Appendix C

Concepts for the Integrated Strategies

Chapter 4 presented the strategies, and some background on the concepts behind those strategies. This appendix provides more detailed information on these concepts.

The main headings in Appendix C are listed below. Important connections between these headings and Chapter 4 are summarized briefly below the headings.

Stand Type Definitions …………………………………………………………... C-2

This section is linked to "Concept 1: Managing for a Diverse Array of Stand Types," under "Basic Concepts for Landscape Management." Stand type definitions and guidelines for classifying stands are included here.

Landscape Management Principles …………………………………………….. C-16

This section is linked to "Concept 2: Landscape Design to Provide for a Functional Arrangement of Stand Types," under "Basic Concepts for Landscape Management." "Landscape Management Principles." The concepts are described in greater technical detail here. Guidelines are given for determining patch types and sizes across the landscape.

Concepts for the Landscape Management Strategies ……………………...……. C-22

This section is linked to the landscape management strategies.

The Array of Stand Structure Types ………………………………………….. C-22

Management Pathways ……………..……………………………….………… C-25

Patch Types, Patch Sizes, and Patch Placement ………………………………. C-28
Managing for Key Structural Components …………………………………… C-36
Silvicultural Practices …………………………………………………………. C-46

Silvicultural tools will be used to implement the landscape management strategies. This section explains common silvicultural tools.

Stand Type Definitions

Pacific Northwest forests follow a typical progression of stand structures over time, after a major stand-replacement disturbance. Forest stands develop along continuums. The stand type definitions given here represent snapshots of stand conditions taken along the various continuums.

Because the definitions describe points along continuums, it will not always be apparent how a particular stand should be classified. The numerical guidelines given in this section can help the field manager to classify stands. In cases where stands do not quite match the numerical guidelines, the stand should be classified as the type indicated by the majority of factors. Some tips are given here for the stands most likely to be confusing.

The stand types are defined briefly in the sidebar on the next page. In the following pages, a detailed description and computer-modeled example are given for each type.

Each of the stand descriptions on the next few pages has four parts: a description of the stand characteristics, an explanation of the stand development process that occurs in that stand type, classification guidelines, and management concepts for that type. The terms for both stand types and development processes are used throughout the FMP. The stand type names are used when the discussion refers to stand condition. The process names are used when the discussion refers to stand development process. The table on the next page shows the relationship of stand types and stand development processes.

Five stand types are described. The stand types apply to conifer, hardwood, and mixed stands. It is anticipated that the landscape will consist primarily of conifer stands with some hardwood component.

This section ends with a brief discussion of old growth and hardwoods.

Stand Type Definitions

Structure-based management (SBM) classifies the many diverse forest stand structures into five basic types.

Regeneration (REG) — This stand type occurs when a disturbance such as timber harvest, fire, or wind has killed or removed most or all of the larger trees, or when brush fields are cleared for planting.

Closed single canopy (CSC) — This stand type occurs when new trees, shrubs, and herbs no longer appear in the stand, and some existing ones begin to die from shading and competition, in a process called stem exclusion.

Understory (UDS) — This stand type occurs after the stem exclusion process has created small openings in the canopy, when enough light and nutrients become available to allow herbs, shrubs, and new trees to grow again in the understory.

Layered (LYR) — This stand type occurs as the process of understory reinitiation progresses where openings in the canopy persist. Shrub and herb communities are more diverse and vigorous, and two or more distinct layers of tree canopy appear.

Older forest structure (OFS) — This stand type occurs when forest stands attain structural characteristics such as numerous large trees, multi-layered canopy, substantial number of large, down logs, and large snags. It is not the same as old growth, although some of its structures are similar to old growth.

Table C-1. Relationships between Stand Type Definitions and Stand Development Processes

Stand Type		Stand Development Process
Regeneration (REG)	—	Stand Initiation (SI)
Closed Single Canopy (CSC)	—	Stem Exclusion (SE)
Understory (UDS) Layered (LYR) Older Forest Structure (OFS)	}	Understory Reinitiation (UR)

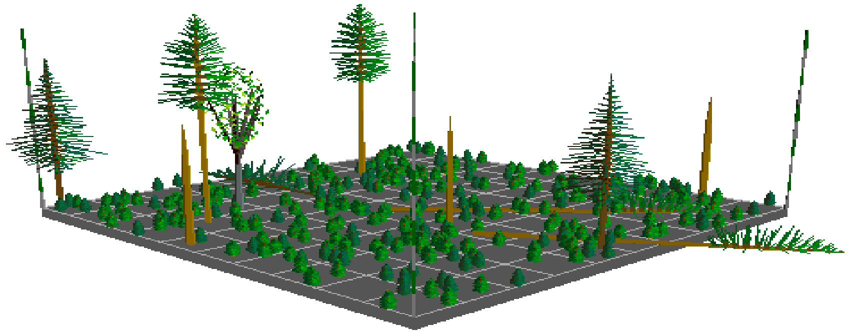


Figure C-1. Stand Type 1 — Regeneration (REG)
(Shrubs and Herbs Not Displayed)
Stand Development Process — Stand Initiation (SI)

Stand Characteristics
The site is occupied primarily by tree seedlings or saplings, and herbs or shrubs. The trees can be conifers or hardwoods. Competition among the trees and other vegetation is not yet resulting in widespread loss of herb or shrub layers. The herbs and/or shrubs are widespread and vigorous. This type includes first year regenerated stands, and continues to the stage when the trees approach crown closure. At that point, the increasing crown closure shades the ground, and causes a significant loss of vigor or death of understory vegetation.

Stand Initiation Process
This process begins when a disturbance such as timber harvest, fire, or wind has killed or removed most or all of the larger trees, or when undesirable vegetation is cleared for planting. Varying levels of herbs, shrubs, or advanced tree regeneration may remain from the previous stand, as well as such stand components as snags, live green trees, and down wood. New plants (trees, shrubs, and herbs) begin growing from seed, sprouts, artificial regeneration, or other means in the early years of this stage. In the later years of this stage, trees begin shading out the other stand components.

Classification Guidelines for Regeneration Stands

Numerical guidelines	Herbs, shrubs, and grasses cover 20 to 80 percent of the ground.
Examples	In most cases, these stands will be stocked predominantly with Douglas-fir, western hemlock, or other conifers. Many of these stands will have 200-400 trees per acre and will range from 1-15 years old. These numbers are not requirements, but descriptions of what to expect.
Classification tips	Regeneration stands that are precommercially thinned and/or pruned should be classified as regeneration stands until either the shrub and herb layer diminishes to the point that the stand is closed single canopy or until the average stand diameter reaches 6-10 inches and adequate understory exists to meet the definition of an "understory" stand.

Management Concepts for Regeneration Stands

- Snags, down wood, and residual live green trees will be carried over or recruited from the previous stand.
- Deciduous trees and fruit-bearing shrubs and trees are desirable components.

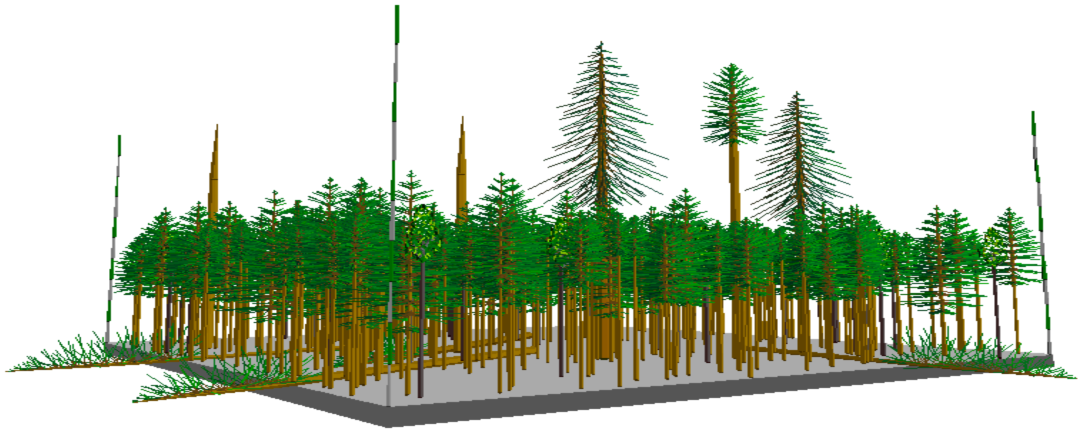


Figure C-2. Stand Type 2 — Closed Single Canopy (CSC)
Stand Development Process — Stem Exclusion (SE)

Stand Characteristics

Trees fully occupy the site and form a single, main canopy layer. There is little or no understory development. Where understory vegetation exists, there is low shrub and herb diversity. The shrub and herb layers may be completely absent or may be short and dominated by one or two shade-tolerant species, such as sword fern, Oregon grape, oxalis, or salal.

Stem Exclusion Process

As the trees established in the regeneration stage grow larger in height, crown size, and root development, they eventually begin to compete significantly for moisture, light, and nutrients. The stem exclusion process begins when new trees, shrubs, and herbs no longer appear and existing ones begin to die, due to shading and other competitive factors. The shrubs and herbs begin to die out of the understory first, and later in the stage, may essentially die out of the stand altogether. The trees begin to show decreasing limb sizes, diameter growth rate, and crown length. Later, less competitive trees die. If root diseases are present they cause additional trees to die. As some trees die, snags and coarse down wood begin to appear in the stand. The surviving trees grow larger and have more variation in height and diameter. Near the end of the stage, enough trees have died and the living trees have enough variation that small gaps form and understory trees, shrubs, and herbs begin to reappear.

Classification Guidelines for Closed Single Canopy Stands

Numerical guidelines	A variety of herbs, shrubs, and grasses usually cover less than 30 percent of the ground, or only one or two shade-tolerant species cover most of the ground.
Examples	Stands in this category include: (listed on next page)

1. Unthinned stands where competition has virtually eliminated or prevented significant herb or shrub development. Any understory trees provide minimal layering and are not vigorous.

   A range of stand types exists in this category. One example is a sapling stand where the trees have recently attained crown closure. In this stand the lack of light and possibly lack of nutrients cause the shrub and herb layers to lose their vigor and in many cases die. In this relatively early stage of CSC the trees are just beginning to significantly compete with each other for light and nutrients. Loss of vigor or death of some individual trees may be evident. However, most of the trees in the stand have not yet lost much of their crowns and they are growing rapidly. Live crown ratios would likely be in excess of 70 percent. If silvicultural thinning or significant natural disturbance does not occur, the stem exclusion process will guide the further development of this stand for some time.

   A second example demonstrates the range of stand conditions that exist in the CSC type. If a stand develops under high stocking densities over an extended period of time, numerous outcomes are possible. One frequent outcome in unthinned stands is that the diameter growth of the individual trees slows, the tree crowns recede, and eventually height growth slows. There is intense competition among the trees for light and nutrients. Minimal light reaches the forest floor. The result can be densely stocked stands with individual trees that have very short crowns (live crown ratios less than 25 percent) and very limited to no understory tree, shrub, or herb development. Stands may remain in this condition for decades. Eventually individual trees may dominate or a disturbance such as windthrow, landslide, or fire will thin the stand out and encourage the onset of the next stage of stand development — understory reinitiation.

2. Thinned stands where the overstory occupies most of the site, preventing development of a diversity of understory trees, shrubs, or herbs. A diversity of herbs and shrubs did not develop after thinning, or all but a few shade-tolerant herb or shrub species have died or will soon die, due to the effects of overstory competition.

   Thinned stands may react similarly to unthinned stands once the stocking density returns to high levels. Stands that are thinned to very low densities or are thinned more frequently may quickly move into the understory reinitiation phase of stand development.

Management Concepts for Closed Single Canopy Stands

- Snags, down wood, and residual live green trees will be recruited from the existing stand through natural processes, carried over from the previous stand, or created from the existing stand in cases where the trees are large enough to be effective habitat components.
- Deciduous trees and fruit-bearing shrubs and trees are desirable components.

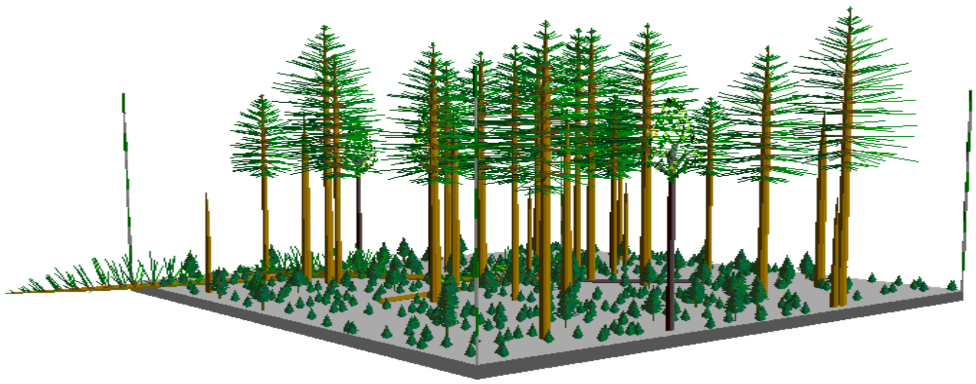


Figure C-3. Stand Type 3 — Understory (UDS)
Stand Development Process — Understory Reinitiation (UR)

Stand Characteristics
These stands have developed more diverse herb or shrub layers than CSC stands and have trees larger than sapling size. Tree canopies may range from a single species, single-layered, main canopy with associated dominant, codominant, and suppressed trees, to multiple species canopies. However, significant layering of tree crowns has not yet developed.

The least developed stands included in this category are stands that consist of a single species, single-layered, main tree canopy with an understory of shrubs and herbs that is more diversified than simply having one or two shade-tolerant species. Adequate light is entering the stands to allow tolerant and intolerant herb and shrub species (e.g., Oregon grape, sword fern, blackberry, huckleberry, twinflower) to develop and flourish through continued stand management or natural processes. This type also includes stands where the herbs, shrubs, and understory trees are vigorous and beginning to diversify. Vertical layering may be developing but is not yet extensive.

In all UDS stands, the shrub and herb layers are likely to continue to diversify and maintain or improve their vigor. These stands offer good potential to develop into highly diversified vegetative communities. Depending on the intensity and timing of density management activities, stands could shift back and forth between the CSC and UDS stand types over time.

Understory Reinitiation Process
The understory reinitiation process occurs after stem exclusion, when enough light and nutrients become available to allow forest floor herbs, shrubs, and tree regeneration to again appear in the understory. The new understory may grow very slowly at higher stand densities. The amount of understory brush and herbaceous species is minimal at the beginning, but increases to a substantial component of the stand by the end of the stage. In a stand where density management activities occur frequently, the understory may never be completely absent. UDS stands are in the early or developmental stages of this process.

