Diversifying Forest Structure to Promote Wildlife Biodiversity in Western Washington Forests

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Introduction

This manual describes management strategies for promoting high quality forest habitat that will support and promote many different species of wildlife. There is an extensive body of scientific literature around this subject that we have distilled here as a summary of best management practices. Supporting scientific references are cited, with complete citations provided in an alphabetical reference list at the end. Readers who wish to pursue a subject in greater depth may wish to explore some of these references with help from their local Extension Forestry Educator. A glossary has also been provided to define relevant terms which are bolded in the text.

Before Proceeding

This Extension Manual includes a more advanced discussion of forest and wildlife management. We recommend that users of this manual first read and understand the following introductory publications:

- Forest Ecology in Washington (WSU Extension Bulletin EB1943)
- Silviculture for Washington Family Forests (WSU Extension Bulletin EB2000)
- Thinning Young Douglas-fir West of the Cascades for Timber and Wildlife (WSU Extension Bulletin EB1927)

These publications are available from WSU Extension at http://pubs.wsu.edu/ or by calling 1-800-723-1763.

We also highly recommend taking the Forest Stewardship Coached Planning class offered by WSU Extension in partnership with the Washington State Department of Natural Resources. To find out when the next class will be offered near you or to locate your local Extension Forestry Educator, please visit http://forestry.wsu.edu/.

Wildlife Biodiversity

Forest owners often cite wildlife habitat as a key forest management objective. This objective may include specific species of interest, but often there is a more general desire to provide habitat for whatever animal species may live in the forest. There can be a misconception that some forests function as habitat while others do not. A more accurate assessment is that all forests provide some level of habitat, and the questions should be: how much habitat is there, and for what species? With this in mind, the concept of **biodiversity** may best address landowner objectives when it comes to wildlife.

Biodiversity has been defined as the variety of all life at the genetic, species, and ecosystem scale for a given area.[42,58,61,63] Therefore, managing forests for biodiversity implies managing to support many different species (or even **genotypes** within species) at once instead of managing for specific, individual species, which can be costly and result in management conflicts.[20,79]

Species-Specific Wildlife Resources

Landowners who are interested in managing for specific wildlife species may find the Woodland Fish and Wildlife publication series helpful. These publications focus on various individual species, including bats, bears, deer, elk, songbirds, cavity-nesting ducks, turkey, quail, band-tailed pigeons, and others. These publications are available to download for free from WSU Extension Publications at http://pubs.wsu.edu/. Hard copies may also be ordered for a nominal fee online or by calling 1-800-723-1763.

The past century of forest management in Western Washington has been characterized by relatively short, clear-cut **rotations** that often include the use of performance-bred seedlings, vegetation control, **thinning**, and other practices to improve timber production.[01] As a result, many Western Washington forests, even those that have not been actively managed for several decades, are very different in structure and function from their natural predecessors. Current and past human activities have reduced the diversity and complexity of **forest structures**, especially those structures associated with older forests.[33,38,41] Nevertheless, even forests without complex structures still provide forest cover and valuable habitat features, and thus support far greater biodiversity than alternative, non-forest land uses such as agriculture or development.[38,53] More importantly, there are a number of management practices that can diversify forest structure to promote increased wildlife biodiversity, even while still achieving wood production and economic goals.[35,53] These practices and strategies include such activities as thinning of trees and shrubs, creating openings between trees, retaining trees and **snags** when harvesting, diversifying the mix of tree species present, and managing over longer rotations.

Key elements of biodiversity management

- Repeated thinning (especially variable density thinning)
- Gap creation
- Promoting tree species diversity
- Maintaining hardwood patches
- Promoting mast-producing species
- Retaining biological legacies when harvesting
- Maintaining an adequate supply of dead wood (both standing and downed)
- Promoting the growth of large trees
- Protecting riparian areas
- Underplanting
- Managing over long rotations

Structural Diversity

To meet the ecological needs of a broad range of species, structural diversity is needed, both in individual **stands** of trees and in the broader **landscape**, to provide a variety of habitat elements.[41,54,71] This means having a three-dimensional variety of shapes, sizes, structures, and spatial arrangements in your forest.[29,41,43,60,68,86,71] Maximum structural diversity is ultimately achieved at the landscape scale, which encompasses a large area and usually many parcels of land with different ownerships.[41,58] This publication focuses on strategies for increasing variety at the stand level, emphasizing what individual landowners can do at their smaller scale. The cumulative effects of these stand-level management strategies can contribute significantly to biodiversity across the greater landscape.

Our review of practices that increase complexity, and thus forest biodiversity, will examine ways to promote both horizontal and vertical elements of structural diversity, which are also noted elements of late-successional and old-growth forests. These elements correlate highly with increased biological diversity as well as with functions that are uniquely associated with old-growth systems.

Horizontal diversity is the variation of tree spacing in the forest. Uniform spacing of similar sizes and species of trees offers poor diversity. Variable tree spacing, with some areas more densely planted than others, occasional open areas (**gaps**), and patches of different species types, such as **hardwoods**, provide greater horizontal diversity (Figure 1).

Vertical diversity is the variation in tree heights and **crown** arrangements in the forest or a stand of trees. A forest **canopy** in which all the trees are of similar height and have short, uniform crown depths produces only one distinct canopy layer and offers poor diversity. Conversely, varying tree heights and crown depths on **overstory** trees, multiple canopy layers that include various **shade tolerant** trees and tall shrubs, and seedling regeneration on the forest floor provide greater vertical diversity (Figure 2).

