Habitat Conservation: Habitat & Forestland

A report developed for
www.biodiversitypartners.org and
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INTRODUCTION

"Forests support approximately 65 percent of the world's terrestrial [life forms]. They are the most species-rich environments on the planet, not only for vertebrates, such as birds, but also for invertebrates and microbes."

- Conserving Forest Biodiversity (Lindenmayer and Franklin, 2002)

Bursting with all that life, forests present immensely complex challenges for biodiversity conservation.

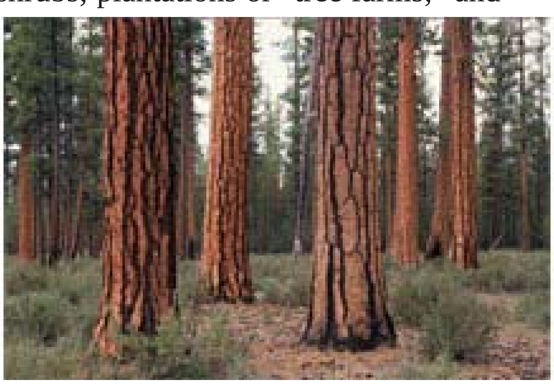
Our purpose with this report is to offer some of the concepts scientists are now using to frame how we think about conservation of forest biodiversity.

We start with a general discussion of forest biodiversity, the ecological processes that shape it, and the very small pieces that are so critical to how forests work. A second section explores some of the issues and challenges affecting forest habitats in the United States. The third major section introduces key concepts underlying some examples of biodiversity management strategies that have begun to emerge in recent years.

I. FOREST BIODIVERSITY

Just consider the immense variety of things we call "trees." They can range from seedlings to giants more than 300 feet tall, some thousands of years old. They come in a variety of life-forms: broadleaved, needle-leaved, evergreen and deciduous. Trees can provide important habitat benefits even after they die, whether still standing (snags) or fallen (logs). Some estimates suggest that about one-fourth of all forest wildlife depend on snags and logs.

The immense variety among trees is mirrored in the diversity of "forests," which the USDA Forest Service defines as lands that are at least 10 percent covered by trees and at least one acre in size. This includes areas in which trees are intermingled with other types of vegetation, such as shrubs; plantations or "tree farms;" and forests that are regenerating naturally after fire or timber harvest.



Open stand of Ponderosa pine. Photo by Tom Iraci for Pacific NW Research Station.

Conservation biologists often describe forests in terms of their structure and functions, which are shaped in part by a variety of dynamic forces - both natural and human related - collectively referred to as disturbance regimes. But forests also encompass a largely unseen world of species and processes that are absolutely critical to the function of these ecosystems.

About the Forest Biodiversity chapter

Forests, in all their variety, provide benefits to biodiversity and management opportunities and challenges that are sufficiently different from other ecosystem types to merit separate consideration.

The material here emphasizes considerations at a landscape scale (typically of at least a few thousand acres), but many of the principles discussed can be scaled up or down, and individual landowners should be able to find some useful suggestions relevant to smaller ownerships.

Readers may detect a bias to examples from the West and Pacific Northwest, which reflects the both the authors' knowledge and the fact that much of the most innovative landscape-scale planning has occurred in these regions. We attempt to acknowledge examples from elsewhere, and believe the principles discussed here are broadly applicable. We also welcome suggestions about examples from elsewhere in the country that we can incorporate as the website is revised and updated.

II. FOREST STRUCTURE AND FUNCTION

In ecological terms, forests can be structurally simple and uniform or highly varied and complex. The structure of a forest and its position in the larger landscape directly affect its ecological functions, including how well it works as habitat for different species.

Some forest stands consist of a single layer of overstory trees forming a canopy with few trees in the understory (ponderosa or long-leaf pine), but more commonly they are comprised of multiple types, species, ages and sizes of trees. Snags and logs of various sizes and states of decay, along with shrubs and herbaceous vegetation, all add to the complexity and habitat value of a forest stand. As a general rule (subject, of course, to many exceptions), greater complexity within a forest stand will provide a greater variety of habitats and thus support more diverse wildlife.