Classification Guidelines for Understory Stands

Numerical guidelines	A variety of herbs, shrubs, and grasses cover 40 percent or more of the forest floor. Average tree size is at least 6 to 10 inches DBH, and tree heights are generally approaching 40 to 50 feet.
Classification tips	Stands that have an actively developing understory of tree species may also be included in this type — even if other herbs and shrubs are not flourishing. Specifically, alder or Douglas-fir stands with developing understories of western hemlock/Sitka spruce would fit this description.

Management Concepts for Understory Stands

- Snags, down wood, and residual live green trees will be carried over from the previous stand.
- Deciduous trees and fruit-bearing shrubs and trees are desirable components.

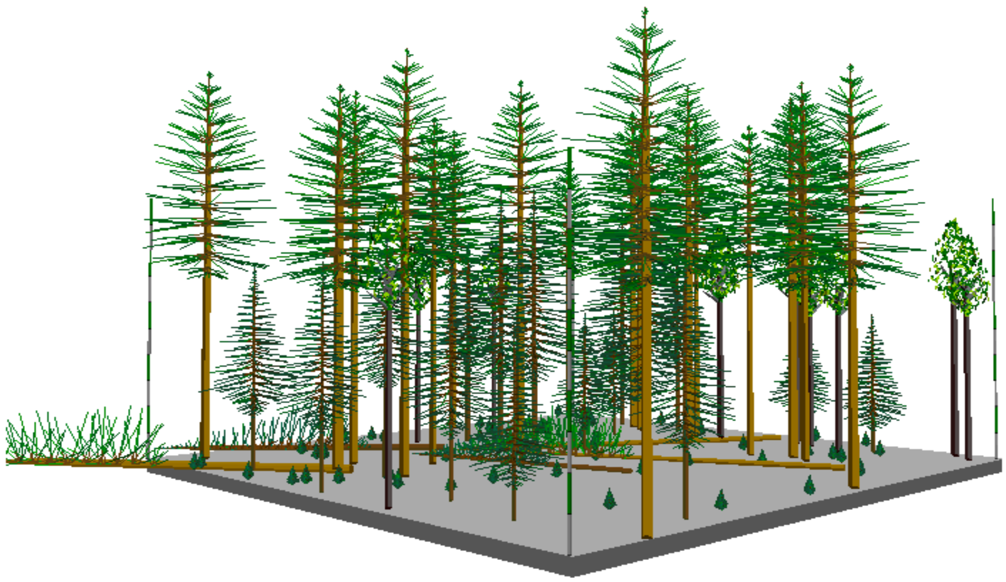


Figure C-4. Stand Type 4 — Layered (LYR)
Stand Development Process — Understory Reinitiation (UR)

Stand Characteristics

The vertical organization and structure of the living plant community are more complex than in the understory type. Vertical layering of herbs, shrubs, and tree crowns is extensive. Plant communities are complex in terms of numbers of species and in vertical arrangement. Shrub or herb layers and tree canopies in two or more layers are present.

At the more ecologically complex end of the range for the LYR stand type are stands that have a mixture of tree cohorts or tolerant (e.g., western redcedar, western hemlock) and intolerant tree species (e.g., Douglas-fir, noble fir), and shrub and herb species (vine maple, huckleberry, rhododendron, Indian plum, prince's pine). The tree crowns are arranged in a variety of configurations with significant layering of tree crowns from the tallest trees to the forest floor. The shrub and herb layers are diverse in terms of species and in vertical arrangement. Overall, the plant community provides a wide range of habitat niches from the forest floor to the top of the tree canopy.

If substantial amounts of down wood and snags exist and stand size is large enough, LYR stands are assumed to provide habitat for species commonly associated with older forests. Older Forest Structure, as defined later in this section, is merely a Layered stand type that has attained some specific measure of these stand attributes. Highly diverse Layered stands that contain all the required attributes of Older Forest Structure but may lack the minimum tree diameters are assumed to provide significant value to wildlife species commonly associated with older forests, such as northern spotted owls, pileated woodpeckers, and flying squirrels.

Understory Reinitiation Process

The understory reinitiation process occurs after stem exclusion, when enough light and nutrients become available to allow forest floor herbs, shrubs, and tree regeneration to appear again in the understory. The new understory may grow very slowly at higher stand densities. The amount of understory brush and herbaceous species is minimal at the beginning of the stage, but increases to a substantial component of the stand by the end of the stage. In a stand where density management activities occur frequently, the understory may never be completely absent. LYR stands are in the later or more developed stages of this process.

Classification Guidelines for Layered Stands

Numerical guidelines

Trees of 18 inches or larger DBH and reaching 100 feet or more tall are predominant in the overstory.

At least 30 percent of the stand is comprised of layered patches. A patch is defined as layered when at least 60 percent of the vertical space from the top of the main tree canopy to the forest floor is filled with layered tree crowns, branches with foliage, and a significant amount of shrubs.

Examples

An example is a Douglas-fir stand that has patches of a younger cohort of western hemlock developing under the main canopy; the younger cohort should be at least 30 feet tall.

A second type of patch that may be considered as layering occurs when the main canopy is interrupted with patches of another, shorter cohort or species throughout at least 30 percent of the stand. In this situation the patches are not subordinate to a higher canopy, but instead exist in groups where the trees are at least 30 feet tall and the tallest tree layer in the patch forms the canopy. These patches are generally no bigger than two acres. An example of this type of Layered stand would be a 150 foot tall conifer stand with patches of 80 foot tall hardwoods scattered through at least 30 percent of the stand.

Classification tips

Shrubs and herbs are an important component in the overall stand. However, there may be few shrubs or herbs in some parts of the stand. For stand classification, it does not matter if shrubs and herbs are missing from some patch types within the stand.

Management Concepts for Layered Stands

- Snags and down wood are recruited from the existing stand to supplement those components carried over from the previous stand.

Figure C-5. Stand Type 5 — Older Forest Structure (OFS)
Stand Development Process — Understory Reinitiation

Stand Characteristics

This stand type occurs when a Layered stand attains the structural characteristics listed below. These characteristics are typically linked with older forests or old growth. The definition is derived from consultation with foresters and biologists and represents their best professional judgment, based on experience and current scientific literature review.

OFS is not intended to be old growth or necessarily to be retained as permanent reserves. It is intended to provide some or all of the structural components commonly associated with old growth. OFS will not necessarily emulate all the processes and functions of very old forests. Over time, research and monitoring will provide better understanding about the similarities and differences between OFS and older forests.

In addition to the variety of trees typically found in a layered stand, Older Forest Structure includes each of the following four characteristics.

- At least 8 or more live trees per acre that are at least 32 inches in diameter at breast height. For site classes 3, 4, or 5 on the Santiam State Forest at elevations greater than 3,000 feet, the diameter standard is lowered to at least 8 or more live trees per acre that are at least 24 inches in diameter at breast height.
- Two or more tree canopy layers. Frequently one of the layers will be a shade-tolerant species.
- Snags — at least 6 per acre, 2 of which must be at least 24 inches in diameter breast height; the remaining 4 must be at least 12 inches in diameter breast height.
- 600 to 900 cubic feet per acre of sound down logs (decay class 1 or 2), or 3,000 to 4,500 cubic feet of down logs in any or all decay classes 1-5.

In addition, the following characteristics are normally associated with older forest conditions, but they may be present to varying degrees and widely differing distributions. These conditions are not required to be present to meet the OFS definition. Managers should retain these components when they are present and should develop them in stands on the OFS management pathway.

- At least one large remnant tree per five acres. The tree must have some of the following characteristics — deeply fissured bark, large limbs or "platforms", broken tops, evidence of fungal decay, dwarf mistletoe, or other evidence of decadence.
- Multiple tree species — at least 2 species including an understory shade-tolerant tree species.
- Some trees within the stand contain defect or indicators of decadence.
- Diverse understory vegetation including herbs and tall shrubs.

Understory Reinitiation Process

The understory reinitiation process described under the Understory and Layered stand types is also the developmental process occurring in OFS stands. The understory reinitiation process occurs after stem exclusion, when enough light and nutrients become available to allow forest floor herbs, shrubs, and tree regeneration to again appear and survive in the understory. The new understory may grow very slowly at higher stand densities. The amount of understory brush and herbaceous species is minimal at the beginning of the stage, but increases to a substantial component of the stand by the end of the stage. In a stand where density management activities occur frequently, the understory may never be completely absent.

OFS stands are essentially LYR stand types that have achieved the structural characteristics identified in the definition of OFS. The characteristics identified are not "magical" thresholds that define a sharp line between use or non-use by species associated with older forests. The characteristics reflect specific structural characteristics often found in old growth conifer stands in the Pacific Northwest.

Old Growth

Numerous definitions exist for old growth. The one used here is taken from the glossary of the FEMAT Report (Forest Ecosystem Management Assessment Team) (USDA Forest Service et al., 1993).

> "Old-growth conifer stand — Older forests occurring on western hemlock, mixed conifer, or mixed evergreen sites that differ significantly from younger forests in structure, ecological function, and species composition. Old growth characteristics begin to appear in unmanaged forests at 175-250 years of age. These characteristics include (1) a patchy multi-layered canopy with trees of several age classes, (2) the presence of large living trees, (3) the presence of larger standing dead trees (snags) and down wood, and (4) the presence of species and functional processes that are representative of the potential natural community. Definitions are from the Forest Service's Pacific Northwest Experiment Station Research Note 447 and General Technical Report 285, and the 1986 interim definitions of the Old-Growth Definitions Task Force."

On the northwest Oregon state forests, large disturbances or timber harvest eliminated almost all old growth stands before the state acquired the lands. Currently only scattered old growth trees and a few remnant patches of old growth are known to exist in the planning area. In the future, old growth will likely occur on state forest lands in areas managed for special purposes such as riparian areas, nesting habitats for bald eagles or northern spotted owls, genetic stock of residual old growth trees remaining from the Tillamook Burn, or other areas of special concern.

Older Forest Structure is the managed stand type that is intended to emulate some, and possibly many, of the functions of old growth. As the *Northwest Oregon State Forests Management Plan* is implemented, scientific research and monitoring will be necessary to determine if Older Forest Structure can provide the functions of Old Growth or if the characteristics of Older Forest Structure should be modified to better emulate specific Old Growth functions.

Hardwoods

Hardwood stands are classified along with conifer stands in one of the five stand structure types. However, for the purpose of facilitating discussion, hardwood stands are defined as those stands where hardwood tree species comprise more than 70 percent of the tree canopy. Seventy percent is a subjectively set measure that identifies when the hardwood canopy is the dominant vegetative feature that characterizes the stand tree canopy and thus will likely control the focus of stand management practices. Seventy percent is also being used to identify hardwood stands by current research such as the "Coastal Landscape Analysis and Modeling Study" (CLAMS) (Tom Spies 1996). Common hardwood tree species include red alder, bigleaf maple, and Oregon white oak.

Field managers may choose to manage hardwood stands on the landscapes for a variety of reasons, such as to obtain economic benefits from hardwood products, to manage tree diseases in the stand, or to introduce or maintain additional vegetative diversity within conifer-dominated landscapes.

At this time it is assumed that a small percentage (probably 10 percent or less) of the landscape will be managed as hardwood stands. Maintaining a component of hardwoods within conifer stands is encouraged and it is anticipated that most stands will have some hardwoods. Implementation plans will better estimate how much of the landscape currently consists of hardwood stands and what portions of the landscape may be managed as hardwood stands in the future. If managers determine it is desirable to manage greater portions of the landscape in hardwoods, the forest management plan may have to be adjusted.

Landscape Management Principles

A **landscape** is defined as an area of land containing a mosaic of habitat patches, often within which a particular "target" habitat patch is embedded (Dunning et al. 1992). There is no one size of landscape for all classes of wildlife since each organism scales the landscape differently. What constitutes a single patch for a deer may be a landscape for a salamander. Planning for wildlife diversity at the landscape level requires consideration at a range of spatial scales. Landscapes are not necessarily defined by size; rather, they are defined by an interacting mosaic of patches related to the wildlife management objective in question.

The landscape **patch** may be defined as an environmental unit between which "quality" differs (Wiens 1976). While the stand may be the management unit "patch", it may or may not be synonymous with the habitat patch required for a particular class or individual wildlife species in question. Patches are dynamic occurring on a variety of spatial and temporal scales. In the case of a forested landscape, patches will change with changes in forest development or with disturbance.

Patches at any given scale have an internal structure that is a reflection of patchiness at finer resolutions. Any patch, therefore, is represented by finer scale patches, each of which is capable of supporting some portion of the habitat needs of the entire wildlife component inhabiting the forest. The lower size limit of a patch for a particular organism is that scale at which the organism no longer perceives it as suitable habitat. The upper limit of size is defined by an individual's home range (Kotliar and Wiens 1990). Patch size for populations or subsets of populations (metapopulations) will be larger. Patch boundaries are only meaningful when considered at a particular scale. An apparent abrupt edge is actually a continuous gradient of patches when viewed at a finer scale resolution.

The term **matrix** refers to the dominant landscape element in which patches are embedded. The matrix is the dominant and most connected landscape element and therefore exerts the greatest habitat contribution to the landscape in question. The relationship between patch and matrix is again dependent on scale, as shown in the figure below. Scale needs to be defined for the organism in question.

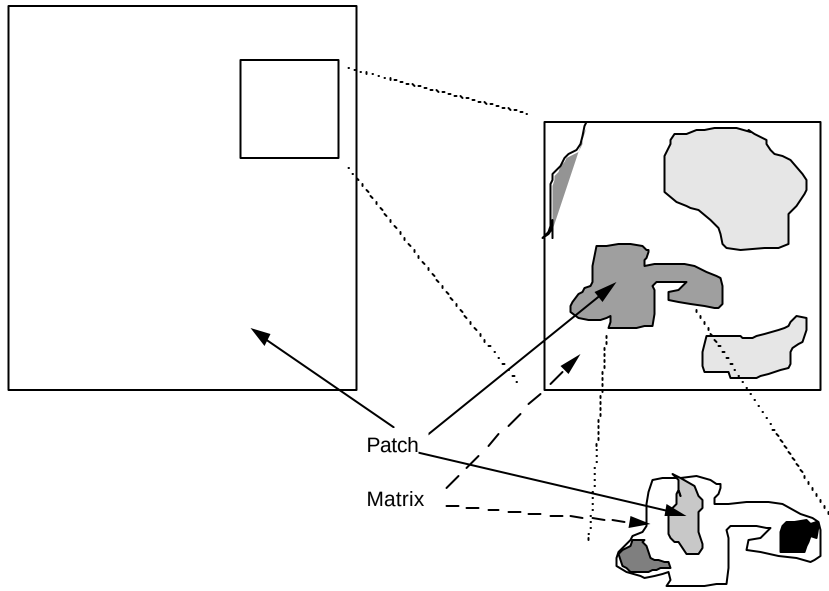


Figure C-6. Change in Patch Characteristics at Different Scales

As a general rule, fine scales can be assembled into coarser scales without the loss of information, but a loss of information will result if coarser scales are evaluated below the level at which the information was obtained.