The introduction of one or more elements of structural diversity (for example, multiple canopy layers, large live and dead trees, or gaps between groups of trees) may not immediately translate into conditions suitable for old-growth- or **late-seral**-dependent wildlife. In some cases, it may take many decades for management practices to achieve the desired structure results, and even then, occupancy and use by wildlife is not guaranteed.[7,26,34] However, the practices described here should greatly shorten the time needed for the development of complex stand structures and the successful recruitment and occupancy by a diverse array of wildlife species. Structural diversity can be achieved through a variety of management practices, the most effective of which is the use of different thinning techniques.

The importance of thinning

Thinning is one of the most important ways to increase stand-level structural diversity. Managed forests, especially plantations, are usually established at high densities, typically around 300 trees per acre (12′ × 12′ spacing) or denser.[66,72,84] Under these

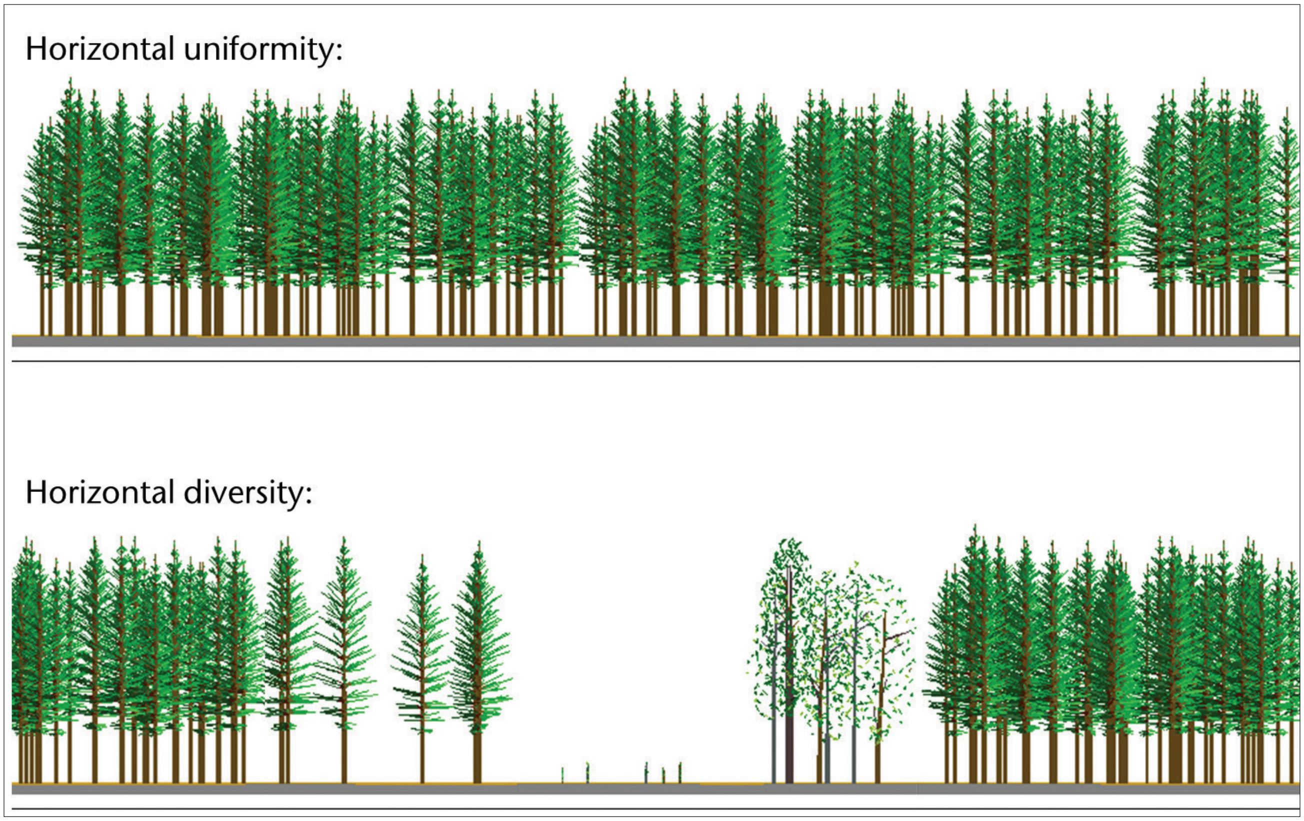

Figure 1. Horizontal diversity includes areas of different densities, openings between plants, hardwood patches, etc.

