hoh River drainage, Olympic National Park, Washington.

MOIST FORESTS

Water/large wood

Western Oregon



Forests and streams are highly integrated components of PNW forest landscapes. Coarse wood is a critical structural element of streams and river ecosystems.

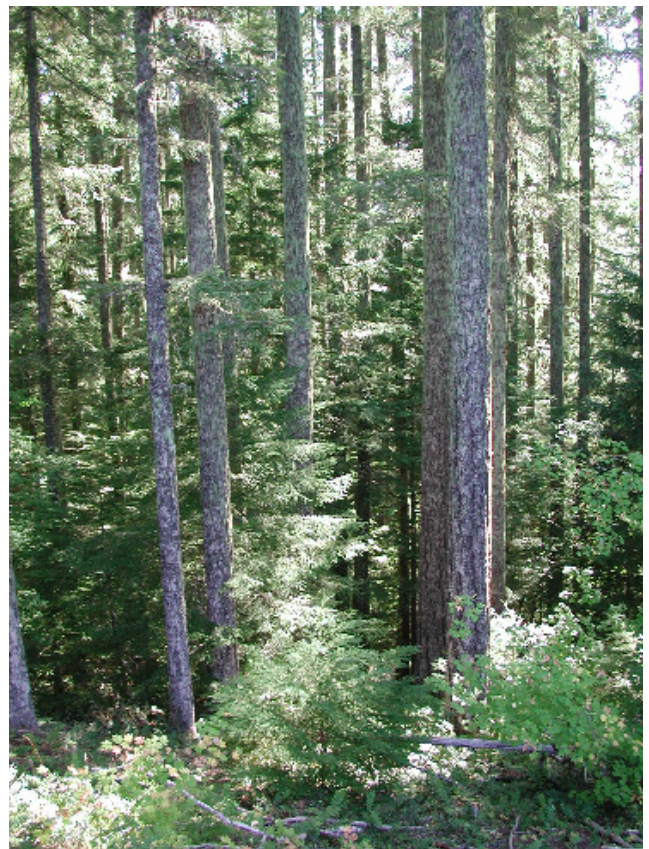
MOIST FORESTS

Old growth/mature

Western Washington and Western Oregon



Left: Old-growth Douglas-fir (Ashael Curtis Nature Trail, Mt. Baker-Snoqualmie National Forest, WA). Right: Mature Douglas-fir stand that established after a wildfire in 1845 (now 160+ years old); western hemlock are abundantly represented as saplings, poles and co-dominants in the overstory, i. e., a continuous canopy has developed from the ground to the top of the dominant Douglas-firs. H. J. Andrews Experimental Forest, Willamette National Forest, Oregon



MOIST FORESTS

Northern spotted owl

Western Oregon



The Northern Spotted Owl has been a flagship species for mature and old growth forests because of its requirement for diverse, structurally-complex forests for nesting, roosting, and (throughout much of its range), foraging habitat. The Northern Flying Squirrel is the primary prey species for the owl throughout the majority of its range. (Photo source: Dan Schafer)

MOIST FORESTS

80 to 120 year-old stands

Western Oregon



Under some management alternatives, regeneration harvests (using ecological forestry principles) would occur in 80 to 120 year old stands within the Matrix allocation of the NWFP; pictured here are two such stands dominated by Douglas firs in the Cascade Range (top) and the Oregon Coast Range (bottom).