The relationship of the dominant landscape patch (matrix) to other types of patches on the landscape is known as **fragmentation** (Franklin and Forman 1987). As fragmentation increases, the matrix becomes smaller, geometrically more complex, and more isolated over time. Maximum landscape fragmentation occurs when no dominant patch exists, as shown in the figure on the next page. In forests of the Pacific Northwest, fragmentation of the older forest matrix is of great concern. While experimental information for Pacific Northwest forests does not provide clear evidence (McGarigal and McComb, 1995), studies from other areas have been generalized to forest lands (Whitcomb et al. 1981, Robbins et al 1998). Classes of wildlife generally considered most sensitive to fragmentation in Pacific Northwest forests are habitat specialists preferring late seral forest interiors and wide-ranging species with low reproductive rates (Thomas et al 1990). Rather than representing a single trajectory, fragmentation in forested landscapes is probably both temporally and spatially dynamic. The mix of seral conditions across a given forested landscape may not represent clear distinctions in habitat suitability but rather gradations in suitability. The degree to which any class of wildlife is affected depends on the amount of habitat fragmentation and the relative suitability and pattern of surrounding habitat patches.

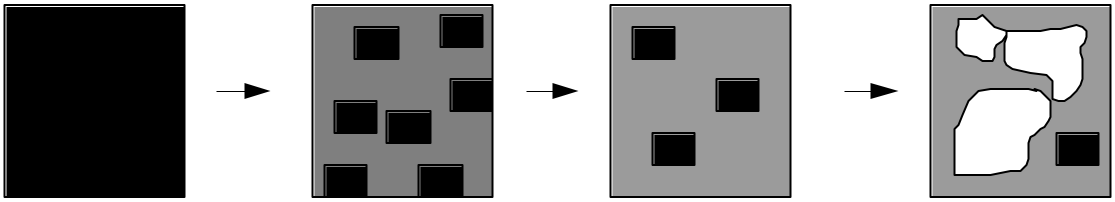


Figure C-7. A Landscape with Increasing Habitat Fragmentation

Landscapes do not exist alone. There is always a larger scale **context** within which several landscapes exist. This larger context provides the setting within which landscapes are evaluated. Context is most important when organisms can easily move between landscapes. Landscapes are generally evaluated at the watershed or several watershed level. A watershed may represent a useful landscape unit for purposes of planning but may not represent a useful scale for certain bird populations that migrate between watersheds. Recognition of the relationship of a particular species to its landscape and surrounding landscapes (context) is essential in order to provide the proper context for management. Proper landscape planning provides an obvious link between larger scales and implementation at the stand level.

Landscape structure is composed of two key landscape elements: **pattern** and **composition**. Both affect ecological processes and related wildlife populations. Landscape composition refers to the presence and amount of each patch type within the landscape independent of placement. Landscape composition is important to many ecological processes. Many species require habitat types of sufficient size and number to maintain themselves on the landscape. Composition alone may fulfill their population requirements.

Other organisms require additional considerations including those of patch size, shape, and placement of patch types relative to other patch types within the landscape. These attributes refer to landscape pattern. Both the distance between suitable patches and the spatial arrangement of suitable patches can influence population dynamics. Using computer modeling, McKelvey et al. (1992) has shown that both factors are important in northern spotted owl use of Pacific Northwest forests. Population dynamics of species with limited dispersal ability, such as amphibians, are affected by the distribution of suitable habitat patches. Likewise, organisms that require two or more different habitat patches may require patches in juxtaposition to assure that their entire life history requirements are met. Individual patch characteristics that have been found important for evaluating wildlife at the landscape scale include the mean and variability of patch size, shape, core area, and density. Similarly, important considerations that affect the relationship among patches comprising the landscape include nearest neighbor distance and connectivity (McGarigal and Marks, 1995). When viewed from a landscape perspective, structure-based management, which focuses on individual forested stands, will influence both pattern and composition.

For wildlife populations that benefit from the juxtaposition of different habitat patches, it is the combination rather than the type of individual patch that is most important. The response of wildlife to this type of landscape is referred to as **landscape complementation** and **landscape supplementation**.

Landscape complementation occurs when the presence of one type of resource in one patch is complemented by the close proximity of a different resource in a second patch so that larger populations can be supported in a given area. Deer and elk are examples of species benefiting from different habitats in close proximity (Wisdom et al. 1986). These wildlife species require both older forests and young forests for different life history requirements. Similarly, certain bird species such as the olive-sided flycatcher in the Coast Range are most abundant when older forest patches are next to patches with open canopies. Suitable nesting habitat is provided by older forests while foraging habitat is found in the open-canopy areas (McGarigal and McComb, 1995).

Landscape supplementation occurs when the juxtaposition of patches (similar or different) provides sufficient amounts of a given resource to sustain a population level above that provided in an individual patch. An example is brown creepers, which require some maximum amount of large saw timber over some area to successfully occupy and breed (McGarigal and McComb, 1995). Northern spotted owls require some cumulative amount of older forest patches within some maximum area for occupancy (Thomas et al 1990). Depending on the species in question, these needs may also reflect landscape composition and/or landscape pattern needs.

Certain landscapes can affect wildlife populations through **source/sink relationships**. In these landscapes, productive source patches supply emigrants to less productive patches termed sinks. Subpopulations within the sink areas are considered unstable and subject to extinction without new immigration from the source areas. In this manner, the total landscape functions to increase overall populations from a relatively small amount of source habitat. Maintenance of local sink populations within the landscape is dependent on the continued presence and proximity to source areas. Both landscape composition and pattern of source and sink patches can have an influence on overall population size (Thomas et al 1990).

Three factors have been found to define the functional patch size: 1) actual size; 2) distance from a similar patch; 3) degree of habitat difference of the intervening matrix (Harris 1984). These considerations are particularly important when dealing with older forest patches and their relationship to interior-dwelling wildlife species. The presence and abundance of a species in a particular patch can be strongly affected by the composition of adjacent patches.

The table on the next page illustrates this relationship. The table is taken from Harris (1984) and adjusted to structural characteristics defined within the *Northwest Oregon State Forests Management Plan*. Data in the table indicate that while different wildlife species prefer different structural categories, overlap in preference is greatest between similar structural types than between those more dissimilar.

These **neighborhood effects** or **edge contrasts** can be both positive or negative. In the case of habitat generalists such as deer and elk, the edge between different patches of habitat is generally considered important to the population. For other species, notably interior habitat specialists, high contrast edge can have negative effects. Rosenberg and Raphael (1984) found that for mature forest patch sizes less than 120 acres the frequency of interior habitat species observations was negatively correlated with the presence and amount of adjacent regeneration and young forest patches. The decrease in interior habitat specialists noted by these authors could have resulted from several factors including predation, competition, and nest parasitism from species occupying adjacent patches. It could also be the result of changes in habitat quality due to microclimatic changes within older forest patches due to increased light intensities, wind, and other unbuffered climatic factors from surrounding open areas (Chen et al. 1992, Harris 1984).

Table C-2. Similarity Coefficients between Stand Structure Types

(Coefficients are between designated pairs of structure types, for wildlife species using each stand type as primary habitat.)

	REG	CSC [1]	CSC [2]	UDS	LYR	OFS
REG	1.0	.91	.53	.52	.43	.42
CSC [1]		1.0	.60	.59	.47	.46
CSC [2]			1.0	.96	.69	.67
UDS				1.0	.73	.70
LYR					1.0	.97
OFS						1.0

Source: Based on Harris 1984, adjusted for *Northwest Oregon State Forests Management Plan*.
1. Seedling/sapling stage.
2. Pole-sized stage.

The degree of isolation between suitable habitat patches due to the influence of edge contrasts can range from complete isolation to partial or only small influences on access to adjacent habitats. **Corridors** have the opposite function of boundaries. Corridors facilitate movement of individuals between habitat patches, serving to connect separate but similar habitat patches within the landscape mosaic. They may act to channel dispersing individuals into pathways between patches or provide “intermediate” habitat of sufficient quantity and quality for survival until the species can find suitable habitat in another patch. The presence and location of corridors provide important contributions to the functionality of patches within a landscape.

The most important wildlife habitat to consider in landscape planning is older forests. This habitat is considered important because of its limited supply within western Oregon and because over 118 species rely on this habitat for most or all of their life history requirements (Harris 1984). Management emphasis of this element also ensures that other developmental phases will be maintained during the course of expected forest development.

The quantity of effective older forest habitat is often smaller than the total amount within a given landscape. **Interior habitat area (IHA)** is defined as that portion of the older forest patch that remains effective when the negative effects of high contrast edge are removed. Three factors influence the amount of IHA in relation to total patch size: 1) degree of edge contrast with surrounding patches; 2) patch configuration which changes the amount of edge and hence the amount of IHA; and 3) size of the older forest patch.

For a given patch configuration, the amount of IHA is smallest when edge contrast is highest. IHA also decreases when the shape of the patch increases the amount of edge. Harris (1984) states that for landscapes where older forest patches are adjacent to high contrast edge (REG or early CSC) patches, habitat conditions within the older forest patch can be negatively affected up to six tree heights (600 feet) from the boundary (see also Chen et al. 1992). A 775 acre circular patch (smallest edge to interior ratio), for example, would consist of 35 percent edge area and provide only 504 acres of IHA. Similarly, a circular stand would need to be 7,000 acres in size to reduce the 600 foot edge influence below 10 percent of the total area. Surrounding patches (late CSC, UDS, or LYR) can be used to moderate climatic and predation influences within older forest patches. Data from Table C-2 suggests IHA can even be increased for certain older forest-dependent species by juxtaposition of complementary structural stages.

Not all older forest-dependent wildlife needs the same size IHA to assure maintenance of wildlife diversity. To assure adequate IHA patch sizes are maintained across the landscape, three factors must be considered: 1) the size frequency distribution; 2) a measure of the central tendency (mean); and 3) a measure of dispersion (variance). Several arguments have been put forth for using a log-normal distribution to define the size and number of habitat patches for maintenance of wildlife diversity. The first argument relates to the relationship between trophic level, home range size, abundance, and spatial movement of wildlife, which tend to follow a log-normal distribution. Second, energy flow within landscapes is related to certain disturbance processes such as fire and windstorms, and landscape features (watershed area and the distribution of stream lengths), which also follow a log-normal distribution (Strahler 1957, Shugart 1984). A theoretical variance for many of these relationships has been calculated to be 0.2. Mean size is dependent on the type of species in question. For those with larger home ranges, a larger mean patch size is necessary than for species with smaller home range sizes. A mean patch size somewhere in the middle of this range is best for conserving overall wildlife diversity.

Concepts for the Landscape Management Strategies

Landscape Management Strategies 1 through 4 are the heart of structure-based management. These strategies are presented in Chapter 4. This section of Appendix C provides a detailed explanation of the concepts behind those strategies.

The Array of Stand Structure Types

Landscape Management Strategy 1 states that the Oregon Department of Forestry will "actively manage the state forest landscape and forest stands to produce [an] array of stand structure types across the landscape…" Table 4-2, on page 4-43 of the plan, displays the long-range desired future percentages for the five different stand types, across the state forest landscape.

The stand structures are not an end in themselves. The stand structures are designed to emulate the diversity of stand types historically associated with conifer forests in the Coast Range and Cascades. Several studies have been done on the historical distributions of older stand types (old growth) in the Oregon Coast Range (Juday 1977, Teensma et al. 1991, Zybach 1993, Spies et al.). These studies have produced a range of possible answers. At the province scale, research suggests that the percentage of older stand types ranged from 30 to 70 percent of the landscape at any point in time. At smaller scales, the variability was even greater, ranging from 15 to 85 percent of the landscape at any point in time.

Once the range of stand types reaches the desired future condition, individual stands on the landscape will continue to change; however, the relative abundance of the different types will be reasonably stable. At some point decades in the future, a dynamic balance will be achieved of the stand types in the desired percentages, and individual stands will move in and out of the various types at a relatively even rate.

Stands will vary in size and exist in a variety of arrangements (see Landscape Management Strategy 2 in Chapter 4, and the other concepts discussions in this appendix). Generally speaking, individual watersheds will have a mix of all stand types. However, some watersheds may have only one or two of the stand types at any point in time. Interior forest habitats will be part of the mix. Decisions on the mix in any given basin will be made at the district level in implementation plans (see Landscape Management Strategy 4).

Determining the landscape percentages — Both objective and subjective processes were used to determine the plan's desired future percentages for the stand structure types. Foresters and biologists from the planning team considered the following factors.

- The available information on historical distributions of older stand types in the planning area (as referenced above). Although the goal was not to re-create these same conditions, the historical patterns helped the team to evaluate what array of stand types might emulate habitat functions for native species.
- The array of habitats necessary to support populations of all native wildlife species, with particular concern for having enough older forest stands to provide for key species of concern (northern spotted owl, marbled murrelet). This decision was based on available information and the professional judgment of wildlife biologists.
- The array of stand types and conditions that could concurrently provide the needed habitats, enhance and maintain biodiversity, and provide for sustainable timber and revenue levels consistent with the plan's goals.
- The current array of stand types on lands in the planning area, and the knowledge that it will take many decades to achieve the desired future amounts of the older stand types. As part of the adaptive management strategy, the plan includes requirements for periodic reviews, as part of implementation. Through these reviews, the desired future condition for stand types can be changed as better information comes available.

The stand structure types correlate with at least four different types of habitats. Open habitats occur during the regeneration stage, and closed canopy habitats are associated with the closed single canopy stage. In the understory and layered stand types, habitats have more horizontal and vertical diversity and offer a variety of habitat niches. Older forest structure and some layered stands provide habitats commonly associated with older forests or old growth.

Precise percentages vs. ranges of stand types — There are several reasons for using percentage ranges for the desired future array of stand types instead of setting an exact percentage, such as 20 percent, for each type. First, the stand types as defined do not always appear on the landscape as clearly defined, discrete types. Regeneration stands blend into closed single canopy stands with the onset of crown closure. A newly developing understory may be short-lived or it may become established. The exact point at which a closed single canopy stand should be classified as understory or an understory stand as layered is open to individual interpretation.

Second, there is no single right answer for the appropriate balance of the stand structures. Historically, the stand structures present in the northwest Oregon state forests have varied greatly. Large wildfires like the Tillamook Burn have significantly reduced the diversity of stand structure types within specific watersheds or regions. Wildlife populations have always fluctuated in accordance with the amount of available habitat, as well as from other natural factors.

There is currently no research that supports one specific, idealized array of stand structures optimal for all species. It is clear, however, that providing for the habitat needs of all native species will require producing all habitat types or surrogates.