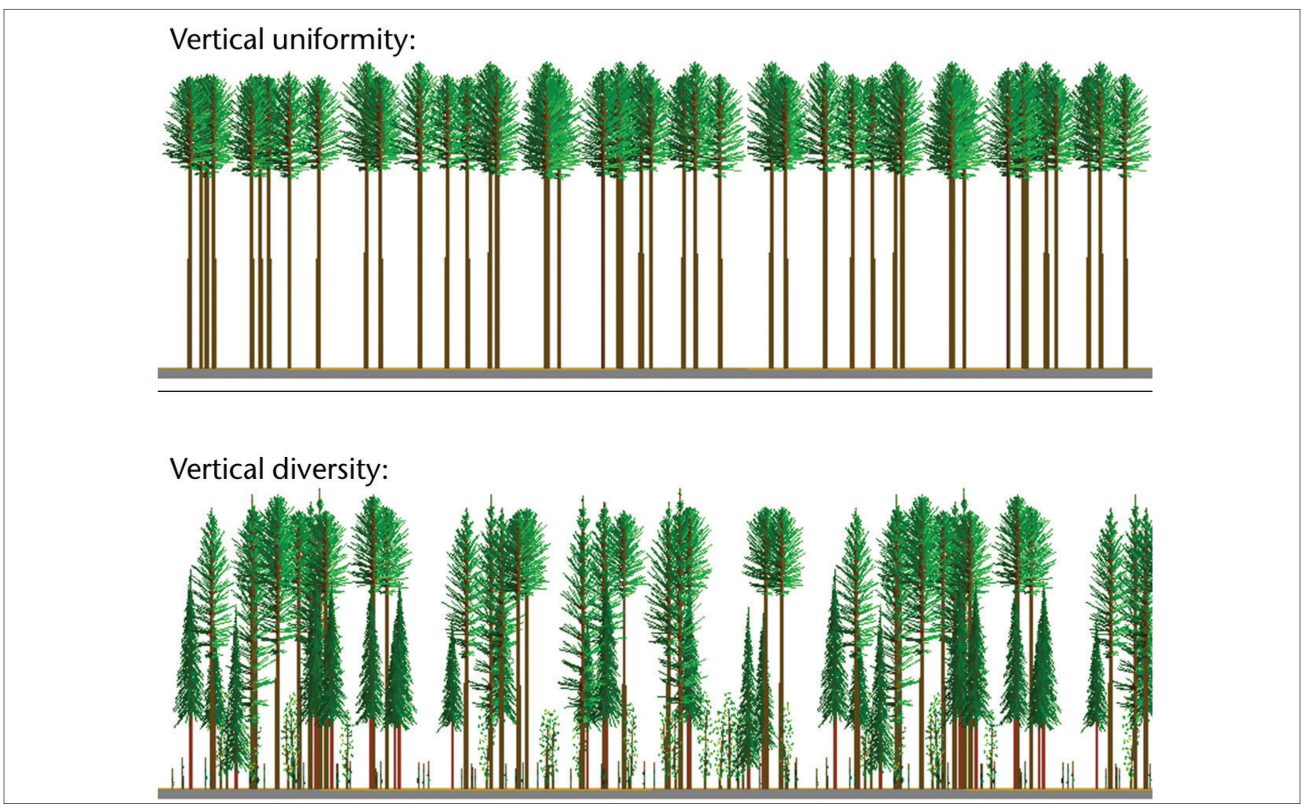

*Figure 2. Vertical diversity is when the forest canopy has multiple layers, including shade-tolerant trees and tall shrubs in the **understory** and overstory trees with different crown lengths.*

conditions, the canopy quickly closes, and the stand moves into the **stem exclusion** stage of development in which the understory vegetation is shaded out (Figure 3).[59] Dense stands in this stage support few wildlife species due to sparse understory vegetation.[37,59] In addition, many of these stands become so dense they also present barriers to bird and wildlife movement. Additionally, the development of more open and complex structures slows or ceases, and the trees can become unstable.[81]

Figure 3. Stands in the stem exclusion phase of forest development are characterized by dense, dark conditions with little or no understory vegetation.

Numerous studies have documented the positive effects of thinning on stand structure and biodiversity. Thinning opens up the stand and allows light to reach the forest floor, producing better-developed understories with greater richness, diversity, and cover.[03,22,75,76] Thinned stands have greater **herbaceous cover**,[16,54] more understory trees and shrubs,[3,54,74] understory species composition more similar to old growth stands,[48] and greater density, survival, and growth of **conifer** seedlings.[04,09,23,54] These elements provide forage for wildlife and also allow the stand to develop multiple canopy layers, which increases vertical diversity.[03,04,54]

Even after a heavy thinning, the canopy may re-close quickly.[07,17] Furthermore, a single heavy thinning may allow understory trees to form a **midstory** layer that subsequently shades out the lower understory layer below it.[17] Thus, to keep the canopy open, to control midstory density, and to continue encouraging understory development and seedling survival, thinning should be repeated regularly as needed.[07,17,40,67]

In making light and other resources available on the forest floor, thinning can result not only in increased growth of native understory vegetation, but also in unwanted exotic vegetation. Exotic species do not necessarily increase disproportionately or displace native vegetation.[02] Nevertheless, in areas where exotic species are a problem, landowners should plan for a potential post-thinning increase in unwanted vegetation.[69] Weed control treatments to mitigate this may be beneficial in these circumstances.

In addition to identifying links between thinning and stand structure, studies also show direct links between thinning and wildlife abundance. It has been observed that thinning resulted in more winter birds;[36] an overall positive impact on birds, including those that are otherwise rare or absent;[39] and increases in the abundance of small mammals.[70,82]

Thinning can accelerate the development of old forest conditions which increases biodiversity, since old forest conditions are highly complex[29] and support a variety of species, some of which depend on late seral (old forest) structures (Figure 4).[27] This structure has become uncommon on the landscape and is difficult to replace.[21]

Key features of the structural complexity of old forests are large conifers.[86] Early, heavy thinnings accelerate the development of large trees since lower stand densities promote greater tree diameter growth.[07, 22,62,86] Indeed, retrospective studies of natural, old-growth stands have found these stands often developed at much lower densities and over much longer initiation periods than today's dense, managed forests.[62,73]

Figure 4. Old forests such as this old-growth stand are characterized by large trees and complex structure.

