Appendix C

Sustainable Forest Ecosystem Management Strategy Information

Chapter 5 presented the strategies, and Chapter 4 presented the concepts behind those strategies. This appendix provides more detailed information underlying the implementation of the strategies.

The main headings in Appendix C are listed below. Important connections between these headings and Chapter 5 are summarized briefly below the headings.

Landscape Design 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 because 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 Figure C-1. Scale must be defined for the organism in question.

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.

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

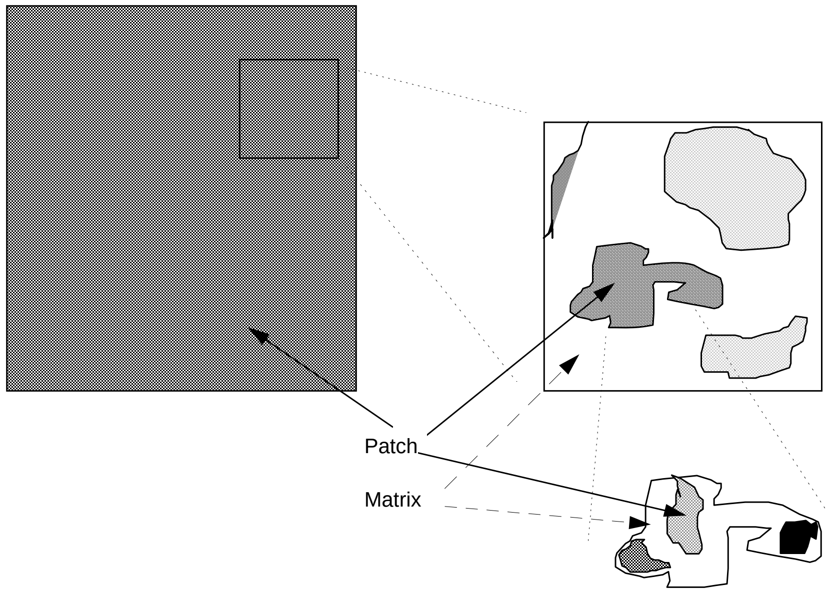


Figure C-1. Change in Patch Characteristics at Different Scales

watersheds. Recognition of the relationship of a particular species to its landscape and surrounding landscapes (context) is essential in providing 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) have 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 ensure 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 composing the landscape include nearest neighbor distance and connectivity (McGarigal and Marks 1995).

The presence and abundance of a species in a particular patch can be strongly affected by the composition of adjacent patches. 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. Predation, competition, and nest parasitism from species occupying adjacent patches have the potential to affect interior habitat species when the edge contrast is high. In addition, 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 can affect the quality of interior habitat (Chen et al. 1992; Harris 1984).

Habitat fragmentation is the process that occurs when original habitat is lost and patch size decreases, which ultimately results in increased isolation of habitat patches (Andrén 1994). In addition to isolation of habitat patches, the effects of habitat fragmentation include an increase in proportion of habitat close to edges and increasing abruptness of edges (Wiens 1994; Lidicker and Koenig 1996). Studies that have examined the effects of habitat fragmentation in forested landscapes on different groups of organisms have found that, while the composition of vertebrate species was similar in all classes of forest patch size and insularity, some species were more abundant in more fragmented situations, while others were more abundant in less fragmented, more continuous forest (Rosenberg and Raphael 1993). In general, habitat specialists (organisms that have narrow habitat requirements) are more vulnerable to landscape changes resulting in increased habitat fragmentation, while habitat generalists (animals able to utilize a variety of different habitats) are less vulnerable or not affected negatively by these changes (Lidicker and Koenig 1996).

Fragmentation is a dynamic process; landscapes change over time. In the forest, as the surrounding landscape regenerates, fragmentation effects can appear or disappear (Lindenmayer and Franklin 2002). It is unlikely that local distribution of individuals among patches in a mosaic will reach equilibrium before further landscape change (Wiens 1994).

Landscape connectivity describes the degree to which patches of habitat allow movement of the species in question. The connectivity of a landscape is perceived differently by organisms with different dispersal abilities and habitat requirements. Species with limited dispersal capabilities may not be able to move across an area of the landscape that does not contain essential habitat elements. These species require habitat patches to be adjacent for the landscape to be perceived as connected. Other species, particularly highly mobile species, are able to cross gaps in their habitat. These species may perceive a landscape to be connected even if suitable habitat patches are not immediately adjacent to each other, as long as the gaps between habitat patches can be crossed.

A number of researchers have modeled landscape connectivity in an attempt to learn more about how the arrangement of habitat affects the population patterns of different species (With et al. 1997). One finding of these studies is that when the proportion of suitable habitat on a landscape exceeds a certain level, populations are randomly distributed and landscapes are perceived as connected. When suitable habitat falls below the threshold, population levels decline more rapidly than predicted from habitat loss alone (Lindenmayer and Franklin 2002).