Fallen trees supporting new growth.
Photos by Rick Brown.

The size or extent of a stand, along with its landscape setting (context), further influence its habitat value. No matter how rich and complex a forest stand may be, if it's small and surrounded by recent clearcuts, agricultural land or residential development, it will provide poorer quality habitat for species associated with complex old forest habitat than a similar stand surrounded by extensive mature and old-growth forests. Habitat degradation of this sort can be a result in part of "edge effects" that allow wind and light to modify microclimates or allow competitors or predators associated with more open habitats to have detrimental effects on forest residents. Habitat value can also be diminished by isolation if surrounding environments prevent population or genetic replenishment by movement of wildlife from other forested areas.

Natural forest landscapes are often a "mosaic" of stands of varying sizes and ages, which adds variety and complexity at another scale, again generally supporting a greater diversity of wildlife than, for instance, an extensive industrial forest of few tree species in a limited range of ages.

These structural characteristics of forests in turn relate to how the forest functions, that is, how effectively does it convert sunlight, carbon dioxide, and water to wood and other living matter (biomass)? How does it influence runoff of water and streamflow? How well are nutrients cycled and soils built and maintained? What habitats does it provide, and how do the wildlife it supports in turn influence forest structure, which in turn affects forest function. One can quickly gain an appreciation for ecologist Frank Egler's observation that ecosystems are not only more complex than we think, they are more complex than we can think.

Above: B & B fire in central Oregon, 2003. Photo by Tom Iraci, PNW Research Station. Below: Walking through trees killed by severe fire. Photo by Rick Brown.

DISTURBANCE REGIMES

Disturbances are generally defined as events and processes that kill or remove substantial portions of trees in a forest: wind, flood, landslides, insect and disease outbreaks, and fire. The term disturbance "regime" is most commonly associated with fire, which often has a fairly predictable severity, season of occurrence, interval between events, extent, etc. in a given region and forest type. These can then be referred to as, for example, a frequent, low-severity fire regime, typical of ponderosa pine in the West or long-leaf pine in the Southeast. Thick, fire-resistant bark allows these species to persist despite frequent fires that historically thinned out smaller trees and shrubs, producing stands described as open and park-like, dominated by older pines.

In more moist areas, infrequent, high-severity fire may kill all or nearly all the trees in a given area. Despite lurid coverage on the nightly news, forests are not "consumed" or "destroyed" by fire. Even when all the trees are killed, it's more accurate to say a forest has been changed by fire (albeit changed rather dramatically from our perspective). Forest soils and biological legacies (including dead standing trees [snags], logs, seeds, living underground rootstocks, and many animals) persist and contribute to the growth and renewal of the green stands that we more readily recognize as a forest.

This total mortality is what some advocates of intensive timber management have in mind when they claim that clearcutting mimics fire. What this analogy overlooks is that fire doesn't remove trees, nor does it build roads, mechanically disturb soils or spray colonizing ("competing") shrubs with herbicides. Modified "clearcuts," with irregular borders and retained biological legacies such as snags, logs and large green trees, more closely approximate the effects of a high-severity fire.

Many scientists have suggested that management that mimics or approximates natural disturbance regimes is more likely to maintain the ecological functions, habitat quality and biodiversity benefits we seek.

This mimicry can take place at the stand level, where it will influence selection of a silvicultural approach, ranging from selectively cutting individual trees, to small patch cuts, to large "clearcuts" covering tens to hundreds of acres. These choices would also influence the frequency with which a manager would return to an area; in general less extractive approaches such as selective logging would require returning to an area every few years, whereas as much as a few hundred years might pass before an area would be "clearcut" again.

LITTLE THINGS THAT RUN THE WORLD

Renowned biologist E. O. Wilson coined the phrase "the little things that run the world" to describe the bacteria, fungi, insects and other invertebrates - all the generally inconspicuous, uncharismatic and often-overlooked small organisms - that are absolutely essential to the proper functioning of ecosystems.

Forest millipede. Photo by Rick Brown.

Brilliant yellow slime mould. Photo by Rick Brown.