Not all old-growth stands developed at low densities, and well-differentiated, naturally regenerated stands may not need thinning to achieve old forest structure.[83] However, the uniform age and spacing that often characterize managed forests make these forests particularly subject to poor differentiation and stagnation.[59] Repeated, heavy thinnings in these stands helps them develop structure similar to natural, old forests in a much shorter time period than would occur if high densities were maintained.[05,10,14,30,46,52,62,73]

Thinning strategies

Different thinning practices have different impacts on stand structural diversity. Thinning done "from below" (removing the smallest and weakest trees, Figure 5) maximizes tree size and canopy height diversity[10] and promotes understory development.[13] Thinning done proportionally (removing trees equally across all size classes) allows recruitment of shade-tolerant species into the overstory.[10]

To create structural diversity, *uniformly* thinning from below (such as would typically be done for timber production) should be avoided. *Irregular* thinning with different densities, unthinned areas, and creation of gaps (small openings) can greatly enhance structural diversity.[21,41]

In a process called **variable density thinning**, a stand is divided into smaller areas that are thinned to at least two different densities in an alternating pattern (Figure 6).[11,13,15,16] Variable density thinning is intended to better mimic the natural forest processes of suppression and mortality that create patterns of horizontal diversity (refer back to Figure 1).[15]

As part of a variable density thinning strategy, some areas should be left unthinned. These areas should include desirable understory features that might otherwise be damaged, such as patches of conifer seedlings (**advanced regeneration**) or desirable tall shrubs.[34,80] Leaving unthinned patches can help

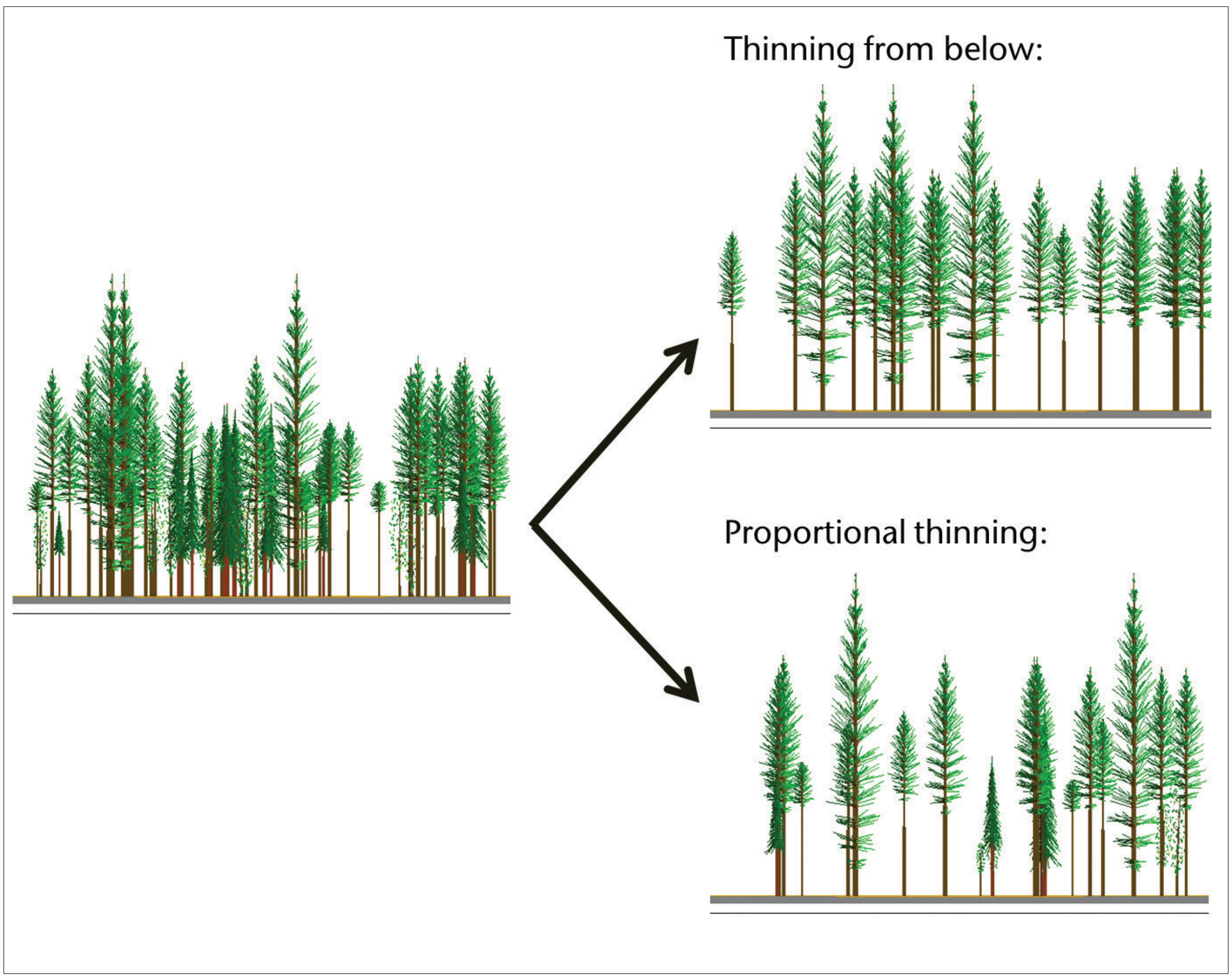

*Figure 5. **Thinning from below** leaves only the largest trees, whereas **proportional thinning** leaves trees across all size classes.*