MOIST FORESTS

Plantations and variable density thinning

Western Oregon and Western Washington

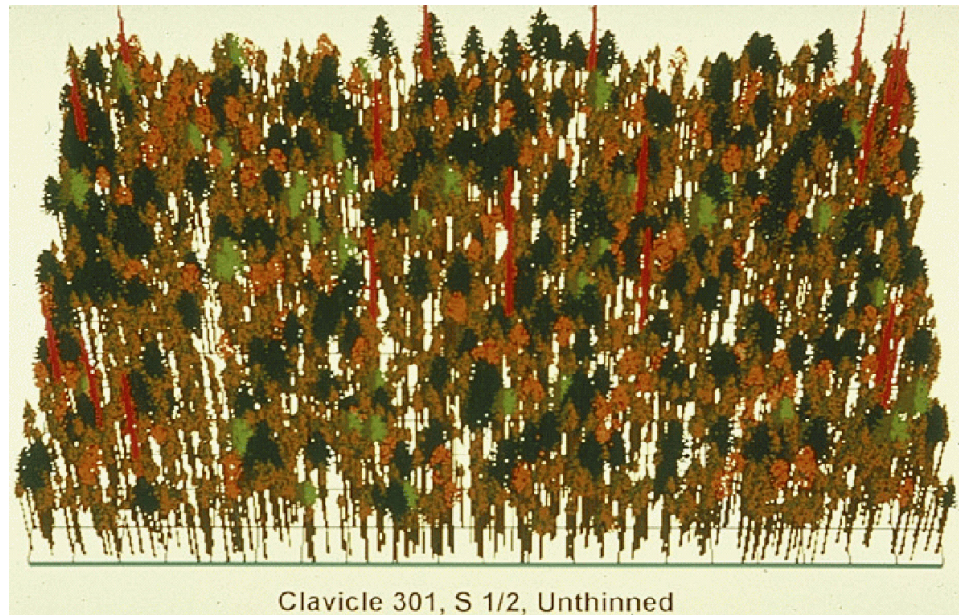


Hundreds of thousands of acres of young plantations exist throughout western Oregon and western Washington. Generally, they are dense and relatively uniform in structure. Variable density thinning and other silvicultural activities can accelerate development of structural complexity such as spatial heterogeneity, coarse wood, and larger trees. Left: view of canopy of plantation (Willamette National Forest); Right: internal view of young forest (Olympic National Forest).

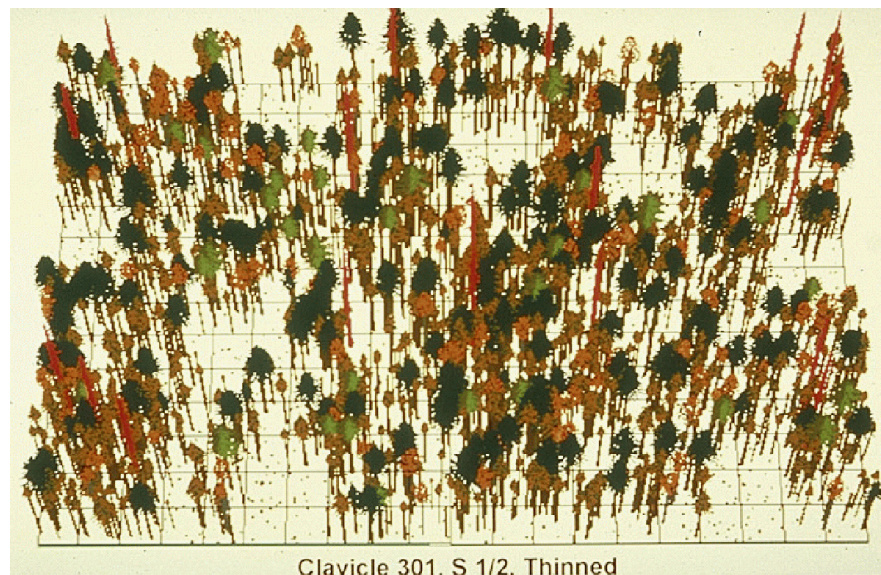


MOIST FORESTS

Western Washington



A competitive exclusion stage forest before thinning. (Olympic NF)



A competitive exclusion stage forest after variable density thinning.

Source: Andy Carey

MOIST FORESTS

Western Washington



Niche diversification multiple variable-density thinnings, Gifford Pinchot National Forest. (Photo source: Andy Carey)

MOIST FORESTS

Retention

Western Oregon



Regeneration harvest with 15 % dispersed retention of dominant Douglas-fir trees; dispersed retention is an effective way to insure that influences on microclimate, biodiversity, and ecosystem processes are well distributed throughout the harvest unit (Willamette National Forest, Oregon).