Warty jumping-slugs *(Hemphillia glandulosa)*. Photo by Bill Leonard for the Pacific NW Research Station.

Puget oregonian snail *(Cryptomastix devia)*. Photo by Bill Leonard for the Pacific NW Research Station.

We understandably focus on the trees and larger wildlife in a forest, but it's important to remember that, for all the awesome splendor of a 500-year old Douglas-fir or the eerily silent swoop of a northern spotted owl, the persistence of the forests we value is probably more dependent on the almost incomprehensibly rich variety of tiny living things residing in or on the soil of the forest.

One-half or more of the total photosynthetic production of trees ends up below ground and ultimately serves as an energy source to support the countless soil creatures that run the forest world. Ensuring the integrity of soils is essential to the long-term conservation of forest ecosystems.

III. HABITAT LOSS AND DEGRADATION

FORESTS IN THE UNITED STATES

A 2002 publication by the Heinz Center, *The State of the Nation's Ecosystems*, provided an invaluable snapshot of the forests of the United States and the biological diversity these habitats support:

Forests cover almost 750 million acres, about one-third of the U.S., down from about one billion acres at the time of European settlement. The amount of forest land has remained relatively stable in recent decades, but forest types have shifted in some areas.

About 20 percent of some 1,700 native animal species that depend on U.S. forests are considered to be at risk, and almost half of those are considered critically imperiled or imperiled. About 1.5 percent of forest species may already be extinct.

Chattahoochie National Forest in Georgia.
Photo courtesy of Georgia.gov.

Grizzly bear. Photo by Hank Fischer.

Most at-risk forest species are vulnerable largely because of habitat loss and degradation, much of it related to human activities, ranging from conversion to non-forests for urban and agricultural uses to invasion by non-native species and fire exclusion.

About three percent of eastern forests and 11 percent of the forests in the West were in "reserved lands" such as wilderness areas and national parks, where timber harvesting is prohibited by law. Intensively managed plantations accounted for four percent of western forests and 10 percent of forests in the East. However, the pervasive risks of biodiversity loss increasingly have shifted conservation biologists' thinking away from traditional "reserve / non-reserve" concepts toward broader biodiversity management strategies across the full range of ownerships and landscape allocations.

At the same time, public policy makers are increasingly recognizing that biodiversity benefits associated with healthy forest ecosystems extend far beyond the edge of the trees. Forests are the principal source of most of the nation's drinking water and have a profound effect on hydrology, air quality, and climate. Their economic, recreational, and aesthetic values are closely linked to the quality of their natural systems.Adverse effects on forest biodiversity can come from a variety of sources, including forest management

Conversion of Forestland to Other Uses

One of the most obvious and dramatic is the conversion of forest land to other uses such as development (dwellings, etc.) or agriculture, which will generally render the land uninhabitable by forest-dwelling species.

Such changes can have influences beyond the absolute decrease in forested acres. Often, development proceeds in a way that creates a patchwork of forested areas and developed/ converted areas. The remaining forest "fragments' may be too small and isolated to provide full habitat benefits.

Roads

Roads contribute to fragmentation if they are a barrier to movement among forested areas. Roads can also facilitate the spread invasive species, including plants, diseases and harmful insects. Unfortunately, many invasives can spread quite effectively even in the absence of roads - consider the chestnut blight that effectively eliminated the American chestnut from vast expanses of the eastern forest where it had previously been a dominant species.

Parcelization

Another trend that can contribute to forest fragmentation is "parcelization," the breaking up of contiguous forest land ownerships into ever smaller ownerships. Not only does this make it more difficult to strategically manage the larger area for a variety of values, each owner may want to build a residence or otherwise develop their parcel, furthering the trends of forest loss and fragmentation.

Development

A U.S. Forest Service study, Forests on the Edge: Housing Development on America's Private Forests published in June 2005 projected dramatic increases in housing development over the next three decades on more than 11 percent of the nation's private forests, more than 44 million acres. The agency estimates that private forests in the Southeast, where three-quarters of all U.S. private forests are located, will experience the most extensive changes. Forestland development pressures will also be high in parts of the Northeast, the Pacific Northwest and California.