For all these reasons, precise numbers are unnecessary for the stand structure percentages, and the loss of flexibility could lead to poor long-term forest management. The planning team identified ranges that would provide a reasonable chance of successfully providing the full array of habitats for native species, without boom and bust cycles.

Regional percentages vs. planning area-wide percentages — The planning team also considered setting regional stand type percentage goals to reflect the local conditions in each management district. Oregon Department of Forestry district personnel, Oregon Department of Fish and Wildlife (ODFW) field biologists, and members of the planning team discussed issues to clarify the regional context for each district. The discussions focused on physiographic conditions that might require different structural goals, based on the different habitat needs of wildlife in various parts of the Coast Range, or differences between the Coast Range and the Cascades. Variations in land ownership patterns among districts were also discussed as a basis for setting different targets.

ODFW biologists from the North Coast Range, Central Coast Range, and Cascades all concurred that although some differences in habitat needs may exist between the Coast Range and Cascades, there was no basis for setting different ranges of stand structure arrays for these two geographic areas. There was no biological reason to use different percentages within the northern and central Coast Range.

The team considered adjusting the desired array at the landscape level based on the habitats that are likely to be provided on adjacent forest lands owned by others. However, history suggests that it is difficult to predict exactly how other landowners will manage their lands over the long term. The one thing that is certain is that these landowners will change their management over time. The team concluded that forest management on adjacent forest lands should be considered at the level of district implementation plans.

Management Pathways

Landscape Management Strategies 1 and 2 state that the Oregon Department of Forestry will use active management to move stands toward the stand structure and landscape design goals. The following descriptions should give the reader a better understanding of how management will proceed with SBM. The management pathways described here are examples, not prescriptions. Silvicultural practices mentioned in this section, such as regeneration harvests, shelterwood cuts, and group selection, are explained later in this appendix, under the heading, "Silvicultural Practices."

Management Pathways for Achieving Stand Types

- ❑ **Stand Type: Regeneration (REG)**

Pathways — Regeneration harvests must occur to maintain or achieve open habitats and stand initiation on 5-15 percent of state forest lands on each district. Clearcuts, patch cuts, shelterwood cuts, and group selection cuts are types of regeneration harvests that will create REG. These harvests will maintain a sustainable flow of timber and revenue to local markets, economies, and governments, and will maintain the desired amount of REG on the landscape.

- ❑ **Stand Type: Closed Single Canopy (CSC)**

Pathways — Many of these stands originate from REG stands that have reached crown closure, or they are stands that have been so densely stocked that virtually no understory exists. They may persist for a long time unless density management activities are carried out to produce understory (UDS) stands, or regeneration harvest returns the stands to the REG stage.

Stands in the closed single canopy stage will be managed to meet the whole range of desired stand structure conditions and products. Each stand will be managed based upon its potential to meet the planning goals. Some of these stands will lack many of the essential components or have low potential to produce more complex forest structures — these same stands may have high value for timber production. Others will have greater potential to develop into more complex forest structures over time. Field foresters will evaluate each stand's potential and determine how many stands are available to produce the array of stand structures. Then they will decide which stands will be managed to produce understory (UDS), layered (LYR), or older forest structure (OFS). See the text box on the next page for an example of the decision process that could be used to develop silvicultural prescriptions for closed single canopy stands.

Example: Developing Prescriptions for Closed Single Canopy Stands

If a stand is in the closed single canopy stage and:

1. It offers good silvicultural potential for future wood growth or development of desirable stand characteristics, then prescribe for:
   A. Pathway that does not head for OFS; retain biodiversity components such as snags, coarse down wood, etc.; or —
   B. Pathway that heads for UDS, LYR, or OFS; retain biodiversity components and develop multi-canopied structure, or —
   C. General density management for vigorous growth that defers the decision on the ultimate stand structure for the given stand.
   D. Regeneration harvest — if there are excess acres in CSC, prescribe regeneration harvest to meet REG goals or to realize timber value.
2. It does not offer good silvicultural potential, then prescribe for regeneration harvest in near future, unless other management priorities exist.

❑ Stand Types: Understory (UDS) and Layered (LYR)

Pathways — A broad range of stand conditions exists in these stages. Stands in both stages are dominated by trees (rather than shrubs or herbs). Stands of trees may range from larger than sapling size to the very largest conifers. The following four conditions represent the range.

- The least developed of these stands consist of a single species, single-layered main tree canopy with an understory of shrubs and herbs that is more diversified than simply having one or two shade-tolerant species (UDS).
- The understory appears vigorous and is beginning to diversify. However, herbs, shrubs, and understory trees are not yet fully diversified. Some vertical layering occurs but is not extensive (UDS).
- The organization and structure of the living plant community is complex. Vertical layering of tree crowns, shrubs, and herbs is well developed (LYR).
- Plant communities are complex, layering is extensive, and snags, down wood, tree litter, and soil organic matter are present (LYR).

Field foresters will evaluate each stand's potential and determine how many stands are available to produce the array of stand structures. Then they will decide which stands will be managed for UDS, LYR, or OFS. Stands with more complex structural development will be more likely to be managed to produce OFS. See the text box on the next page for some possible silvicultural prescriptions for UDS and LYR stands.

Example: General Prescriptions for Understory or Layered Stands

Here are some possible general prescriptions for stands in the understory stage.

A. Pathway that does not lead to OFS; retain biodiversity components such as snags, down wood, etc.

B. Pathway that maintains understory condition or leads to layered or OFS; retains biodiversity components and develops multi-canopied structure.

C. General density management for vigorous growth that defers the decision on the ultimate structure for the given stand.

D. Regeneration harvest for excess acres in this type that are not necessary contributors for other structure types.

- ❑ **Stand Type: Older Forest Structure (OFS)**

In this stage, further LYR stand development features include large trees, canopy layering, snags, and substantial down wood. Time has allowed functional processes to develop among a broad biotic community. These stands should be maintained on the landscape for a period of time (generally 20 or more years) to allow them to function ecologically.

These stands will be managed to maintain their desirable biodiversity characteristics, vigorous growth, and timber yield. These stands will be valuable for their outstanding timber production and standing volume, and for their biodiversity benefits.

Example: General Prescriptions for Older Forest Structure Stands

At least two general prescriptions are likely.

- Pathway for vigorous stand growth, biodiversity components, and multi-canopied structure.
- Regeneration harvest of excess acres in this stand type.

Patch Types, Patch Sizes, and Patch Placement

Landscape Management Strategy 2 states that the Oregon Department of Forestry will "actively manage the forest stand types to create a variety of patch types, patch sizes, and patch placement on the state forest landscape."

In order to conserve biodiversity at the landscape level, planning must address both fine and coarse scale resolutions. This strategy is a coarse scale approach. The **coarse scale** includes all scales from the regional context down to the stand (fine scale). The number of different patches and their size, shape, location, and relationship to other patches (landscape composition) determine landscape structure. Coarse scale planning is accomplished by using individual stands of similar structure as the basic building blocks to form different sized patches of similar habitat value. These patches are then arranged across the landscape to optimize habitat connectivity through time and space.

This strategy describes the patch types, and addresses considerations for landscape planning at the regional, district and management basin level. In this plan, the stand is the **fine scale** unit of analysis. Composition at this scale will be addressed using the within-stand approaches identified in SBM Strategy 4. These include considerations of stand vertical stratification, snags, residual live trees, down wood, and species composition.

Wildlife use discriminates between three fundamental patch types on forest land: young, pole-sized, and mature forests. The table below compares patch types to the stand types used in this plan.

Table C-3. Comparison between Landscape Patch Types and Stand Types

Landscape Patch	Stand Type
Young forest	Regeneration through closed single canopy sapling stands
Pole-sized forest	Closed single canopy pole-sized through layered stands
Mature forests	Closed single canopy, understory, layered, and older forest structure stands (trees larger than pole-sized)

It is difficult to plan simultaneously for sufficient patch structures within all patch types. But because forest stands develop through a typical progression of stages, it is possible to plan for some specific patch types and then assume that the stands will progress through the other stages. We emphasize mature forest patches and interior habitat area (IHA) in our planning. This does not mean that other patch types are any less essential. All stand types and the corresponding patch types are essential if habitats for all species are to be provided. This approach simply chooses to anchor landscape design to the development of interior habitat areas. The rationale for this decision is given on the next page.

- IHAs are only associated with mature forest patches.
- The wildlife component associated with IHAs is usually the component limiting our ability to reach wildlife diversity goals in forested landscapes.
- Acreage of mature forest conditions that produce IHAs are limited within the planning area.

We know that IHAs are critical for many wildlife species that prefer mature forests and that older forest structure, layered, and to a lesser extent, understory structural stages are components of mature forests. Associating layered/understory structural stages with older forest structure can increase functional IHA size for these species. This allows us to increase the amount of IHA above that possible if we assumed that older forest structure is the only stand type that can produce IHA. Forest management can help to develop a landscape where older forest, layered, and understory stands are next to each other, and maintain greater amounts of IHA than would occur if these stands were scattered. An increased number of IHAs and resulting decreases in average nearest-neighbor distance across the landscape will benefit wildlife associated with IHAs in the ways listed below.

- Facilitating conservation of endemic species in unique habitats and genetic variation within species.
- Providing improved linkage to similar habitats.
- Facilitating potential immigration and genetic interchange within wildlife populations.
- Increasing the probability for frequent colonization of species extinct from a particular portion of the landscape.
- Increasing use by territorial wildlife species.
- Providing buffers against widespread disease or catastrophic events.

Guidelines for IHAs and Other Patch Types across the Landscape

Each scale of consideration addresses different landscape functions and different wildlife conservation issues. The table on the next page is a matrix that identifies the types of landscape considerations to be addressed at each scale.

Regional Scale

The regional scale is the largest scale considered. Decisions at this scale typically address regional conservation goals such as threatened species recovery strategies and are therefore generally broad. Decisions made at this level generally do not consider the importance of IHAs specifically. This is left to the implementation planning, typically conducted at the district and basin levels. It is important to emphasize that this forest plan alone cannot solve regional conservation issues. Consideration at this scale does, however, provide a rational basis to assess the contribution of state forests to these larger management issues and to determine the appropriate role of this plan within this larger context. Also see the proposed *Western Oregon State Forests Habitat Conservation Plan* for an assessment of the state forests' contribution to regional conservation goals for northern spotted owls and marbled murrelets.

Table C-4. Matrix of Planning Decisions Appropriate at Various Scales of Landscape Planning

Considerations	Region	District	Basin	Stand
Contribution to population goals for T&E and sensitive species	X	X		
Structural goals		X		
Patch size distribution		X		
Recreational sites		X		
Sites with operational constraints (unstable/steep slope)		X	X	X
Unique habitats such as wetlands, eagle sites, etc.		X		
Scenic corridors and viewsheds		X		
Desired basin stand structures		X	X	
Current stand condition			X	
Riparian management strategies			X	
Placement of patch & stand structure types			X	
Consideration of isolated stands			X	
Consideration of adjacent land uses and adjacent basin patch location			X	
Edge considerations			X	
Connectivity between patches		X	X	
Patch relationships between aquatic and upland management units			X	
Location of replacement stands/patches		X	X	
Big game management considerations		X	X	
Timber harvest plans and operation-specific decisions			X	X
Structural components (down wood, layered canopy, snag goals)			X	X
Within stand diversity (gaps)				X
Species composition				X

District Scale

The district scale is where stand structural goals are set and the frequency distribution of IHA patch sizes is defined. It is also at this level where decisions are made on how the overall frequency distribution of IHA patch sizes should be allocated across various basins based on current age structure, regional conservation contributions, and the relationship with other plan considerations including recreation, scenic quality, operational constraints, etc. Decisions can lead to allocation of certain basins to emphasize different parts of the distribution, for example, high fragmentation versus low fragmentation basins.

The frequency distribution should act as a guideline rather than specific allocation targets. Questions asked should revolve around whether the general proportion of stand sizes and numbers are represented district-wide, and how each management basin plan individually and collectively contributes to the range of patch sizes and numbers. As an example, a size frequency distribution has been developed for the Tillamook State Forest in the table below and the figure on the next page. The example illustrates the criteria described earlier to define the number and size of IHA patches required to meet biodiversity objectives for a specific land unit. The following assumptions apply to the example.

- Total acreage is 250,000 acres, 90 percent of which is managed forest land.
- Percent allocated for structural types LYR and OFS is at low end of range.
- 90,000 acres possible in LYR/OFS patches.
- Average patch size of 250 acres.
- Minimum patch size of 40 acres.
- Variance of 0.4.

Table C-5. Example: Summary of Patch Sizes for the Tillamook State Forest

Number of Patches	IHA Patch Acreage Range and (midpoint)	
63	0-80	(40)
128	80-120	(100)
85	120-200	(160)
68	200-320	(260)
41	320-520	(420)
19	520-840	(680)
7	840-1360	(1100)
2	1360-2180	(1780)
0.5	>2180	(2880)

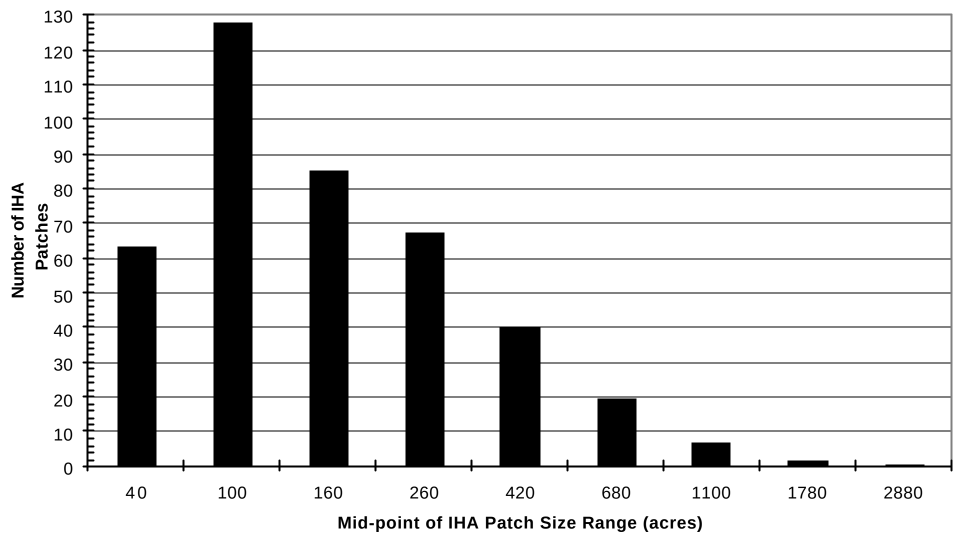


Figure C-8. Frequency Distribution of IHA Patch Sizes for the Tillamook State Forest

Management Basin Scale

The management basin is the scale at which most implementation planning decisions are made. Broad decisions have already been made at the district level that recognize relative contributions of the basin to district-wide distribution of patch sizes based on certain constraints and management options. These decisions indicate, generally, how much fragmentation exists or will occur, and the mix of large and small patches desired. Based on this information, management basin planning will make refinements to define the desired range of stand structures for the area.