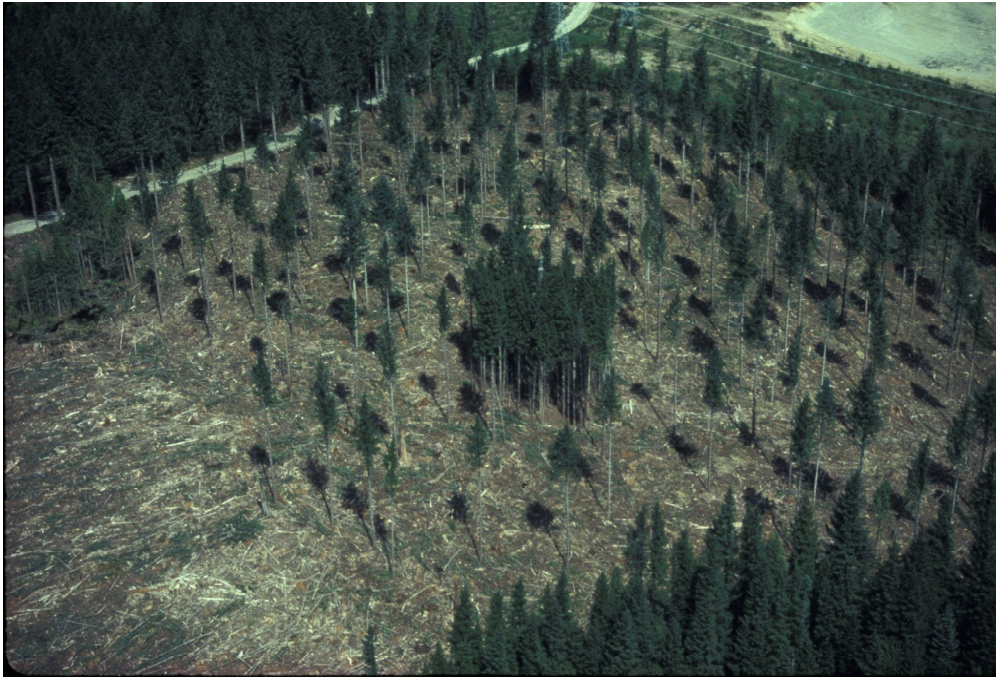


The same stand 15 years later.

MOIST FORESTS

Retention

Western Washington and British Columbia



Regeneration harvest using both dispersed and aggregated retention at a level of 15% of the original stand; many silviculturalists prescribe both dispersed and aggregated retention on harvest units to achieve a wider array of ecological objectives (City of Seattle Cedar River Municipal Watershed, Washington).



Variable-retention regeneration harvest unit with 15 to 20% of the area of the stand retained in intact aggregates; retention of aggregates are particularly effective at lifeboating a diversity of forest plant, animal, and fungal species until a new stand is re-established on the harvested part of the unit (land managed by Weyerhaeuser Company at the time of harvest on Vancouver Island, British Columbia, Canada).

MOIST FORESTS

Diverse early seral

Western Oregon and Western Washington

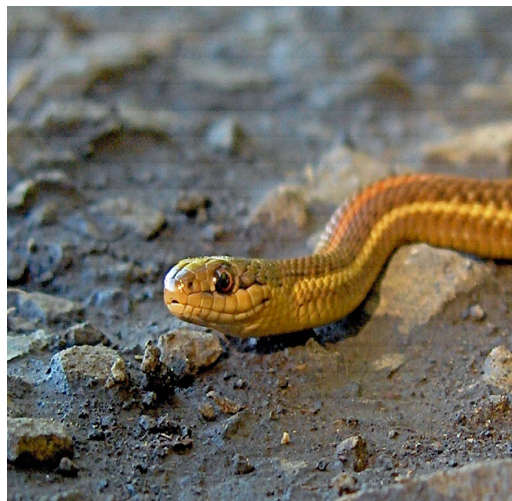
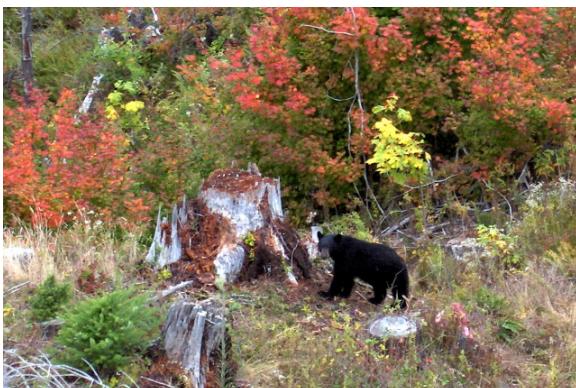