Forest Simplification or Homogenization

Intensive forest management often involves simplification or homogenization of forests that can reduce the diversity they support. Plantations of one or a few species, managed on short rotations, never develop the variety of tree species, ages and sizes, and snags and fallen logs, that are typical of natural forests. While this can lead to decreased diversity in these intensively managed stands, enhanced timber production from such forests can, at least theoretically, reduce the need to extract timber from other, more sensitive areas, allowing less intensive, more biodiversity-friendly management on these other lands. The challenges are to ensure that such trade-offs actually occur and that allocations are made strategically to optimize production of both timber and biodiversity.

Fire Exclusion

Exclusion of fire in some forests - typically drier types that were historically maintained by frequent, low-severity fires - can have detrimental effects on biological diversity and forest sustainability. Frequent fires historically maintained Ponderosa pine forests in the West and long-leaf pine in the Southeastern United States in an open, park-like, predominantly old growth condition. Long-leaf pine has been extensively converted to plantations of other

About Management

Management is a term that seems open to widely varying interpretations.

For us, the essence of management is that it is informed and intentional. If one has a reasonable level of knowledge of an area of forest and how it functions, has objectives that are consistent with the ecological capacity of the land, and treats the land in a way that has a reasonable likelihood of achieving those objectives, then that treatment can legitimately be called management. Active management employs manipulation of one or more elements of the forest ecosystem (cutting trees, setting prescribed fire, etc.); passive management allows natural processes such as growth, mortality or succession to achieve objectives. Management can be contrasted with neglect or abuse, treating (or ignoring) the land without understanding how it works or without clear objectives that the land can sustainably provide, potentially losing crucial ecological elements or functions.

species. Millions of acres of ponderosa pine on National Forests have been altered by combinations of high-grade logging and fire exclusion. Dense stands of smaller trees that have grown up in these forests pose a risk of uncharacteristically severe (crown) fires and compete with remaining old pine trees for moisture and nutrients, putting them at greater risk of being killed by insects or disease. Even without crown fire or death of old pine trees, these changes in forest structure and composition will lead to changes in populations of wildlife and plants, often to the detriment of species of conservation concern.

Chestnut blight *(Endothica parasitica)* starts as trunk swelling, splitting of the bark and cankers. The cankers cause girdling and death. Photo courtesy of the Environmental Protection Agency.

Clearcuts creating a fragmented forest. Photo by Rick Brown.

IV. HABITAT AND FORESTLAND: BIODIVERSITY MANAGEMENT STRATEGIES

Although humans have been actively managing forests for production of food and other forest products for thousands of years, it's only recently that biodiversity conservation has begun to receive much consideration by forest land managers.

The traditional approach to conservation of forest habitats and species has focused heavily on establishment of reserves, where timber harvest, road-building and other human activities are prohibited or severely restricted. The vast majority of these forests in the United States are public lands specially designated to protect their natural values, such as parks and wilderness areas.

But most of these reserves encompass less productive forests found at higher elevations, often in rugged terrain that made them inaccessible or less attractive for timber harvest and development. Many of the most productive and biologically diverse forests are in private ownership and - like most public forests - are largely managed for commodity production.

Given the inadequacy of existing reserves, and the limited prospects for significant additions to the current conservation network, many conservation biologists are increasingly looking to the broader landscape for options to help conserve forest biodiversity.

Rather than viewing forests as "protected" or "unprotected", this approach considers biodiversity management on a continuum, ranging from strict conservation management at the high end to minimal conservation value at the low end. Although large, ecologically intact reserves remain a cornerstone of most conservation strategies, more modest changes in management that effectively move lands to higher levels on the biodiversity management spectrum can make important contributions as well.

Biodiversity management strategies can be applied at a variety of scales. Large regional or landscape-scale strategies like the federal government's Northwest Forest Plan, which extends across three states within the range of the northern spotted owl, focus heavily on land use allocations to protect a diversity of habitat types and species.
Site-level management strategies typically

emphasize specific management techniques, often within the context of on-going commercial timber production, to create landscape conditions targeted to support specific elements of biodiversity.