These critical thresholds are the result of the interplay of species interactions with landscape structure (With and Crist 1995). Critical thresholds have been reported in the range of 30 to 60 percent habitat, depending on the assumptions of the model and species being considered. At 60 percent suitable habitat, models in which habitat was randomly distributed resulted in habitat forming a continuous cluster spanning the landscape (With et al. 1997; With and Crist 1995, Gardner et al. 1987). Real forest landscapes tend to have habitat more aggregated, in patches that are larger and farther apart than random dispersion (Andrén 1994). Modeling on more realistic, fractal landscapes resulted in lower critical thresholds, ranging from 30 to 50 percent habitat, depending on the species (With et al. 1997). The critical threshold is lower for habitat generalists and for organisms that can cross gaps and are not constrained to movement in adjacent habitat cells (With et al. 1997). The threshold is higher for habitat specialists that have narrow habitat requirements. A study modeling northern spotted owl habitat in the Coast Range, Richards et al. (2002) found that a threshold of 40 percent habitat within a spotted owl home range resulted in a distribution of home ranges throughout the study area similar to known distribution of northern spotted owl habitat. Monkkonen and Reunanae (1999) suggest caution in interpreting critical thresholds for management purposes, as observation evidence is limited.

Understanding landscape connectivity and fragmentation requires an understanding of the mechanisms behind these concepts, including habitat selection, dispersal distances, and movement patterns for different species (Wiens 1994). Although there is a tendency to consider landscapes as either fragmented or connected, fragmentation and connectivity exist as gradients. The response of species to changes in fragment size is usually not linear (Wiens 1994). For example, some species are present in virtually all patches above a certain size and occur much less frequently in small patches (Wiens 1994). Finally, the composition of the habitat patches determines whether a species is able to move through them, and thus whether the habitat is perceived as connected or fragmented.

Patch Types, Patch Sizes, and Patch Placement

Landscape Management Strategy 3 states that the Oregon Department of Forestry (ODF) will actively manage the forest stand types to create a variety of patch types, patch sizes, and patch placement on the state forest landscape.

The number of different patches and their size, shape, location, and relationship to other patches (landscape composition) determine landscape structure. 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. Composition at the stand scale will be addressed using the within-stand approaches identified in Sustainable Forest Ecosystem Management Strategy 4 or the Strategies for Integrated Resource Management. These include considerations of snags, residual live trees, and downed wood or other significant resource values.

Guidelines for Providing Functional Wildlife Habitats Across the Landscape

Each scale of consideration addresses different landscape functions and different wildlife conservation issues. Table C-1 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 recovery strategies for threatened species, and therefore are generally broad. It is important to emphasize that this Forest Management Plan (FMP) 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 FMP within this larger context.

District Scale

The district scale is the scale on which this FMP is based. At the district scale, stand structural goals are set, and decisions are made on how the patch sizes should be allocated across various basins based on current forest structure, regional conservation contributions, and the relationship with other plan considerations, including conservation areas, recreation, scenic quality, operational constraints, etc.

Questions asked should revolve around whether the general proportion of stand sizes and numbers are represented districtwide, and how each management basin plan individually and collectively contributes to the range of patch sizes and numbers.

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 districtwide distribution of patch sizes based on certain constraints and management options. Based on this information, management basin planning will make refinements to define the desired range of stand structures for the area.

In addition to the guidelines listed in "Sustainable Ecosystem Management Strategy 3," the following habitat considerations are intended to aid managers during implementation planning to ensure that a functional arrangement of wildlife habitats is provided on the landscape.

- Anticipate patch placement through time. It is important to maintain interior habitat until it is confirmed that replacement patches will be available. This can best be accomplished 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.

  We know that interior habitat is critical for many wildlife species that prefer mature forests, and that advanced structure, and to a lesser extent, intermediate structural stages, are components of mature forests. Associating intermediate structural stages with advanced structure can increase functional interior habitat for these species. This allows us to increase the amount of interior habitat above that possible if we assumed that advanced structure is the only stand type that can produce interior habitat. Forest management can help to develop a landscape in which advanced and intermediate structure stands exist next to each other, and maintain greater amounts of interior habitat than would occur if these stands were scattered.

- 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 of advanced structure must be larger to be functional because of the expected high edge effect.