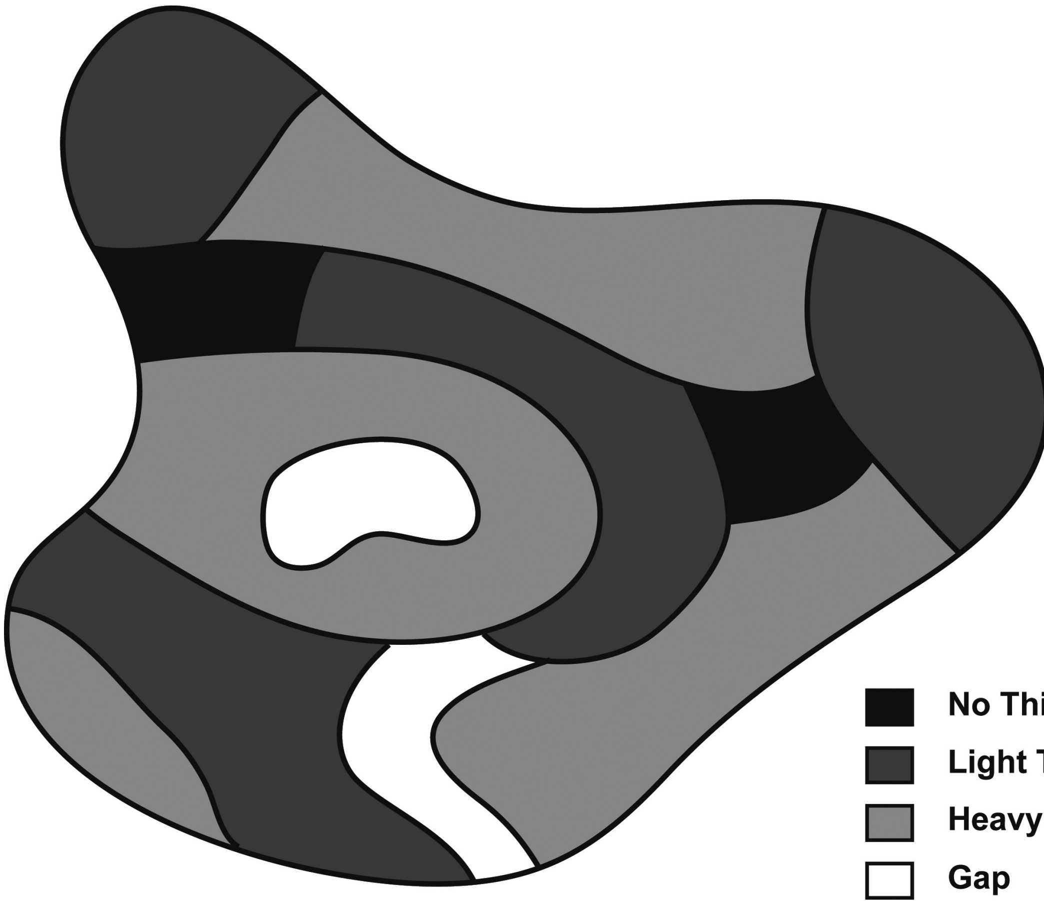

Figure 6. A simplified variable density thinning pattern with alternating areas of heavy and light thinning with gaps and unthinned areas mixed in. Feathering the edges or using topography or existing stand conditions to contribute to the complexity of the spatial pattern can increase effectiveness.

protect minor tree and shrub species as well as a diversity of tree sizes, which is especially important when thinning from below.

Creating gaps (small openings or micro-clearcuts) is another important aspect of variable density thinning. Creating openings provides for both species and structural diversity.[31,80] Since gaps can re-close quickly, some larger gaps should be created to maintain long-term openings.[80] Variable density thinning does not increase the risk of wind damage when compared to conventional thinning, although gaps should not be located in topographic areas vulnerable to wind.[64]

While some slash created by thinning may provide ground-level structures and cover for wildlife, too much slash may increase the risk of wildfire spread or impede wildlife movement. Reducing the quantity and thickness of the slash, or creating corridors, may be necessary.

Plant Species Diversity

In addition to maintaining structural diversity and a mix of different densities, maintaining a mix of different plant species is important for supporting wildlife biodiversity.[21,34,37,41] Thinning practices, especially pre-commercial thinning that typically removes all non-crop trees, should incorporate protection of minor tree species occurring in the stand.[21,23,34] A mixture of different conifer species, especially shade-tolerant species such as western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*), provides different tree sizes, live-crown lengths, and shapes.[85] A mix of both conifer and hardwood species provides a broader variety of shelters and food sources for wildlife.