LANDSCAPE-LEVEL MANAGEMENT STRATEGIES

The most ambitious example of a landscape-scale plan for conserving forest biodiversity is the Northwest Forest Plan, designed for federal public lands managed by the Forest Service and the Bureau of Land Management in western Oregon and Washington and northwestern California. The plan established an extensive system of reserves to protect the northern spotted owl, listed as threatened under the federal Endangered Species Act, and other at-risk species.

The federal government's plan provoked intense controversy because it dramatically reduced timber harvest levels on federal lands in the Pacific Northwest while allowing continued logging in some of the region's remaining old growth forests. A decade later, the initial results in terms of biodiversity are just beginning to be understood. Analyses of 10-year status and trends under the Northwest Forest Plan show general improvements in most biodiversity-related measures, although spotted owl populations continued to decline in many areas.

However, scientists warn that in the long-term, landscape patterns in the north-west will become increasingly bifurcated, with very old forests, very young forests, and hardly anything in between. Under this scenario, the reserves on federal lands will be dominated by forests older than 200 years, and most of the rest of the landscape will be in intensively managed forests with maxi-mum ages ranging from 35 to 80 years. Sharp, high-contrast edges between matrix

Northern spotted owl. Photo courtesy of the Regional Ecosystem Services, Roseburg, Oregon.

and reserve lands may reduce habitat values in some old forests, and species that need old-forest habitats will be rare or absent on private lands.

Scientists working at the H.J. Andrews experimental forest in the western Cascade Mountains of Oregon have been examining an alternative approach under the Blue River Landscape Study in the McKenzie River watershed. The "dynamic landscape management" approach used in this study provides more flexibility in managing large blocks of land in ways that more closely mimic historic natural disturbance regimes. Computer modeling suggests that it may over time result in development of more older forests with better habitat values than those likely under the reserve and matrix system of the Northwest Forest Plan.

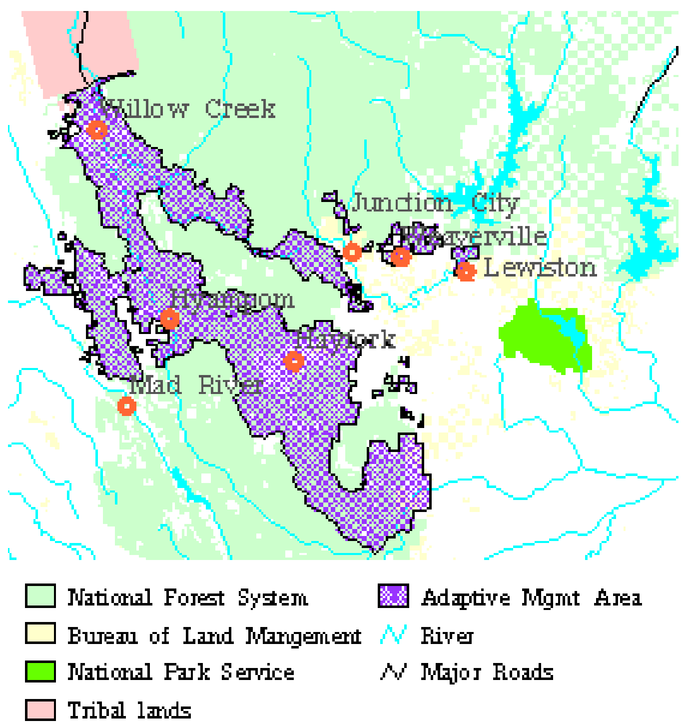
NORTHWEST FOREST PLAN

The Northwest Forest Plan, adopted in 1995, established land allocations and land management practices for some 24 million acres of federal land, most of it conifer forests. The plan is complex and addresses biodiversity conservation at multiple levels.

At its heart the plan is a system of late-successional reserves that are intended to provide essential habitat for northern spotted owls and other terrestrial wildlife associated with old-growth forests, as well as protecting streams and aquatic biodiversity.

Example of the Northwest Forest Plan: Hayfork Adaptive Management Area

A 350,000 acre area in northern California, in the Klamath, Northwest Sacramento, and Coastal California physiographic provinces. The Hayfork Adaptive Management Area is managed by the Shasta-Trinity and Six Rivers National Forests and the Redding Resource Area of the Bureau of Land Management.