Considerations in Determining The Location, Number, Size, and Configuration of IHAs (Interior Habitat Areas)

I. Size, composition, and configuration

- IHAs can include OFS, or OFS with some combination of UDS/LYR/UDS when adjacent or in the immediate proximity to each other. Whenever possible OFS should be located near the center of the patch.
- Minimum patch size 40 acres IHA, with minimum edge to interior ratio. This lowest size class must be made up of only the OFS structural stage. OFS patches less than 40 acres do not count toward the OFS percentage of stand structures.
- OFS/LYR/UDS in juxtaposition can be used to define IHA patches above the minimum (midpoint 100 acres) when:
  1. 50 percent or more of the IHA patch is OFS, and
  2. 15 percent or less is UDS, and
  3. OFS stands contributing to the patch have 15 percent or less insularity (border REG, CSC, UDS).

- For larger patch sizes (greater than the midpoint of 420 acres), the percentage of LYR and UDS can increase. The UDS patch contribution cannot exceed 40 percent.
- Larger IHA patch sizes are necessary to obtain similar function if the patch is oriented in a manner (rectangular, oblong) that increases the ratio of edge to interior habitat. A long, narrow IHA patch such as one associated with a riparian management area may not represent any IHA unless it extends upslope to decrease its edge to interior ratio. It is best to make a rough approximation of the edge influence from adjacent REG, CSC, or UDS patches in determining the correct patch size.

II. Corridor and patch placement

Patch placement will be a function of topography, relationship to corridors, and silvicultural considerations.

- Laying out riparian protection areas with scenic, recreational, unique habitat, unstable slope, and owl conservation areas (if applicable) and using natural drainage patterns can give a first approximation of where IHA patches can be located to serve several complementary functions.
- Final locations should include consideration of how the patches are linked together using habitat corridors. Smaller or narrow patches scattered throughout the planning area act as corridors to enhance wildlife movements between suitable habitat patches. Such areas may be smaller than the minimum patch size for IHAs and may not contribute to the OFS percentage in the array. Nonetheless they enhance the function of IHA patches. Corridors can be as narrow as riparian management areas and as small as unique habitat areas. Riparian management areas can be used effectively to link patches within a drainage. This will also provide linkages between upland and riparian mature forest areas. Corridors can also be dispersal habitat linking northern spotted owl conservation areas. For spotted owl emphasis areas, corridors can link a series of IHAs to form a patch of larger suitable habitat. See Figure 8 on the next page as an example of patch placement within a drainage.
- Minimum patch distance between IHA patches should be a function of size and frequency within a management basin. Smaller patches should be placed closer together than larger patches.
- For an isolated patch, with greater than 50 percent of its boundary adjacent to REG/CSC or surrounded by forest land where future patch contributions are not anticipated, such as plantations on other land ownerships, the minimum size should be increased to 120 acres. Isolated patches below 120 acres will provide benefits for only a limited array of species inhabiting older forest conditions. Retention of isolated patches below 120 acres should only be maintained when addressing short-term biodiversity goals. Long-term biodiversity is best accomplished where corridors and similar habitats are in close proximity.

- Anticipate patch placement through time. It is important to maintain IHA habitat until sure that replacement patches will be available. This can best be done by focusing on maintenance of the entire patch and how forest management will maintain similar habitat through time rather than on individual stands making up the patch.
- As a general rule, the size of the IHAs should follow the size of other landform units within the basin. This means that smaller IHAs would be placed higher in the drainage associated with smaller stream and corridor networks. IHAs placed in headwater areas can function as Amphibian Emphasis Areas as detailed in the riparian management strategies.
- Place IHAs near drainage divides to enhance species movements between watersheds.

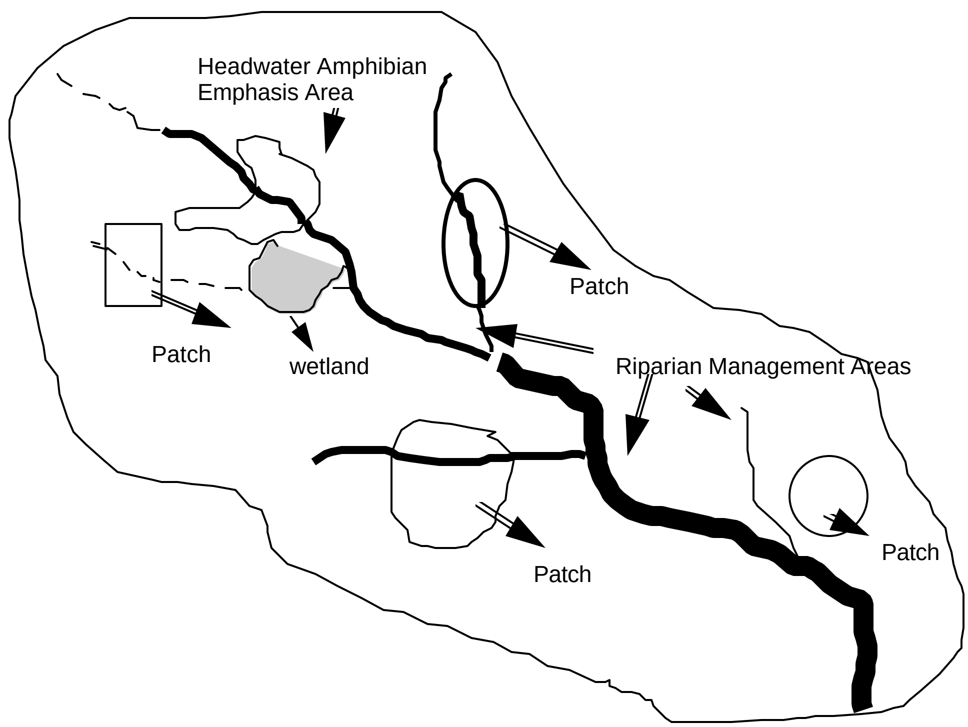


Figure C-9. Example: Patch Placement in a Drainage

The figure shows corridor linkages with riparian management zones of different sizes.

III. Relationships between basins and adjacent land ownerships

Each basin will have a different amount and placement of IHAs, riparian corridors, and other unique habitat areas. Each of these areas can maximize its contribution to overall wildlife diversity when considered in relation to other similar habitat within the basin (see the figure above) as well as in relation to similar habitat within adjacent basins.

- Consider basins collectively rather than in isolation when establishing patch placement. Plan from larger scales to smaller.
- Consider adjacent land ownership. If the adjacent ownership emphasizes late successional forests, location of smaller patches along the boundary can increase the effective size of the patch. Similarly, if adjacent land ownership manages primarily for early seral types, the patch size to produce IHA habitat will need to be larger to be functional because of the expected high edge effect.
- Effective IHAs can be increased by sharing structural stages (UDS/LYR/OFS) across basin boundaries. A small habitat area (less than 40 acres) may not count toward the OFS percentage of the stand array by itself, but placement of it next to similar habitat in an adjoining basin may make it sufficiently large to count.

Managing for Key Structural Components

Landscape Management Strategy 3 presents approaches for managing the key habitat components listed below, followed by the reasons why it is important to provide these habitat components within the managed forest.

- Remnant old growth trees
- Residual live trees
- Snags
- Down wood
- Multi-layered forest canopies
- Multiple native tree species (conifers and hardwoods)
- Herb/shrub considerations
- Gaps

Structure-based management requires managing the structural components of stands, as well as arranging structure types on the landscape. This challenge requires managers to weigh all factors important to the long-term sustainability of the forest ecosystem, and also to consider the short and long-term productivity of the forest for human needs. Effective control of wildfires may be adversely affected by multi-layered canopies, down wood, and tall snags. Through careful planning of the spatial arrangement and temporal occurrence of stands and structural components on the landscape, managers can find reasonable approaches to develop the desired forest structural characteristics for wildlife and biodiversity, while still protecting the forest from unwanted wildfire. It is likely that trade-offs will have to be made in specific locations within districts. However, on a district-wide basis, both fire control and the desired array of stand structures can be accomplished.

The structural components will be retained during any management activities unless they create clear safety or fire hazards, or if their retention would result in unacceptable additional operational difficulties, environmental hazards, or threats to public improvements. Examples of unacceptable operational difficulties include situations where the location of a tree might require relocating a road to a less stable place, or require that a substantially longer road be built to avoid the tree. Examples of situations where a decision may be made to remove a residual tree, snag, or patch of trees include situations where if the tree(s) came down through windthrow or other natural causes, they would likely damage improvements such as bridges or buildings, or cause road washouts or other road damage. It is expected that the vast majority of structural components will be retained, and there will be few situations where these components must be removed.

Remnant old growth trees — Existing old growth in the planning area occurs as widely scattered individual trees, and occasionally as small isolated patches. Because the occurrence is limited, the Department of Forestry's intent is to retain all existing old growth to provide this element of diversity in present and future stands. The discussion below about residual live trees applies to remnant old growth trees also.

Residual live trees — Residual live trees help to meet the short-term habitat needs of species, to serve as a source of future snags and down wood, and to provide legacy trees in future stands. Legacy trees are living trees that are carried forward into a new stand following disturbance, with the intent that they will remain.

When remnant trees survive a disturbance or are retained after regeneration harvest, they have major effects on the forest stand that grows on that site. Remnant trees are important for recruitment of snags and down wood within the developing stand. Patches of green trees of various sizes, ages, and species promote species diversity and may act as refugia or centers of dispersal for many organisms including plants, fungi, lichens, small vertebrates, and arthropods (USDA Forest Service et al., 1993). In addition to providing raptor perches and foraging substrate for animals living in young plantations, residual green trees in regeneration harvest units may allow development of structurally diverse stands and landscapes in later stages of forest development (Zenner 2000).

A key structural component of older forest structure stands is the presence of large trees. One way to sustain this structural component within a managed forest is to retain enough residual green trees in regeneration harvest units to provide the required level of large trees in a future older forest structure stand.

Diversity of tree structure should be considered when selecting trees for retention. Complex canopy structure and especially leaning boles are beneficial for some lichens. Trees that are asymmetrical provide a diversity of habitat substrates and often have more lichen and moss epiphytes on large lateral limbs than symmetrical trees (USDA Forest Service et al., 1993). Trees with some level of defect are likely to die and become snags sooner than straight, healthy trees. Relatively sound trees with healthy crowns are more likely to survive and contribute to habitat structure throughout the next rotation.

Distribution — Live trees can be left in either a scattered or clumped distribution in final harvest units. Both distributions provide many of the same wildlife benefits, but each provides unique benefits not provided by the other distribution.

Providing leave trees in a scattered distribution over part of the landscape may substantially reduce the amount of the time it takes for the stand and the landscape to develop multi-storied canopies.

On the other hand, patches or clumps of trees may provide better protection for special micro sites such as seeps, wetlands, or rocky outcrops (USDA Forest Service et al., 1993) than scattered individual trees. Placement of clumps of leave trees in headwater drainages may protect important habitats for amphibians.

Providing a diversity of arrangements is the key to managing for a range of species. Managers must combine these habitat ideas with operational considerations to make decisions on a site by site basis, within the landscape context of providing a diversity of arrangements.

Diversity of tree structure should be considered when selecting trees for retention. Complex canopy structure and especially leaning boles are beneficial for some lichens. Trees that are asymmetrical provide a diversity of habitat substrates and often have more lichen and moss epiphytes on large lateral limbs than symmetrical trees (USDA Forest Service et al., 1993). Trees with some level of defect are likely to die and become snags sooner than straight, healthy trees. Relatively sound trees with healthy crowns are more likely to survive and contribute to habitat structure throughout the next rotation.

Snags — Snags help to meet the habitat needs of cavity-using species and to serve as a source of future down wood. Snags can be provided in all stand types, through a combination of existing snag retention, natural mortality in maturing stands, and artificial creation.

Standing dead trees are important to many species of wildlife, including woodpeckers, other cavity-nesting birds, raptors, bats, marten, bear, and many other birds and mammals. In fact, 55 species of wildlife require or frequently use snags for breeding, roosting, or denning in the Pacific Northwest (Weikel and Hayes 1999).

The number and diversity of cavity-using species in a forest stand are heavily dependent on the number of suitably sized snags within that stand. In natural forest stands, the highest level of cavity-nesting bird habitat is usually found in old growth forests, followed by newly regenerating stands (Mannan et al. 1980, Nelson 1989). With sufficient snag retention, managed forest stands in the regeneration stage may support healthy populations of cavity-using species; however, clearcuts where snags have been removed support very few (Schreiber 1987, Morrison and Meslow 1983).

It is apparent that, without special management, the number and diversity of cavity-using wildlife will decline within forests managed under traditional silvicultural systems. Current projections suggest that few commercial forests will be allowed to develop beyond 80 years of age (Sessions et al. 1990). Stands with an 80-year rotation will not be able to develop naturally the biological legacies of snags and down wood that are currently found in many plantations. However, if snag recruitment is properly managed during the rotation, snag management can retain a functional community of cavity nesters within the managed forest.

The snag management guidelines presented in this forest management plan are designed to provide nesting, roosting, foraging, perching, and denning habitat for the various species of wildlife that use snags in the forests of northwest Oregon.

Very little information exists on the size and abundance of snags required to maintain viable populations of species that use snags for part of their life history. Neitro et al. (1985) developed a model to determine the number of snags needed to maintain specific population levels of certain species of cavity-nesting birds. A critical assumption of this model is that if there are enough snags to provide nesting habitat for the target species, there will also be sufficient foraging habitat available to provide for the desired population levels. Weikel and Hayes (1999) contend that consideration of nesting resources alone in managing for cavity-nesting birds is probably inadequate, and that foraging resources also need to be considered. An adequate prey base cannot necessarily be supported when providing only for nesting trees. Given the uncertainties of the model's assumptions, the department is taking a different approach to snag management on state forest lands.

The department's approach is to manage for snags at levels approaching known historical levels. Spies et al. (1988) characterized snags and down logs in fire-originated stands in western Oregon and Washington, offering a view of the historical condition of snags in these areas. In the Oregon Coast Range, they found an average of 2 to 4 snags per acre greater than 20 inches dbh and more than 16 feet tall. In the Cascade Range they reported an average of 3 to 6 snags per acre of this size. These researchers included snags in all decay classes, from old, soft snags, to recently created hard snags. Soft snags may take many years or even decades to develop. The Department of Forestry's strategy is to retain all existing snags wherever possible and to provide at least 2 hard snags per acre across the landscape. In stands designated for older forest structure, the strategy is to manage for 6 snags per acre.