Hardwood species are broadleaved, usually deciduous trees that bear flowers and fruits. Common examples in Western Washington include red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), bigleaf maple (*Acer macrophyllum*), bitter cherry (*Prunus emarginata*), cascara (*Rhamnus purshiana*), and the evergreen Pacific madrone (*Arbutus menziesii*), among many others. Some drier forest types might also support Garry oak (*Quercus garryana*).

Hardwoods provide particularly important habitat elements for all sorts of wildlife including small mammals[13] and birds.[32,54] Even small amounts of hardwood canopy cover in an otherwise coniferous forest can greatly increase the abundance of birds.[24] Hardwood species that produce hard and soft **mast** (nuts and berries, respectively) are particularly important wildlife food sources.[8] This includes both tree and understory shrub species.

Occasional suppressed hardwood species in the understory will not meet wildlife objectives,[31] rather, patches of hardwood species are needed. These patches should be large enough so that the hardwoods do not become overtopped and suppressed by surrounding, taller conifers.[34,80] Hardwood species require adequate space and sunlight to develop full crowns and produce mast.[8,34,78] The thinning and gap creation practices described above are particularly important tools for creating adequate spaces for hardwood patches. Unproductive or off-limits locations for timber production, such as wetland or **riparian areas**, make good places to promote patches of hardwood growth.[31]

Biological Legacies

Retaining biological legacies when harvesting trees is another important way to increase structural diversity. Biological legacies include elements of the pre-harvest stand left to enrich the regenerating post-harvest stand.[26] Examples include large live trees, snags, downed logs, and patches of intact forest with undisturbed understory. Leaving these legacies when harvesting timber better mimics natural disturbances and enriches managed forests with a structure more like natural stands.[28,33] Legacy retention can "**lifeboat**" species by helping them to tolerate post-harvest conditions, create habitat features much sooner than would be possible without legacies, and facilitate dispersion.[25,26] These features can be left in place through subsequent management rotations, to enhance forest structure.[06,25]

There are two spatial approaches to retaining biological legacies: leaving retained elements evenly dispersed throughout the stand (Figure 7) or aggregating them in clumps (Figure 8). Both approaches have advantages and disadvantages. **Dispersed retention** provides retention throughout the stand, but it also poses some operational challenges and hazards. **Aggregated retention** has fewer operational challenges and allows for protection of elements like snags, sensitive areas, and undisturbed areas.[06,25] Dispersed retention has been found to be more visually appealing initially, but aggregated retention has been found to be more visually appealing in the long term.[44] **Variable retention harvesting** leaves a varying mix of both aggregated and dispersed retention which can be advantageous for both biodiversity and timber production.[25,26]

Figure 7. Dispersed retention has left trees evenly distributed around this harvest unit.

Figure 8. Aggregated retention has left clumps of trees in this harvest unit.

Even small snags have value. Leaving a high stump (greater than three feet) when cutting a tree, especially if the bottom of the tree is deformed with minimal commercial value, provides a short snag useful for wildlife (Figure 9).[8] This technique provides wildlife habitat whether harvesting timber or simply cutting down a hazard tree near your home.

There's life in dead wood

Dead wood comprises one of the most important ecological elements of the forest, consisting of standing dead trees (snags) and downed wood (also called coarse woody debris). There are 93 wildlife species associated with snags in northwest forests and 71 species associated with downed wood.[65] Both conifer and hardwood species add value as snags and cavity trees.[31]

Figure 9. Leaving high stumps that are unmerchantable provides short snags for wildlife.

Figure 10. This snag was created by topping the tree and then notching it so that moisture would collect and promote decay.

Figure 11. Nest boxes can provide artificial cavities.

In addition to protecting existing snags and downed wood as part of a harvest retention strategy, these features can also be created manually by topping (Figure 10), girdling, or inoculating trees with decay organisms.[05,21,23,28,30] Create downed wood by cutting down trees and leaving them to decay on the forest floor. Simulate artificial cavities by providing nest boxes (Figure 11), although this may less effective or efficient than natural structures.[31] If no large material is available for creating downed wood, smaller diameter logs can be bundled. Although decaying faster, such bundled wood does provide considerable habitat.

Large snags and downed wood are particularly important for wildlife and are often missing from today's managed forests. Growing and retaining large, live trees provides a future supply of large, dead wood.[31]

Retaining living buffers to protect riparian areas from harvest impacts are an important part of any harvest retention strategy.[25] Riparian forest areas around streams, wetlands, and other aquatic features exhibit a high diversity of species and ecological processes.[56,57] Riparian areas not only provide habitat for certain **obligate species** that depend on them, but also provide significant habitat for **generalist species** as well.[13,45] In order to maintain the high

The Forests and Fish Rules

As part of Washington's forest practices regulations, the Forests and Fish Rules protect riparian areas. In Western Washington, these rules prescribe a three-zone buffer around fish streams when harvesting timber. No harvesting is allowed in the zone closest to the stream, while partial harvest may be possible in the zones farther from the stream. The riparian buffer width ranges from 90 to 200 feet depending on the quality of the site. The rules also prescribe timber harvest buffers to protect non-fish streams, wetlands, and sensitive aquatic features, such as seeps and springs. These buffers help protect areas that are especially important for biodiversity.