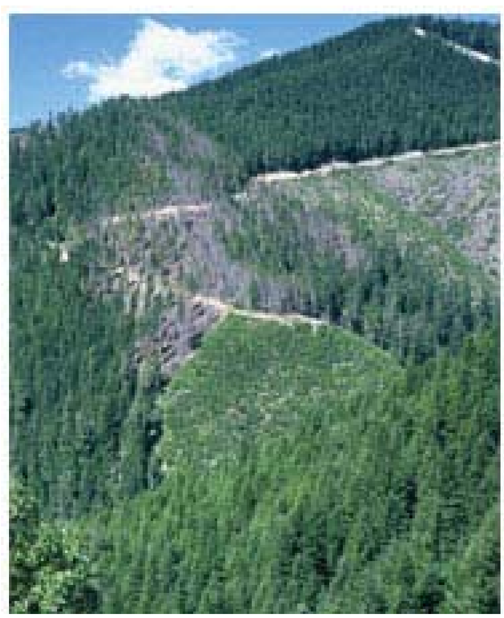
Riparian conservation areas designated along all streams are intended to provide additional aquatic protections, as well as making some contributions to a well-connected old-growth forest ecosystem and allowing for movement of wildlife among larger blocks of habitat.

The late-successional and riparian reserves are surrounded by a matrix of lands to be managed for timber production while providing limited habitat for wildlife associated with older forests by requiring retention of green trees, snags and logs where logging occurs. Matrix lands would generally be logged on 80-year rotations, limiting the development of old-growth characteristics.

BLUE RIVER LANDSCAPE STUDY

U.S. Forest Service researchers are exploring alternative approaches to achieve the objectives of the Northwest Forest Plan through the Blue River Landscape Study on Oregon's Willamette National Forest. The "dynamic landscape management" alternative would relax riparian standards for smaller streams and approach aquatic conservation objectives by relying more on overall management of small watersheds. The landscape plan also tries to use logging and prescribed fire to more closely mimic historic disturbance regimes characteristic of particular sites represented by combinations of elevation, aspect and vegetation. This leads to a more variable approach in terms of frequency of logging and the amount of trees left, as well as in the use of prescribed fire.

Based on computer simulations, the Blue River study indicates that significant differences in landscape patterns can be expected between following the Northwest Forest Plan versus the landscape plan over the course of 200 years. Not only would the landscape plan result in more old-growth forest at that time, but, since there would be fewer riparian reserves, the old-growth forest would occur in larger blocks with less dramatic contrast in



Blue River: Timber harvest and prescribed fire simulate historical fire regimes. Photo by Tom Iraci for the Pacific NW Research Station.