Spies et al. (1988) found that old growth stands had the greatest abundance of large snags, and younger stands had higher densities of small snags. Preference for large diameter snags has been documented for several species of cavity-nesting birds (Mannan et al. 1980, Schreiber and deCalesta 1991, Zarnowitz and Manuwal 1985, Bull et al. 1997). Neitro et al. (1985) reports that 10 of 11 species of cavity-nesting birds occurring in western Oregon and Washington used snags with diameters of 15 inches and greater. In the Coast Range, the overall mean snag diameter for 26 species of cavity-using species ranged from 12 to 29 inches, with only 2 species using cavities in trees less than 20 inches dbh (Weikel, unpublished data). The Department of Forestry's strategy is to provide snags of at least 15 inches dbh across the landscape, and in older forest structure at least 2 of the 6 snags per acre will be greater than 24 inches in diameter.

Rationale for snag distribution requirements — The distribution of snags is an important consideration. Most cavity-nesting birds defend nesting and foraging territories and exclude all other individuals. Snags may be distributed in either a clumped or scattered distribution.

Cavity nesters in natural forest stands tend to nest within aggregations of snags, or snag patches (Nelson 1989). However, this tendency may occur simply because snags in natural stands tend to occur in clumps (Cline 1977, Hemstrom and Logan 1986, Spies et al. 1988). A given number of snags uniformly or randomly distributed over a stand may provide habitat for more individuals of a given species than the same number of snags in one clump within the stand. Such a scattered distribution may allow the "packing" of more territories within a stand. However, a scattered distribution also has the potential to create many perches for hawks and other predators.

The key to managing for a range of species is to provide a diversity of arrangements. Managers will combine habitat considerations with operational requirements to make decisions on a site by site basis, within the landscape concept of providing diverse habitat conditions on the forest.

Down wood — Down wood on the forest floor provides many important functions in forested ecosystems. Some of the identified functions are mineral cycling, nutrient mobilization, maintenance of site productivity, natural forest regeneration (nurse logs), substrates for mycorrhizal formation, and provision of diverse habitats for wildlife species.

Wildlife use down wood for a variety of habitat needs including thermal and hiding cover, dispersal pathways, denning, feeding, food storage, reproduction (nesting), and resting (Franklin 1982, Bartels et al. 1985, Franklin et al. 1981, Maser et al. 1979). Studies have correlated or predicted that the abundance of small mammal and amphibian species in Douglas-fir forests is related to the abundance, size, and decay class of down wood (Corn and Bury 1991, Bury and Corn 1988, Aubrey et al. 1988, Corn et al. 1988). Carey and Johnson (1995) also found that species biomass and relative productivity of small mammals was greater in old growth than managed forests, and suggested that the amount of down wood and understory vegetation development appeared to play important roles in the observed differences.

Wildlife species have also shown preferences for different attributes of down wood structure, including debris size and decay condition. For example, in a study in the Oregon Coast Range, Corn and Bury (1991) found that clouded salamanders preferred large Douglas-fir logs with attached bark, an early decay stage, but ensatinas were found more often in well-decayed logs. The study also found that clouded salamanders appeared to prefer larger logs, in both diameter and length. Another study of amphibian species in southwestern Oregon and northern California found that large, well-decayed logs were the most heavily used down wood, though the use of particular size and decay classes of debris varied among salamander species (Welsh and Lind 1991).

Down wood is an integral component of the structure of old forest stands and provides a biological legacy from old stands to young stands after catastrophic events. This legacy can also be provided in managed stands if appropriate requirements are incorporated into timber harvest plans.

Over the life of a stand, the abundance of down wood tends to follow a U-shaped curve with high abundance in early stand ages (30 to 80 years), a low point during the mature stand phase (100 to 200 years), with increasing amounts and a peak as logs accumulate faster than they decompose during the old forest stage (Franklin et al. 1981; Spies and Cline 1988; Franklin and Spies 1991). After a catastrophic event in an older forest stand, such as a fire or windstorm, a biological legacy of down wood and snags remains as the new stand develops. This material gradually decomposes and the abundance declines, reaching a low point during the mature stand phase. Once the stand reaches the old growth stage, the recruitment of dead material begins to increase. In old growth stands of western Oregon and Washington, the volume and biomass of woody debris (snags and logs combined) average more than twice the amount found in mature stands (Spies and Cline 1988).

In young managed stands growing after a clearcut harvest, the abundance of down wood can be substantially less than in natural stands, due to the loss of down logs from salvage during harvest and site preparation activities, and the lack of large trees left as a source of future down wood (Spies and Cline 1988; Carey and Johnson 1995). Down wood in managed stands also tends to be of smaller average diameter than found in natural stands (Spies and Cline 1988). This pattern may be caused by the removal of down logs during timber harvest for utilization of the material, to clear sites for tree planting, and to reduce the risk of fire (Spies and Cline 1988). Periodic thinning and removal of trees in managed stands may also reduce the abundance of down wood, since the self-thinning processes found in natural stands are reduced in the managed stand.

The size class distribution of fallen logs varies among young, mature, and old growth stands. Old growth stands have the highest number of large fallen trees, defined as greater than 24 inches dbh (Spies and Cline 1988). The size of down logs can affect the functions of this material and its suitability as wildlife habitat. The size of the log affects its decomposition rate and, therefore, its longevity on the site. Since large logs decay more slowly than small logs, large logs will persist longer and will provide wildlife with habitat continuity over longer periods of time (Franklin et al. 1981). For this reason, this plan contains strategies to replicate old forest conditions that include requirements for the size of down logs.

Large logs typically persist in the forest environment for substantial time periods, often up to several centuries, due to slow decay rates (Franklin and Spies 1991). Since decomposition of this material is gradual, down logs in natural stands are present in a variety of decay stages. These stages are classified as decay classes I-V. The distribution of total down wood biomass in these decay classes has been shown to vary with stand age (Spies and Cline 1988).

In old growth stands, the greatest proportion of down wood occurs in decay class III (the intermediate class), with the remainder of the down wood nearly equally distributed between heavily decayed and nearly new fallen logs (Spies and Cline 1988). Highly decayed material (decay classes IV and V) only accounts for 26 percent of the total biomass of snags and logs in these old forest stands (Spies and Cline 1988). Young stands tend to be more dominated by heavily decayed down wood (Spies and Cline 1988). To replicate old forest conditions, it may be necessary to maintain or create these decay class distributions.

Given the variety of habitat preferences of wildlife species using down wood, a wide range of down wood should be maintained, by retaining or creating the debris in a diverse array of size classes and decay stages. Replicating old forest structural patterns of down wood is a logical strategy for maintaining a diverse wildlife community.

Currently, there is no scientific quantification of the exact amount of down wood needed to maintain a diverse community of forest wildlife species. Scientific research has documented that this structural material is important to many species, but detailed information is lacking on the minimum amount necessary to support the habitat requirements of the many species that use it. For example, Carey and Johnson (1995) suggest that 15 to 20 percent ground cover of down wood, well-distributed over the forest floor, appears to be adequate to maintain small mammals, whereas a 5 to 10 percent cover would not allow the animals to reach their potential abundance. These authors also caution that this substrate is not only important for small mammals but also provides critical habitat for birds and amphibians. Currently, there does not appear to be a definitive estimate of the amount of down wood needed to maintain all these groups of wildlife.

The Department of Forestry's approach is to manage for down wood at levels approaching known historical levels. Spies et al. (1988) characterized snags and down logs in fire-originated stands in western Oregon and Washington, offering a view of what the historical condition of snags in these areas may have been. In stands in the Oregon Coast Range, they found an average of 1,000 to 3,200 cubic feet of down wood per acre, and in the Cascade Range they reported an average of 2,200 to 4,900 cubic feet per acre. In their inventories, Spies et al. (1988) included down wood in all decay classes, from very decayed wood, to down logs that showed little evidence of decay. Approximately 20 percent of the down wood measured was in early stages of decay and considered hard down wood (T. A. Spies, personal communication). It may take many years or even decades to develop down wood that is very decayed. The department's strategy is to protect existing down logs wherever possible and to supplement existing down wood by providing additional logs during harvest entries. In regeneration harvest units, an average of at least 600 to 900 cubic feet of hard down logs per acre will be provided. In stands designated for older forest structure, the strategy is to manage for 3,000 to 4,500 cubic feet per acre of down wood in all decay classes.

Multi-layered forest canopies — Complex layering of forest canopies generally creates diverse habitat niches and benefits biodiversity. The more heterogeneous and complex the physical environment becomes, the more complex the plant and animal communities that can be supported, and the higher the species diversity (Krebs 1972). This is because structurally diverse habitats provide more available niches than do more homogeneous habitats.

Research has demonstrated that several closely related species with similar habitat requirements are able to live within the same area and avoid competitive exclusion by partitioning the available resources into several distinct subsets. For example, MacArthur (1958) observed that five species of similar-sized insect-eating warblers were able to co-exist within the same forest primarily because they fed at different positions in the canopy. Furthermore, MacArthur and MacArthur (1961) found that foliage-height diversity (a measure of stratification and evenness in the vertical distribution of vegetation) was even more valuable in predicting bird-species diversity than was plant-species diversity. This evidence indicates that a heterogeneous canopy structure provides more available niches that would allow the presence of a greater number of wildlife species.

The uniform, even-aged forest stands produced under traditional forest management can not support the diversity of species found in most natural stands, or in managed stands that have a complex vertical structure. The species found in low-diversity plantations usually are habitat generalists or aggressive habitat specialists that exclude other species from the limited number of available niches. As increasing acreages are managed in low diversity stands, the species that are excluded from low-diversity plantations may become scarcer, some even to the point of classification as threatened or endangered. For this reason, under this forest management plan, forest management will be used to develop complex stands with multi-layered forest canopies.

Multiple native tree species (conifers and hardwoods) — Increased tree species diversity within and among stands generally creates more diverse habitat niches and benefits biodiversity. Structurally diverse habitats provide more available habitat niches and can support a greater wildlife species diversity than do more homogeneous habitats (Krebs 1972). Hagar (1992) found that the presence of hardwoods within Douglas-fir stands was an important factor influencing the presence and abundance of several species.

Multiple tree species in a stand may lead to several wildlife habitat benefits.

- Different growth rates, tree forms, and shade tolerance result in increased vertical and horizontal within-stand diversity.
- Different tree species support different insect communities, which may lead to a greater diversity of foliage- and bark-gleaning wildlife species.
- Presence of short-lived species, such as red alder, may lead to an important source of within-stand decadence within younger stands as individuals begin to decline and die around age 40 to 65.

Herb/shrub considerations — Diverse herb and shrub vegetation layers provide important forage for wildlife, provide diverse habitat niches, and benefit biodiversity. Herbs and shrubs in recently harvested units provide an important source of forage for big game species. Other native plants, such as bitter cherry and elderberry, provide important forage for a large variety of non-game species. Large bigleaf maple trees are an important source of natural cavities and habitat structure in the forest. Unfortunately, these same plants compete with the planted and seeded trees that will grow to form the new forest stand. Plantation vegetation management is designed to control vegetation that is competing with commercial tree species. Overly aggressive vegetation management assures a successful plantation, yet greatly reduces the habitat value of the young plantation for wildlife. Aggressive vegetation management also truncates the herb-shrub (regeneration) stage and accelerates the onset of the closed single canopy stage, which has a much lower wildlife habitat value.

Morrison and Meslow (1984) studied differences in habitat structure and bird communities between young plantations in the Oregon Coast Range that were sprayed with phenoxy herbicides (2,4-D and/or 2,4,5-T) and unsprayed controls. Four years after spraying, the main vegetative difference between the control units and treatment units was a reduction in vegetative complexity on treated sites. This simplification in vegetation was primarily due to reduced deciduous tree cover. Although rapid re-growth of shrubs was evident following treatment, deciduous trees remained suppressed at least four years after spraying. The researchers found that bird communities were similar between the control and treatment units. They speculated that this was because of a rapid recovery of the shrub component after phenoxy herbicide spraying. The greatest impact of spraying was on bird species that mainly used hardwoods for foraging, although some of these birds modified their behavior and foraged on shrubs in the treatment units.

The researchers concluded that by maintaining a shrub component within the unit and by maintaining small patches of deciduous trees, managers could maintain bird communities similar to those on untreated sites. In other words, as long as the vegetation control practices are designed to control, rather than to eliminate competing vegetation, the impact of vegetation management on bird communities is minimal.

Wildlife habitat can also be affected by changes that occur in the vegetation community as stands progress from the regeneration to closed single canopy stage. Wildlife species that prefer the open habitats of the regeneration stage will gradually become excluded as canopy closure progresses. As the overstory reaches full canopy closure, understory vegetation will be severely reduced or eliminated and the wildlife values provided by this vegetation will be lost. Specifically, the abundance of forage, cover, and the vertical diversity provided by tall shrubs becomes reduced. However, succession into the closed single canopy stage can create other important wildlife habitat elements. The closed single canopy stands can provide thermal, hiding, and escape cover, especially for big game mammals. For these reasons, it is important to have closed single canopy stands as a part of the forest landscape.

As stand development progresses through the regeneration stage, the changes in the understory vegetation community cause changes in wildlife habitats and wildlife communities in the stand. As these stands become more open and the understory develops, wildlife habitat components such as forage and cover are provided and some species that prefer more open habitats may begin to recolonize the site. Development of multiple layers of vegetation will increase the amount of vertical diversity in the stand, and provide additional habitat niches that can support increasing numbers of wildlife species. However, the response of wildlife to these vegetative changes will also be affected by the abundance of other important structural habitat components, such as snags and down wood.

Gaps — Gaps increase the horizontal diversity within stands, provide important forage for wildlife, provide diverse habitat niches, and benefit biodiversity. A within-stand "gap" is an interruption in the continuity of the vegetative community in a stand. These gaps are generally small openings (½ to 2 acres) where herbs, shrubs, and new trees are being established, within larger stands with a dominant overstory tree canopy. One example of a gap is an opening created by windthrow in a densely stocked stand of trees.

Much research has been done on the ecology and wildlife dynamics of large, between-stand gaps in forests, such as those created by wildfire or clearcutting (Dyrness 1973, Agee and Huff 1981, Hemstrom and Franklin 1982, Halpern 1987). However, relatively little information is available on the ecology of small canopy (within-stand) gaps. Spies et al. (1990) presented data supporting the concept that small-scale gap disturbances and vegetation response are important driving forces in the dynamics of Douglas-fir/western hemlock forests. They found that gap formation rates and vegetative responses were slower in these forests than in other forest types.

Understories in old growth stands tend to be much patchier than in younger forest stands. This patchiness is partially a response to varied overstory conditions. Gaps are important structural features of old growth stands and typically persist for long periods. Well-developed understories of herbs, shrubs, and small trees characterize such open habitats. Heavily shaded sites ("anti-gaps"), also characteristic of old-growth forests, produce areas from which green plants may be almost totally absent (Franklin and Spies 1991, Spies et al. 1990).