More information about the Forests and Fish Rules can be found in Forest Practices Illustrated, which is available from the Washington Department of Natural Resources (DNR) at http://dnr.wa.gov.

diversity and important habitat provisions of these areas, riparian protection should be a priority when managing for biodiversity.[13,56]

Other Management Practices

Underplanting

Planting seedlings in the forest understory (that is, under an existing forest canopy), a practice called **underplanting**, can add to both structural diversity and plant species diversity by increasing the number of canopy layers as well as the variety of plants present.[05,09,17,23,26,76] In order for underplanted seedlings to survive and contribute to forest diversity, they need light and space. Underplanting should be done in conjunction with repeated, heavy thinning and gap creation to ensure adequate **growing space**.[17,18,50] Underplanted seedlings are unlikely to survive in unthinned stands because of the competition from established trees and the lack of sunlight.[18,50]

Western hemlock, Sitka spruce (*Picea sitchensis*), and even **shade-intolerant** red alder, when planted in a space with adequate light, work particularly well for underplanting. Western redcedar and bigleaf maple, although shade tolerant, can be difficult to grow as underplanted seedlings due to heavy animal **browse damage**. Successfully establishing these species requires protecting the seedlings from damage.[50]

Fertilization

In general, fertilization often hinders understory development by accelerating **canopy closure**.[75] However, applying fertilizer to individual trees or groups of trees rather than all over as a uniform application, promotes differentiation and greater vertical diversity.[21,23]

Pruning

Pruning variably instead of uniformly adds diversity, increases understory growing space, and allows more light to reach the forest floor.[23] Pruning lower branches, coupled with thinning, creates increased space for birds to fly within the stand. In addition to structurally altering the treated stand, this intermediate operation may enhance the ability of young stands to serve as connectors between older, more structurally diverse stands.

Long Rotations

Implementing practices to increase biodiversity in managed forests will be most effective in conjunction with longer rotations. Forests need adequate recovery time between harvest cycles in order to establish certain species and structures associated with complex older forests.[26] Longer rotations provide adequate time for treatments, such as variable density thinning, to have a meaningful impact on forest structure and biodiversity.[02] Even with management strategies that greatly accelerate the development of complex, old forest conditions, it still takes around 120 years to develop these conditions.[14,46,52] Typical rotations in Western Washington managed forests range roughly from 35 to 60 years.[01]

Longer rotations also have significant landscape-level benefits. Long rotations help balance the distribution of age classes on the landscape by allowing for the development of older forest stages, whereas short rotation management limits stands to only the early stages of development where the majority of stands remain in the stem exclusion stage.[19,20,21] Longer rotations also reduce the amount of land harvested each year, minimizing the level of major disturbance on the landscape.[19,25]

Combining the management practices described above with long rotations forms an overall management strategy known as a **biodiversity pathway**. The goal of biodiversity pathway management is to promote and accelerate the development of old forest structure and function in support of increased biodiversity.[11,12] Biodiversity pathways usually include multiple variable density thinnings that are heavier than traditional commercial thinnings and that favor multiple species. Harvesting incorporates a variable retention strategy to retain key ecological features. Studies of biodiversity pathways in managed forests show they can create ecological conditions necessary for biodiversity that are not possible with traditional timber management. These studies also show that biodiversity pathways achieve conditions favorable to biodiversity much sooner than a no-action strategy.[12,14]

When planning long-term biodiversity management strategies, it is important to remember that forests are dynamic and subject to unpredictable disturbances. Small forest ownerships, especially when surrounded by industrial clear-cuts, agriculture, or non-forest uses, may be difficult to protect against physical disturbances such as wind. In addition, biological agents such as root disease and mistletoe may impact stands or limit management options. Such disturbances add to structural diversity by creating snags, downed logs, deformed trees, and open areas for new trees and plants to become established (which can include different species than what was growing there previously). However, these types of events may negatively impact other landowner objectives. In the long term, though, diverse forests tend to be less vulnerable to both physical and biological disturbances.

Developing a written forest stewardship plan helps you develop a biodiversity management pathway in the context of the conditions and constraints specific to your property and ownership objectives. You may wish to enlist the help of your local WSU Extension Forester, a DNR Stewardship Forester, or a professional consulting forester. WSU Extension also offers classes and resources on developing forest stewardship plans; visit http://forestry.wsu.edu/ for more information.

Economic Considerations

When considering management practices to support increased biodiversity, it is important to also consider the economic impacts. Private forests are often business enterprises for which landowners are working toward some level of economic return. Practices that promote biodiversity are less likely to be successfully implemented if they are cost prohibitive. Unfavorable economic returns may even motivate landowners to convert their forestland to non-forest uses,[55] which reflects recent trends in forestland **conversion** in the Pacific Northwest.[51,77] Economic costs need to be considered when planning strategies to increase biodiversity since forest conversion represents the worst scenario for biodiversity.

Practices promoting biodiversity have associated economic trade-offs. Heavy thinnings result in lower economic returns since growing space is not as fully utilized.[14,37,49] Variable retention harvesting increases logging costs and retention impacts the growth of the subsequent rotation, which decreases wood production.[25] Long rotations result in perhaps the most significant costs since delaying harvest revenues until further in the future significantly discounts the present value of those revenues relative to management costs.[14,46,49] One study found that a biodiversity pathway management strategy reduced economic value by 50 percent.[47]

However, heavier biodiversity thinnings do remove more wood sooner, which can offset some present value losses. Heavier thinnings and longer rotations may also produce larger, higher quality wood later in the rotation, and that wood will be of higher value and further offset costs.[14,49] Unfortunately, more open-grown trees also have more branches, so the overall impact on quality is unclear.[46] Furthermore, recent evidence suggests lost price premiums have reduced the incentives to produce large logs or to prune.[72] Thus, high quality wood production should not be relied upon as a solution to offset biodiversity costs.