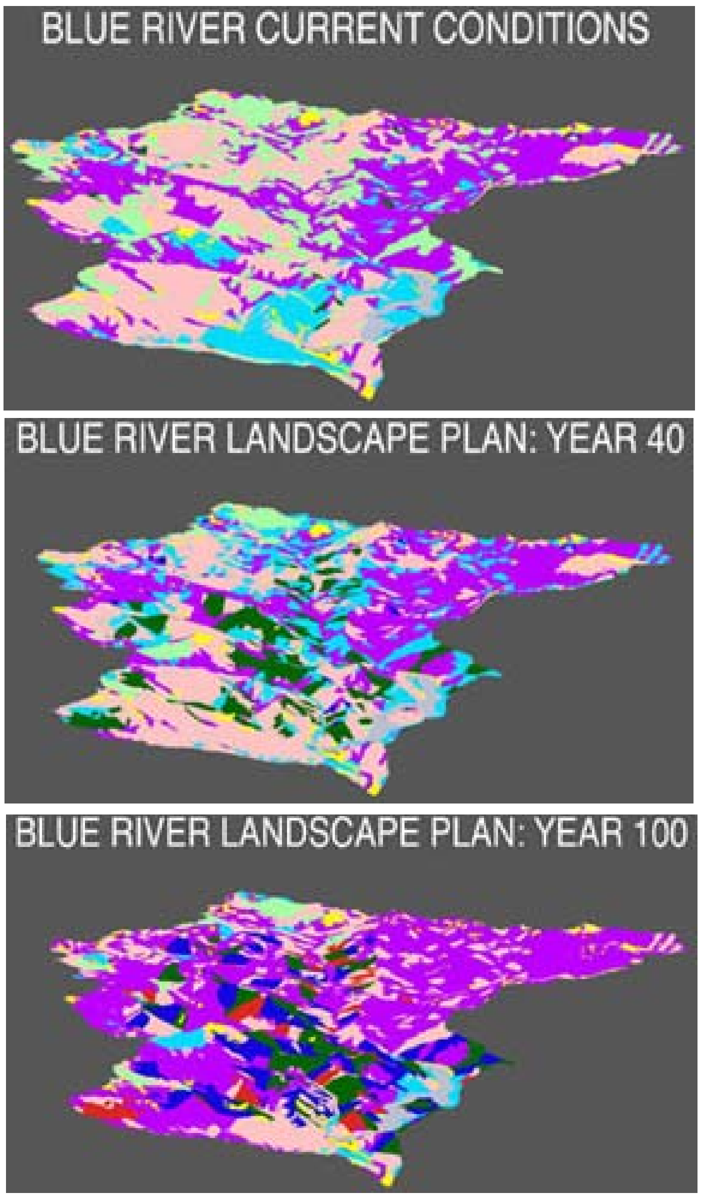
age with their surroundings. In general the landscape plan would also provide a forest mosaic that more closely resemble historic conditions and that would be expected to better support wildlife adapted to these conditions.

THINNING TO PROMOTE BIODIVERSITY

Scientists in the Pacific Northwest have been working on techniques to speed development of old-growth characteristics in second-growth forests as one way to enhance biodiversity values on landscapes that have

The Blue River Landscape Study

The Blue River Landscape Study is a long-term project designed to test an alternative landscape management strategy based on historical fire regimes and other disturbance processes. This strategy contains less frequent and less intense timber harvest activities and an alternative reserve configuration.



1. Light thinning. Photo by Dave Pilz, Pacific Northwest Research Station.

2. Light thinning with gaps. Photo by Dave Pilz, Pacific Northwest Research Station.

3. Heavy thinning with gaps. Photo by Dave Pilz, Pacific Northwest Research Station.

already been heavily modified by human activities.

Economic analysis suggests that some of these techniques may ultimately allow biodiversity-oriented land managers to generate financial returns approaching those produced by intensive management for commodity production.

The federal government's Northwest Forest Plan calls for extensive use of thinning in existing plantations to accelerate the processes that create complex older forests. Although research has focused on young (less than 80 years) stands on federal lands designated for management as "late successional reserves," the findings could apply to any forest ownership and at various scales.

Forest Service researcher Andy Carey, now retired, has focused on how stand complexity and the presence of "decadent" elements such as snags and logs affects biodiversity. He specifically examined the effects of various forms of thinning on squirrels and other small mammals, birds, fungi, as well as the interactions among those species.

Carey's research indicates that "variable density" thinning may have better prospects for maintaining or restoring biological diversity than would either traditional thinning or simply letting dense second-growth forests alone. Traditional thinning leaves evenly spaced trees.

Variable density thinning allows more flexibility to retain existing snags, logs and deciduous trees, as well promoting shrubs and complex canopies. The traditional thinning goal of increasing the growth rate of retained trees would still be achieved.

In late-successional reserves on federal public lands, thinned stands would be left to develop into old forests that would be more likely to exhibit complex ecological and habitat values.

However, variable density thinning also holds out promise for improved biodiversity values on other public and private lands managed for timber production - especially when combined with longer rotations and retention of biological legacies (snags, logs, green trees) when the stand is harvested.

Computer modeling indicates that stands managed with variable-density thinning and extended rotations may provide 82 percent of the economic return produced through conventional thinning and short rotations, traditional strategies to maximize economic values.