Silvicultural Practices

The application of silvicultural tools to achieve the long-term goals of SBM is based on identifying the current options for the management of existing stands, understanding the future options likely to result from current silvicultural manipulations, and effectively implementing the necessary silvicultural prescriptions to achieve the desired future condition. These are the everyday skills that foresters have used for decades. The key adaptation that must be made is to focus is on a different desired future condition.

Each basin or grouping of stands will differ in their current condition and potential for future stand development. Therefore the range of options that can be created within stands or the speed with which the desired future condition can be achieved will vary (for example, a basin consisting largely of unmanaged older stands will often have fewer future options than younger managed stands that have been subjected to appropriate density management).

There are no specific single or fixed set of treatments that can be applied to all stands to achieve the desired future condition. Specific prescriptions must be developed for each set of stand and environmental conditions. The silvicultural tools themselves will have to be applied in a variety of ways to meet the various goals in the forest management plan.

Over the long term, SBM focuses on producing a desired array of stand structures across the landscape. However, most planning will focus on a shorter time frame — perhaps the next 10 years for planning and accomplishing specific management practices, and the next 20 years for projecting stand and landscape development and tentatively scheduling future activities. Adaptive management approaches and monitoring will provide the feedback and tools to make future prescriptions.

This shorter time frame is a more realistic planning period within which current stand and forest conditions can be assessed in light of the long-term goals, various management scenarios can be analyzed, and future stand options considered. Stand conditions as they exist today are the basis for silvicultural manipulations, which will be planned to move the northwest Oregon state forests toward the desired future conditions.

In the short term, silvicultural treatments will aim to create diverse options for stand and forest management in the future, while providing timber and revenue, improving wildlife habitats, and maintaining biodiversity today.

In stands not planned for short-term regeneration harvest, SBM's basic approach is active management of vigorous stands to maintain vigorous tree growth, produce valuable forest products within practical economic timeframes, encourage shrub and herb development, and to retain, maintain, or enhance the structural complexity of those stands to the extent possible. Where regeneration harvests occur, structural components will be retained in order to enhance the complexity of new stands.

The silvicultural tools that will be used are listed below, and discussed in the following pages.

a. Regeneration harvests
   - Clearcuts
   - Clearcuts with modifications
   - Seed tree cuts
   - Shelterwood cuts
   - Selection harvests, single-tree and group selection
   - Modifications to retain structure and snags
   - Rehabilitation of brush and serious plantation failure areas

a. Reforestation
   - Site preparation: fire, mechanical, chemical
   - Planting (and rarely seeding) — species, selection, appropriate stock, and genetics
   - Natural regeneration
   - Introduction of additional species (for example, forage seeding)
   - Seedling animal damage control
   - Vegetation management: manual and chemical
   - Interplanting and replanting
   - Control of bear foraging

a. Density management
   - Cleaning and thinning through precommercial thinning and hand release
   - Commercial thinning

a. Combination regeneration harvests/ density management treatments

b. Laminated root rot control

c. Pruning

d. Fertilization

e. Genetics

Silvicultural Tools, Silvicultural Practices, and Forest Management

Silvicultural practices are the tools available to achieve the desired future condition described in this plan. Many tools are available. Silvicultural results depend on the practice chosen, the way the treatment is applied, and the conditions in the treated stand. Silviculture works with stands (groups of trees that interact with each other over areas of several acres to several hundred acres). In the northwest Oregon planning area, most stands are even-aged.

Silviculture works with the ecological processes of stand development and stand recovery following disturbance. Disturbance is a part of nature. Forests are affected by windstorms, fire, drought, soil movements, insects, animals, and disease organisms. Forests are adapted to respond and recover from disturbances. Most silvicultural practices deliberately disturb stands and/or remove parts or all of the stands to encourage subsequent stand development along desired pathways. Some of these removals provide the harvests from the forest.

Stand response to a treatment depends on the stand's condition before and after the treatment. Two key attributes of stand condition are the variation in tree size(especially diameter) and stand density (the number of trees, considering their diameter). Stand density is explained in the sidebars on the next two pages.

Stands with different structures develop differently after silvicultural treatments. Natural stands and plantations react differently. Existing plantations generally have less variability and less structure than natural stands. They are usually in more need of deliberate treatment to maintain stand vigor and development. Silvicultural practices may enhance or decrease stand structure.

Stand development is driven by density. Individual trees must grow larger or die. They cannot mark time unchanged. This means that any group of trees will eventually grow large enough to interact and interfere with each other. This process drives stand development. Active management adds nothing new, but may sharply increase the pace of stand development or forestall negative developments.

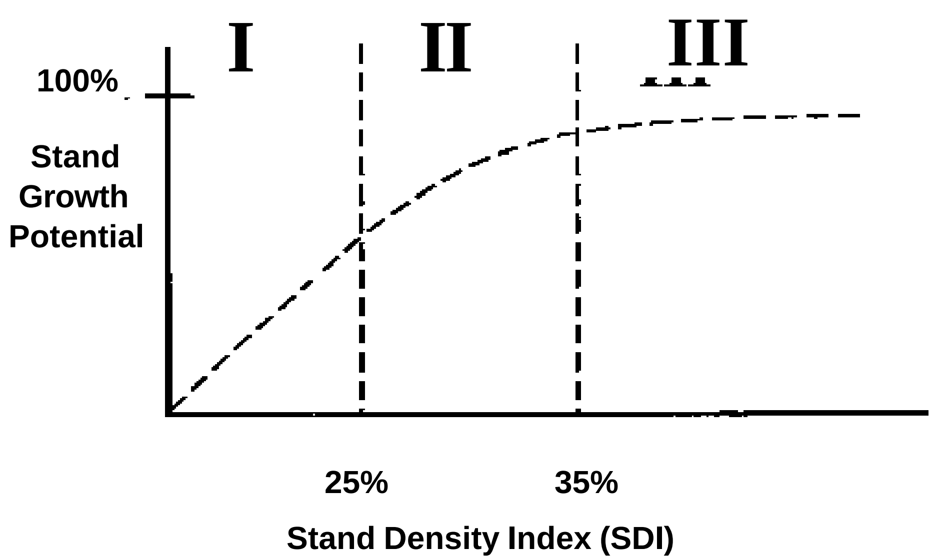
Silvicultural practices can only be prescribed and evaluated when management has clearly described the desired future condition. Silvicultural practices may be chosen to take stands along different paths depending on the management goal. For example, precommercial thinnings may be prescribed to produce a uniform stand of large diameter evenly-spaced trees or to produce a more varied stand of large and small trees with clumps and open areas. The former may be most appropriate to optimize certain values and the latter more appropriate for others.

Silvicultural accomplishment must be measured against the management goal. For example, 95 percent plus reforestation success may be an appropriate goal for optimal young stand management; it may or may not be necessary or desirable for wildlife goals. Economic considerations are an essential part of silvicultural practice. There are often several ways of achieving the same results. Rational choice of silvicultural methods requires explicit identification of objectives and calculation of costs and revenue, including the time value of investments.

Stand Density

Foresters have found that the total production of cubic volume, by a stand of given age and species on a given site, is for all practical purposes, constant and optimum for a wide range of stand density. This is the basis of all thinning. Foresters can grow the same volume in many small trees or fewer large trees.

From a density standpoint, there are three stages of stand growth.



I. Open growth — Stand is in the regeneration stage. There are no density-related light, water, or soil nutrition limitations. Non-tree vegetation is often lush. Trees grow at their full potential unless affected by competing vegetation other than trees (such as shrubs).

II. Onset of competition — Stand enters the closed single canopy stage. Trees compete for light, water, and/or soil nutrients, and not all trees can grow at their optimum rate. Understory vegetation declines.

III. Maximum stocking — Density-related mortality occurs. Understory vegetation is minimal or absent.

Stand Density

Department foresters measure stand density with Reineke's Stand Density Index (SDI). This index is calculated from the stand's average diameter and the trees per acre:

$$SDI = TPA \times (Diameter/10)^{1.6}$$

The maximum SDI is 600 for Douglas-fir, 800 for the more tolerant western hemlock, and 440 for the more intolerant red alder. Stand density is often expressed as a percentage of these maximum values. For example, a Douglas-fir stand with 300 trees per acre and an average diameter of 10 inches has an SDI of 300 and a relative density of 50 percent.

The silvicultural significance of several key SDI values is explained below.

SDI	**Silvicultural Interpretation**
25%	Crown closure and onset of self-pruning, competition, and discouragement of understory.
35%	Lowest limit of full site occupancy. Self-pruning, competition, and halt in understory development become significant.
55-70%	Trees stressed. Self-thinning begins — earlier in stands with well-developed stand structure; later in stands without stand structure. Understories disappear.
100%	Maximum stocking; rarely observed.

Density management prescriptions for wood growth are thus straightforward. To grow the most wood, help the stands reach 35 percent SDI as quickly as possible, use precommercial or commercial thinning to keep them between 35 and 55 percent during their growing years, and let them reach 70 percent just before final harvest. However, foresters modify these prescriptions to achieve other management objectives besides wood growth. Examples of other objectives are the retention of understories, the development of larger trees, or the production of natural mortality. These stand characteristics produce diversified wildlife habitat, meeting the needs of wildlife species.

This theory applies to idealized, average stand conditions. Stands in the real world are rarely homogeneous. Understories may develop and persist in less stocked areas of otherwise well-stocked stands. Thinned stands are particularly variable due to variations in individual trees, skid road and cable corridor openings, etc.

Regeneration Harvests

Regeneration harvests are intended to replace an existing stand. The trees are removed and the stage is set for reforestation. Regeneration harvests are appropriate prescriptions where the existing stand is mature by the management objectives, contains defective or undesirable growing stock as defined by the management objectives, or has low vigor with a significant risk of loss.

To trigger reforestation and allow it to develop, stand density must be reduced below 25 percent SDI and maintained below 35 percent until the new trees are part of the stand. This density level differentiates regeneration harvest from thinnings. Regeneration harvests may be referred to as reinitiation harvests.

There are several types of regeneration harvest. For most stands in northwest Oregon state forests, the most appropriate type to assure successful establishment of new trees is the clearcut or clearcut with modifications. A group selection harvest may be appropriate in some circumstances. The seed tree or shelterwood method may be appropriate for regeneration of western hemlock. Single tree selection may be appropriate for certain mixed western hemlock, Sitka spruce, or western redcedar stands. Elsewhere, seed tree, shelterwood, and single tree selection methods will rarely be appropriate.

Clearcuts — Clearcuts remove all trees in a stand. On almost all sites in northwest Oregon state forests, clearcuts will provide the best conditions for successful plantation establishment. However, clearcuts, by definition, eliminate the carryover of residual stand characteristics.

Clearcuts with modifications — In this plan, clearcuts are modified to leave residual green trees, snags, or trees destined to become snags specifically for their biological or environmental values. In this harvest method, the intent of the modifications is not to help achieve regeneration, but rather to provide for the other values. In fact, these modifications may detract from reforestation. In other harvest methods, such as seed tree cuts, shelterwoods, and selection harvests, trees are left to help achieve regeneration. Thus, trees left for biological or environmental values may be of significantly different species, condition, or location than trees left to help regeneration. In a clearcut with modifications, overstory trees, if alive and reasonably vigorous, will contribute to the overall stand stocking and may compete with the regeneration. SDI may be approximated by calculating and summing the overstory and understory SDIs.

Seed tree cuts — Seed tree cuts leave scattered stable trees of appropriate species for natural seeding of a new stand. This method works well with western hemlock on moist sites. With all other species and on other sites it cannot be considered sufficiently reliable to meet the Oregon Forest Practices Act.

Shelterwood harvests — In this method, the original overstory is removed in two or three stages over several years. This method will work with most conifer species found in northwest Oregon state forests, but is not necessary to regenerate any of them. Because of its logistical difficulty and careful timing requirements, it will rarely be appropriate on northwest Oregon state forests. The exception may be western hemlock stands where western hemlock regeneration is desired but the overstory trees are not considered sufficiently windfirm for seed tree methods.

Selection harvests: single-tree and group selection — Unlike the previous even-aged regeneration methods, selection harvests develop and maintain many-aged stands. Regeneration harvests, precommercial thinnings, and commercial thinnings are combined in this method. Trees are removed individually (single-tree selection) or in groups of half-acre to several acre patches. As the patch size increases, group selection tends toward clearcutting. The operative difference is whether the regeneration develops under the influence of the overstory.

Individual tree selection may be appropriate for mixtures of tolerant western hemlock, Sitka spruce and western redcedar where stand continuity of older forest characteristics is desired. With proper attention to vegetation management and reforestation, group selection methods should work with any tree species in the northwest Oregon state forests other than red alder, though growth of the new stand should not be expected to be as high as with clearcut methods.

Rehabilitation methods — Where desired by management, the replacement of brush fields, grass areas, and/or failed plantations will generally be by methods similar to clearcuts. Only minor acreages of these remain in northwest Oregon state forests. An exception is the extensive acreage of Swiss needle cast-infected Douglas-fir plantations in Tillamook County. Regeneration may be the most appropriate practice for these areas.

Comparison of regeneration harvest methods — Regeneration harvests will have obvious impacts on stand structure. Selection methods will retain the most structure. Clearcuts with modifications will retain some structure. Regular clearcuts have the least structure and provide more limited opportunities for structural development in the future. Seed tree and shelterwood cuts retain and promote a fair degree of stand structure, primarily through their less certain and more variable regeneration. Stand structure also influences selection of the regeneration harvest method. Dense stands, with skinny, crowded trees (often referred to as “doghair” stands), often are not windfirm enough to handle partial cutting; clearcutting may be the only practical method for these stands.

Reforestation

Reforestation to the standards and timeframes of the Oregon Forest Practices Act is not easy or automatic in the conditions found in the northwest Oregon state forests. Reforestation requires various combinations of site preparation, planting, animal damage control, vegetation management, and occasionally interplanting or replanting. These practices must be considered and prescribed for individual stands on a site-specific basis.

Common silvicultural practices for reforestation are discussed briefly on the next page.

Site preparation — In many circumstances, the harvest operation provides sufficient site preparation for planting. In other circumstances, slash, organic debris, and duff are physical barriers to planting, or the site is already occupied with existing or sprouting competing vegetation that will prevent or delay tree establishment. In these cases, site preparation by fire, mechanical means, or chemicals is appropriate.

Planting — In most circumstances trees are hand-planted. Natural regeneration, as a primary mechanism for reforestation, is usually restricted to western hemlock on moist sites or to fill-in with additional trees. Appropriate species selection and use of the appropriate nursery stock are important. These procedures are well worked out with Douglas-fir, and to a large extent, with western hemlock, but it has been difficult to obtain appropriate planting stock for western redcedar, true firs, and hardwoods.