Early-successional or pre-forest communities that develop between a stand-replacement disturbance and re-establishment of a closed forest canopy have high levels of biological diversity and often structural complexity due to biological legacies carried over from the pre-disturbance forest (such as standing dead trees and logs): (top) Early successional community twelve years after a high-severity wildfire showing abundant regeneration of Douglas-fir but, also, a well developed shrub community of snowbrush (foreground) and vine maple (background) and an abundance of large snags, logs, and other coarse wood (Warner Creek Fire, Willamette National Forest, Oregon); (bottom) A persistent early-successional community dominated by a variety of plant life forms, including trees and shrubs, that has been maintained by repeated disturbance (Sawtooth Huckleberry Field, Gifford Pinchot National Forest, Washington).

MOIST FORESTS

Diverse early seral species

Western Oregon



Early successional communities on forested sites have high levels of biological diversity, including many species that require such environments (they are habitat specialists) or find conditions there optimal for their development. As pictured here these include many species of butterflies and moths, birds (such as many neotropical migrant songbirds and other species dependent upon snags), reptiles, ungulates (such as elk), and omnivores (such as bear). Key elements of the early successional communities are a diversity of plant life forms (including large shrubs) that provide diverse food sources and legacies of standing dead and down trees created by the disturbance that killed the previous forest. (Photo source: Steve Reed)

MOIST FORESTS

Legacy after wildfire

Western Washington



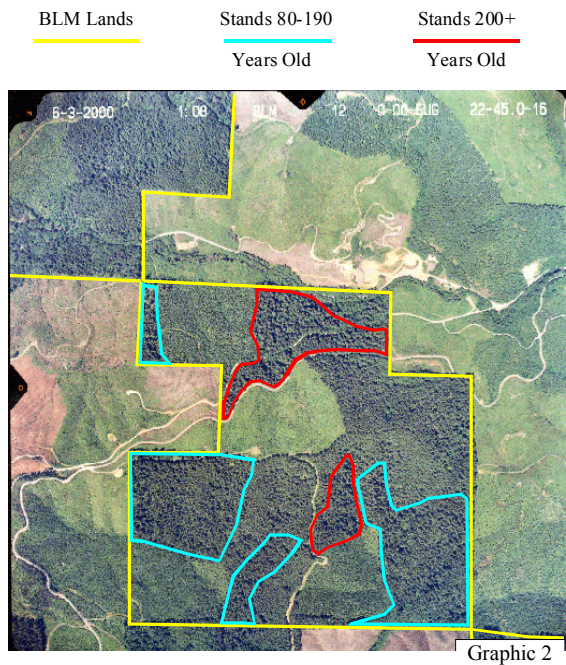
Dead wood legacies of natural disturbances can persist and sustain biological diversity and critical ecological functions for centuries, particularly when they are of species that have high levels of decay resistance; pictured here is a standing and nearly intact western redcedar snag (left foreground) and another recently fallen snag (right midground) that were killed over 105 years ago in the 1902 Siouxon Burn (Washington Department of Natural Resources-managed trust lands in Lewis River drainage, southwestern Washington).



High severity stand replacement fires are characteristic of the subalpine forests in eastern Washington and Oregon; pictured here is a burned subalpine fir stand at Harts Pass (Okanogan National Forest, Washington).

MOIST FORESTS

Western Oregon



Federal forest ownership and harvest patterns. a) National forest landscape on Willamette NF (top). The national forests cover large, generally contiguous forest. Harvest units on the Moist Forests display the dispersed “staggered setting” pattern—40-80 acre clearcuts scattered over the forest. Planting generally followed harvest resulting in plantations, many of these plantations are currently being thinned. Much of the intervening forest is over 160 years and would not be harvested under the options examined here. Therefore, long-term management of moist forests would be focused on the patchwork of young stands. Within the plantations, very few older trees remain; therefore, a rule that trees in the plantations now over a certain age (80-120,160) be reserved could easily be applied. b) BLM forest landscape on the Eugene District (Bottom). The BLM forests show a “checkerboard pattern”, with BLM sections alternating with private sections. Within the BLM checkerboard, the BLM also utilized a staggered setting approach and created plantations after harvest. BLM grouped the stands of its Eugene District into 20-year age classes as part of the development of its recent Western Oregon Plan. This information could be utilized to identify those stands over 80, 120, or 160 years of age.