V. LINKS, RESOURCES & PUBLICATIONS

INTERNET RESOURCES

Pacific Northwest Research Station, *Science Update*, "Second-Growth Forests and Habitat Diversity" (Issue 1, May 2002). http://www.fs.fed.us/pnw/scienceupdate1.pdf

Pacific Northwest Research Station, *Science Findings*, "Biodiversity and Intentional Management: Intentional Pathways" (Issue 9, November 1998). http://www.fs.fed.us/pnw/sciencef/scifi9.pdf

Pacific Northwest Research Station, *Science Findings*, "Wisdom from the Little Folk: The Forest Tales of Birds, Squirrels, and Fungi" (Issue 16, July 1999). http://www.fs.fed.us/pnw/sciencef/scifind16.pdf

Pacific Northwest Research Station, *Science Findings*, "If You Take a Stand, How Can You Manage an Ecosystem? The Complex Art of Raising a Forest" (Issue 27, September 2000). http://www.fs.fed.us/pnw/sciencef/SciFi27.pdf

Pacific Northwest Research Station, *Science Findings*, "Squirrels Cannot Live on Truffles Alone: A Closer Look at a Northwest Keystone Complex" (Issue 60, January 2004). http://www.fs.fed.us/pnw/sciencef/scifi60.pdf

Forests for Watersheds & Wildlife is the national habitat conservation program of the American Forest Foundation which works with partners and family forest owners to conserve and create critical habitat for imperiled wildlife species. http://www.conservationforestry.org/

State of Minnesota. Landscape-Level Forest Resources Planning and Coordination Program. http://www.frc.state.mn.us/Landscp/Landscape.html

The Blue River Landscape Study is a large scale, long-term effort to develop and monitor the effectiveness of an alternative landscape management strategy. http://www.fsl.orst.edu/lter/research/related/ccem/brls/brls.html

Heinz Center Forest Indicators, introduction to forests chapter. http://www.heinzctr.org/ecosystems/forest/indicators.shtml

Willamette Basin Explorer. Information to help local citizens and policymakers make decisions about land and water use in Oregon's Willamette River Basin. http://www.willametteexplorer.info/

Pacific Forest Trust. The Pacific Forest Trust is committed to alleviating the threat to the integrity and productivity of America's private forests. http://www.pacificforest.org/

Coastal Landscape Analysis and Modeling Study is a multi-disciplinary research effort whose goal is to analyze the aggregate ecological, economic, and social consequences of forest policies of different land owners in the Coast Range. http://www.fsl.orst.edu/clams/

RELATED PUBLICATIONS:

Thinning, Fire, and Forest Restoration: A Science-based Approach for National Forests in the Interior Northwest. By Rick Brown. November 2000. http://www.defenders.org

Global Markets Forum: Summary Report May 4, 2005. National Commission on Science for Sustainable Forestry. http://www.defenders.org

Forests on the Edge: Housing Development on America's Private Forests. By Susan M. Stein, et al. This report displays and describes housing density projections on private forests, by watershed, across the conterminous United States. http://www.fs.fed.us/projects/fote/reports/fote-6-9-05.pdf

Franklin, J. F. and K. N. Johnson. 2004. *Forests Face New Threat: Global Market Changes.* Issues in Science and Technology, Summer 2004. http://www.issues.org/issues/20.4/franklin.html

Science and Biodiversity and Sustainable Forestry. A Findings Report of the National Commission on Science for Sustainable Forestry. http://www.ncseonline.org/ewebeditpro/items/O62F4867.pdf

USDA Forest Service, Pacific Northwest Research Station, *Science Findings*. View list of projects: http://www.fs.fed.us/pnw/publications/scifi.shtml View Issue 27, September 2000: http://www.fs.fed.us/pnw/sciencef/SciFi27.pdf View Issue 54, July 2003: http://www.fs.fed.us/pnw/sciencef/scifi54.pdf

USDA Forest Service, Pacific Northwest Research Station, *Science Update*. View publications and products: http://www.fs.fed.us/pnw/publications/sci-update.shtml. View Issue 1, May 2002: http://www.fs.fed.us/pnw/scienceupdate1.pdf

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Report written for the web by RICK BROWN

Defenders of Wildlife
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