Tree improvement — Trees are genetically adapted to certain sites. Selection and control of seed source is critical. Unimproved seed is collected from local seed zones. Tree improvement programs are underway for Douglas-fir and western hemlock; most trees being planted today are from the tree improvement program. These trees are expected to display better health and more vigorous growth.

Introduction of additional species — In some cases wildlife forage crops may be seeded in order to benefit wildlife. Reforestation may be aided if the crop displaces what would otherwise be a more competitive species.

Tree protection — Seedlings may be harmed or destroyed by animal browsing. Elk, deer, mountain beaver, rabbits, and rodents may all be problems. Some species, such as western redcedar, are particularly favored by animals and often eliminated. Thorough site preparation and large planting stock are the best indirect controls; these get the trees off to a good start and allow them to outgrow damage. In many other cases direct control or prevention of animal damage is essential. Significant mountain beaver populations must be trapped. Seedling protection by bud caps, netting, or Vexar tubes is appropriate in many circumstances. Repellents have potential, but results have been erratic.

Vegetation management — The northwest Oregon planning area has some of the most productive tree-growing areas in the world. However, it also supports some of the most competitive native and introduced herbs, shrubs, and hardwood trees in the world. Vegetation management is usually needed to allow conifers to reach full stocking within Oregon Forest Practice Act timeframe requirements. Chemical applications are usually the preferred method of vegetation management as they allow precise targeting with minimal site damage or side effects.

Cleaning (hand release) — A common practice in conifer stands is the removal of red alder stems, vine maple stems, and/or bigleaf maple sprouts that are overtopping conifers. This is usually done with hand-applied chemicals (hack and squirt). The current emphasis is to leave any individuals that are not overtopping conifers or any areas of only minor overtopping, in order to encourage biodiversity.

Interplanting and replanting — These practices are now infrequent.

Control of bear foraging — Black bears may forage on conifer trees in the spring, damaging or killing individual trees or patches. Bears attack vigorous trees 6 inches in diameter and larger. Control methods include feeding bears and/or snaring individual problem bears.

Status of reforestation in the northwest Oregon state forests — Department foresters have worked out excellent methods of reforestation. Fully stocked Douglas-fir plantations occupy over 95 percent of most past sale areas. However, management objectives are changing for many stands, and foresters must adapt their reforestation methods to meet the new objectives. More work and adaptive management procedures will be needed to achieve successful reforestation with different and multiple tree species, to incorporate modifications to clearcuts, and to meet the needs for a diversity of stand structures and wood quality.

Most young stand management practices in reforestation have produced plantations with reduced stand structure. Good planting stock is uniform. Site preparation, vegetation management, and control of animal damage all make growing conditions more uniform. Given this, subsequent silvicultural practices will be needed to introduce or encourage stand structure in managed plantations.

Most Coast Range plantations developed over the last 20 years are growing well in excess of expectations. Individual trees are reaching 4.5 feet heights in 2 or 3 years and crowns in unthinned plantations are closing in about 5 or 6 years. Many stands on site class II and III soils are growing at rates expected on site class I soils. Biomass volumes may be 50 to 75 percent ahead of projections. This result is probably due to the reforestation practices listed above, and early precommercial thinning. However, there is serious concern about the wood quality of many of these fast-growing trees. The trees have frequent multiple tops, large and persistent ramicorn branches, excessive sinuosity and deformations in the main stem, and patterns of many large branches in multiple whorls. These problems are most serious over the lower 10 to 30 feet, which normally becomes the most valuable log in the mature tree. The extent of these problems has encouraged agency foresters to increase initial planting density and delay precommercial thinning, to let greater density slow the vigor. Other possible solutions are removal of poorly formed trees or marking during initial commercial thinning.

Density Management: Precommercial and Commercial Thinning

Thinning regulates stand density. In precommercial thinning, the cut trees are left unused and the operation is carried out at cost. In commercial thinning, some or all of the cut trees are used and the operation produces revenues. Both practices have the same silvicultural impact. Thinning decreases natural mortality, maintains stand vigor, and develops healthier, larger, more windfirm, and generally more valuable trees. By removing trees that would otherwise die in the competition for light, nutrients, and water, commercial thinning increases net stand production over time. Thinning may also directly improve tree quality and tree size through selection of the better and larger trees for the residual stand. Potential drawbacks to thinning are the lower wood quality associated with larger branch diameters and increased stem defects in young stands thinned before crowns close and growth slows on lower branches; loss of snags for wildlife in thinned older stands; and decreased stand structure. Residual stand damage is minimal with proper contract administration.

Both precommercial and commercial thinning are optimally carried out before density-related competition reduces tree vigor, i.e., between SDI 25 and 55 percent. Precommercial thinning may be delayed to the higher end of this range to suppress branch growth. Commercial thinning is usually delayed to the upper end of the range to maximize harvest volumes, in order to improve sale revenues and reduce the number of stand entries. Thinning reduces the stand density to the point from which the stand will grow back to the desired stand density at the projected next entry, either another thinning or a regeneration harvest. This point may be anywhere from 25 to 45 percent. Some very vigorous young stands may be taken temporarily below 25 percent SDI, as these stands recover and quickly exceed 25 percent SDI. Thinning is marginal or inappropriate in overly dense stands with high height/diameter ratios.

Tree selection in precommercial thinnings is carried out by tree cutters, with species selection and the number of residual trees specified by foresters. Tree selection in most commercial thinnings is also done by cutters, with foresters specifying the minimum average diameter of residual trees and acceptable residual stand basal area. These “auto-mark” thinnings have provided better results than thinnings where trees are individually marked. Fallers can consider all aspects including tree selection, lead, and location of skid roads and cable corridors. Individual wildlife trees, trees of minor species desired in the residual stand, or any other exceptions to auto-mark specifications need to be individually marked or otherwise specified. In the future more individual tree marking or alternate contract specifications may be necessary due to the increased stem defects in managed plantations and the need to carefully select against these.

In the short term thinning may reduce the range of tree diameters through removal of smaller trees and forestalling future mortality. However, in the long term, thinning may increase future stand structures by developing larger, more windfirm trees that will respond to future treatments designed to enhance stand structures. Thinning also encourages the development of a more diverse group of shrubs and herbs. Modifications can be made to maintain and/or enhance stand structure. These modifications include maintenance of existing older or larger overstory trees and snags, deliberate creation of snags, and retention of unthinned areas within stands.

Regeneration Harvests and Density Management Treatments Combined

In the Oregon Coast Range, many stands consist of mixtures of clumps of mature or slow-growing red alder with scattered emergent conifers and generally over-stocked stands of conifers. The conifers are chiefly planted or seeded Douglas-fir but include natural western hemlock and scattered western redcedar, Sitka spruce, and true firs. In the absence of management, these stands will quickly lose vigor through density-related competition. With management, stand structure can be maintained and greatly enhanced.

Department foresters have developed sale prescriptions that simultaneously: 1) thin over-stocked but still vigorous conifer areas; 2) regeneration harvest mature hardwood areas and over-stocked and non-vigorous conifer areas; and 3) retain most emergent established conifers and many of the existing snags, as modifications to the regeneration harvests. Regeneration harvest areas included in these sales range from small clearcuts to group selection openings. Reforestation and management of competing vegetation is planned on the regeneration harvest areas; natural regeneration of minor species is also likely to occur in many areas.

Regenerated areas in these sales are not expected to produce as much timber volume as plantations on clearcut areas. However, the commercially thinned stands produced by these treatments will be much more productive than if regeneration harvested and converted at this time. There are many future silvicultural options for these stands. They could be rethinned a number of times and carried to long rotations; they could be gradually converted to many-aged stands through group selection harvests; or they could be regeneration harvested through clearcuts and be replaced by plantations. In many cases, decisions on these options need not be made for many years, even decades.

Laminated Root Rot Control

Laminated root rot is the most widespread disease in the northwest Oregon state forests. It occurs in scattered clumps on about 10 percent of the forest area. It is most damaging to Douglas-firs and true firs. Western hemlock is affected but is not lost to the disease. Hardwoods are immune. Western redcedar, western white pine, and ponderosa pine are resistant. The only known control is to remove affected conifers from infected areas until all conifer roots are completely decayed.

The main silvicultural option for control is to remove all affected conifers from infected areas and buffer zones and to keep affected conifers out of these zones. This treatment has been done during commercial thinnings. Foresters have attempted to regenerate treated areas to red alder, western white pine, and western redcedar. This has been only partly successful due to the difficulty of regenerating these species. Options are to continue these practices, regenerate appropriate areas with the more easily reforested western hemlock, or accept continued losses. Another option would be to reforest the openings with bigleaf maple, a more appropriate hardwood species for many higher elevation areas in northwest Oregon. However, techniques for successful establishment of bigleaf maple seedlings are not currently known. Another silvicultural option is stump removal. Final harvest removal of large stumps is expensive, impacts the soil, and may leave some root rot. Tree pushing instead of felling may also be effective for stump removal. Removal of smaller stumps at commercial thinnings may be more feasible wherever ground logging equipment is working. With stump removal, regeneration to any conifer, including Douglas-fir, would be appropriate.

Stand structure will be maintained or enhanced by laminated root rot control since the stand will contain openings with or without control.

Pruning

Production of structural grade wood generally requires that knots be kept to 1.5 inches diameter or less. This standard can be achieved by maintaining Douglas-fir plantations at 250 to 300 trees per acre or more, until crowns close and are 30 to 40 feet above the ground. Larger knots may be tolerated in very large diameter trees. Where such management is not desired; where stands have already been spaced to lower stocking; or where plantation losses to competing vegetation, bears, mountain beaver, deer, and elk have reduced stocking to lower levels; pruning is appropriate. Pruning will also create clear wood wherever it is carried out. It is the only method of producing clear wood over rotations of less than 100 years.

Pruning is optimally done to maintain a small diameter, cylindrical, defect core in the center of the tree. Pruned trees must maintain a minimum of 50 percent live crowns. The percentage of live crown equals the percentage of the tree bole that has live branches, i.e., a tree 40 feet tall must have live branches on at least 20 feet of its trunk. To maintain the live crown and minimize the core, pruning should be done in several lifts as the tree grows. The first log up from the ground is the most valuable part of the tree, and the most vulnerable to large branches in plantation culture. Pruning should be carried out to as high a point as is practical (at least 18 to 24 feet and possibly to 40 feet) where large valuable trees are expected.

Effective techniques for pruning with loppers and ladders have been developed based on New Zealand experience.

Pruning is not needed to grow structural wood in western hemlock stands. It would be needed to grow clear wood. Pruning, along with early trimming to one central stem, is also anticipated as a necessary practice in red alder plantations. However, this pruning need not reach as high up the tree.

Pruning should not alter stand structure. Pruning most trees in a stand, especially when combined with early precommercial thinning, will significantly increase light to the forest floor, thereby prolonging the regeneration stage and herb and shrub forage values.

Fertilization

Many forest stands are deficient in nitrogen. Douglas-fir and true fir stands have been shown to respond to nitrogen fertilization by increasing volume growth for 4 to 12 years after fertilization. Average response is 1,000 or more board feet per acre to fertilization with 200 pounds N (nitrogen) in urea. Response is better in thinned stands than in unthinned stands, and better on lower sites than on higher sites. Response is especially likely in the Tillamook Burn because the fires undoubtedly released much of the nitrogen on the sites. Where intermixed red alder has added nitrogen to stands, response is less likely. Response is limited on site I soils and does not occur in western hemlock or red alder stands. Response has been demonstrated for the period following stand closure up to about age 80. Stand response past that age is unknown. Applications may be repeated, with similar response, at 4 to 8 year intervals. Application is via helicopter in the winter.

The optimum extent and frequency of fertilization are economic investment questions. Fertilization adds volume, and therefore value. However the effects on overall stand development have not been well documented and different situations will likely result in different outcomes. In some circumstances, fertilization may accelerate stand development, but it is unlikely to significantly change other forest attributes. Fertilization will not necessarily increase stand structural complexity. In other cases it may slow the stand development progression by improving the diameter growth of smaller trees and delaying mortality.

Fertilization prescriptions may change in the future for plantations. In the Coast Range, many of these plantations are observed to be growing at significantly higher rates than previously expected. They may well respond differently or not at all to nitrogen fertilization. Foresters are considering trying balanced application of multiple nutrients with prescriptions tailored to individual sites after analysis of foliage. Response may be very significant, especially where response to nitrogen alone is not observed. Application of minor nutrients may also reduce the incidence of stem defects frequently observed in high site Douglas-fir plantations in the Coast Range. These stem defects are of serious concern for wood quality.

Some studies have been done on tree response to urea fertilization in managed stands, and additional studies are being done. Formal research work with balanced nutrition has not been carried out.

Genetics

Reforestation projects on state forest lands will take advantage of the highest quality seed to assure that forest trees and forest stands are well-adapted to planting locations and are capable of growing vigorously with resilience to forest health threats.

The Department of Forestry has initiated genetic tree improvement efforts for several forest tree species like Douglas-fir, western hemlock, western redcedar, western white pine, Sitka spruce, and red alder. The principle objective of improvement efforts is to ensure that high quality, well-adapted forest tree seed is available for reforestation programs. The breeding phase includes the selection and breeding of healthy, vigorous trees and field testing across a variety of environmental conditions. The production phase involves the propagation of the best selections into a seed orchard to enable the cost-efficient production of genetically improved seed.

The Department of Forestry's J. E. Schroeder Seed Orchard produces seed from a wide variety of forest tree species for general, specific, and forest structure silvicultural objectives. For species like Douglas-fir and western hemlock, seed orchard seed will be used for planting and seeding programs on state forests. Seed is mixed from a number of selected families to insure that an adequate level of genetic diversity is maintained in planted forest stands. Seed from certain selected seed orchard trees may be used to achieve specific objectives such as improvement in wood quality characteristics and the value of timber at maturity.

The Department of Forestry is also involved in genetic improvement efforts to improve levels of pest resistance. Douglas-fir tree selections that demonstrate a tolerance to Swiss needle cast are being used in planting projects in cooperation with other landowners. The Department of Forestry is also working to develop tip weevil-resistant Sitka spruce. This pest has caused extensive damage to this conifer species. Field trials to test potential tip weevil-resistant spruce trees have been planted on two state districts, Astoria and Tillamook. In a cooperative project with the U.S. Forest Service, the Department has access to western white pine seed that is genetically resistant to blister rust, a deadly pathogen that kills almost all natural white pine trees. All western white pine currently planted on state forest land comes from blister rust-resistant seed stocks.

The development and use of appropriate genetic stocks that survive well, are adapted to a variety of environmental conditions, and produce healthy, vigorous forest trees is a basic tool that helps provide forest stands that meet landscape and the desired future condition for stand structure.