Family forest owners who place a high value on wildlife habitat and are willing to forgo maximum monetary returns may be in the best position to incorporate long-term management strategies that promote biodiversity. Government cost-share programs may also be available to offset the costs of forest management activities that improve wildlife habitat.

Summary

Changes in stand-level management practices can significantly increase biodiversity in managed Douglas-fir forests in Western Washington. Developing more diverse and complex stand structures is the key to providing for a diversity of species and processes. Using heavy, repeated thinnings minimizes the dense stem exclusion stage, stimulates the understory, and accelerates the development of complex, old forest structure. Favoring multiple species and sizes when thinning enhances structural diversity. Variable density thinning, which creates a mosaic of different densities along with unthinned patches and small open spaces, works well for enhancing structural diversity.

When harvesting, biological legacies such as large, live trees, snags, and downed wood should be retained to mitigate harvest impacts and to provide structure for the new stand. Retention can be left dispersed throughout the stand, in aggregate clumps, or a combination.

Riparian areas should be protected since these are areas of particularly high diversity. Underplanting, selective fertilization, and pruning can also be used to add structural complexity. All of these strategies work best over longer rotations that allow enough time for complex structure to develop and minimize cumulative harvest impacts on the landscape.

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Glossary

Advanced regeneration. Tree seedlings that establish naturally from seed in the understory.

Aggregated retention. Trees that are retained in clumps when harvesting.

Biodiversity. The variety of life forms in an area.

Biodiversity pathway. An overall management strategy that uses multiple variable density thinnings, variable retention harvesting, and other forest management practices over long rotations to promote biodiversity.

Biological legacy. Elements of the previous stand such as snags, down wood, and large, live trees that are left behind to enrich the regenerating stand after the harvest of timber.

Browse damage. Damage caused by animals (for example, deer, elk) eating branches and leaders off trees.

Canopy. The upper part of the forest, established by tree branches and foliage.

Canopy closure. The point in the development of a stand at which the tree crowns completely fill in and touch each other enough that sunlight can no longer directly reach the forest floor.

Conifer. Cone-bearing tree species (usually evergreen), such as Douglas-fir, western hemlock, or western redcedar.

Conversion. Replacing a forest with a different land use, usually real estate development.

Dispersed retention. Leaving trees evenly distributed throughout a harvest unit.

Forest Structures. Physical elements of the forest, including trees, plants, dead wood, and other organic material.

Gap. An opening in the forest where there are no trees.

Generalist species. A species that can grow and thrive in a variety of different types of habitat.

Genotype. The genetic makeup of an individual.

Growing space. The resources needed for a plant to grow, including both physical space and resources such as light, water, and nutrients.

Hardwood. A fruiting and flowering tree species (usually deciduous), such as red alder, black cottonwood, or bigleaf maple.

Herbaceous cover. Understory plants that do not have persistent, woody stems (for example, grasses, forbs, wildflowers).

Horizontal diversity. The variety in how trees are spaced—how far apart they are—in the forest.

Landscape. A broad geographic area composed of different patches of vegetation.

Late-seral. Pertaining to the later stages of forest development (for example, old growth).

Life boating. The practice of providing interim habitat structures to help species survive in an area following timber harvest.

Live crown. The top portion of a tree with live foliage.

Mast. Fruits and seeds from trees or shrubs, eaten as food by wildlife, including nuts and acorns (hard mast) and berries (soft mast).

Midstory. The middle vertical layer(s) of a forest, composed of trees established between the overstory and the understory.

Obligate species. A species that can only survive in a certain type of habitat.

Overstory. The top-most layer of a forest, composed of the crowns of the tallest trees.

Proportional thinning. Thinning that is done evenly across different size classes of trees.

Riparian area. The biological zone adjacent to an aquatic feature such as a river or stream.

Rotation. The period of time between timber harvests.

Shade intolerance. A plant's inability to grow and thrive in the shade of other trees or plants.

Shade tolerance. The ability of a plant to grow and survive in the shade of other trees and plants.

Snag. A standing dead tree.

Stand. A group of similar trees growing together. This is the basic management unit of a forest.

Stem exclusion. The stage of forest development following canopy closure, characterized by dark, dense conditions on the forest floor with a sparse understory and heavy competition between trees. No new trees ("stems") are added to the stand.

Structural diversity. The variety of different physical elements in a forest (for example, tree and plant species, sizes, arrangements, and life stages).

Thinning. The systematic removal of some of the trees in the forest to create more space for the remaining trees.

Thinning from below. Thinning that removes the smallest-diameter trees and leaves the largest-diameter trees.

Underplanting. Planting seedlings to grow under an existing forest canopy.

Understory. The bottom-most layer of the forest composed of herbs and shrubs growing on the forest floor.

Variable density thinning. Thinning to at least two different densities in an alternating pattern, along with gaps and unthinned areas.

Variable retention harvesting. Leaving a mix of both dispersed and aggregated retention when harvesting timber.

Vertical diversity. The variety of tree heights, crown arrangements, and canopy layers in the forest.

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EM044