Table C-1. Matrix of Planning Decisions Appropriate at Various Scales of Landscape Planning

Considerations	Region	District	Basin	Stand
Contribution to population goals for threatened and endangered 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 and 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 (downed wood, layered canopy, snag goals)			X	X
Within stand diversity (gaps)				X
Species composition				X

The Array of Stand Structure Types

Sustainable Forest Ecosystem Management Strategy 1 states that the ODF will actively manage the Elliott State Forest for a diversity of stand structures across the landscape. Table 5-1 in Chapter 5 displays the long-range desired future percentages for the three 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 Oregon Coast Range. Several studies have been conducted on the historical distributions of older stand types (old growth) in the Oregon Coast Range (Juday 1977; Teensma et al. 1991; Zybach 1993; Wimberly et al. 2000). 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 a 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 "Sustainable Forest Ecosystem Management Strategy 1" in Chapter 5, and the other discussions in this appendix). Generally speaking, individual management basins will contain a mix of all stand types. However, some management basins 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 (IPs) (see Sustainable Forest Ecosystem Management Strategy 2).

Determining the Landscape Percentages—Both objective and subjective processes were used to determine the FMP'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 stand structure 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 advanced structure 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 structure 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 FMP's goals.
- The current array of stand structure types on lands in the planning area, and the knowledge that it will take many decades to achieve the desired future amounts of the advanced structure stands. As part of the adaptive management strategy, the FMP includes requirements for periodic reviews, as part of implementation. Through these reviews, the desired future condition for stand structure 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 early intermediate structure stage. In the late intermediate and early advanced structure stand types, habitats have more horizontal and vertical diversity and offer a variety of habitat niches. Advanced structure 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 structure types rather than setting an exact percentage. First, the stand structure types as defined do not always appear on the landscape as clearly defined, discrete types. Early structure stands blend into intermediate structure 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 an intermediate structure stand should be classified as advanced structure 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 Elliott State Forest have varied greatly. Large wildfires such as the Coos Bay Fire 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 in response to 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 Areawide Percentages—The planning team also considered setting regional stand type percentage goals to reflect the local conditions in the district. ODF Forestry district personnel, Oregon Department of Fish and Wildlife field biologists, and members of the planning team discussed issues to clarify the regional context for the district. The discussions focused on physiographic conditions that might require different structural goals, based on the different habitat needs of wildlife in this part of the Oregon Coast Range. Adjacent land ownership patterns and practices were also discussed as a basis for setting different targets.

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 certainty 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 IPs.

Regeneration Harvest Calculation

The rate of timber harvest and the amount of early structure are determined by current stand conditions and the desired future condition of structure types across the landscape. These two factors also affect the timing of timber harvest operations. The amount of stands harvested through regeneration harvest determines the amount of area of the early structure type at any given time. Modeling indicates that regeneration harvesting would average approximately seven percent of the forest per decade for the first 50 years, or about 650 acres per year. However the number of acres harvested in any one year may vary above or below the 650 acre estimate.

Stands on a pathway to intermediate structure may be harvested on relatively short cycles, emphasizing timber production. Stands on a pathway toward advanced structure will be harvested on longer cycles ranging from 100 to 160 years. Developing the basic characteristics of more complex structures generally requires approximately 80 years, and those stands will be retained for at least 20 more years to function as advanced structure. A small percentage of stands, above what is needed to meet the advanced structure target, will be put on an advanced structure pathway. This will facilitate harvest from all stand types as the amount of advanced structure stands exceeds the amount needed to meet future goals.

Silvicultural Practices

The application of silvicultural tools to achieve the long-term goals 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.

Each basin will differ in its current condition and potential for future stand development. Therefore, the range of options that can be created and how quickly 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.

No fixed treatments can be applied to all stands to achieve the desired future condition. Specific prescriptions must be developed for each stand and set of environmental conditions. The silvicultural tools will be applied in a variety of ways to meet the various goals in the FMP.

Over the long term, a desired array of stand structures across the landscape will be produced. 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, management scenarios can be analyzed, and future stand options considered. Stand conditions as they exist today are the basis for silvicultural manipulations planned to move the Elliott State Forest toward the desired future condition.

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, the basic approach is active management to maintain vigorous tree growth; produce forest products within practical economic timeframes; encourage shrub and herb development; and retain, maintain, or enhance the structural complexity of those stands. Where regeneration harvests occur, structural components will be retained to enhance the complexity of new stands.

The following silvicultural tools will be used (as discussed on the following pages).

- Regeneration harvests
    - Clearcuts
    - Modified clearcuts
    - Retention cuts
    - Selection harvests, single-tree and group selection
    - Modifications to retain structure and snags
    - Rehabilitation of brush and serious plantation failure areas
- Reforestation
    - Site preparation: fire, mechanical, chemical
    - Planting (and rarely, seeding) – species, selection, appropriate stock, and genetics
    - Natural regeneration
    - Introduction of additional species (e.g., forage seeding)
    - Seedling animal damage control
    - Vegetation management: manual and chemical
    - Interplanting and replanting

- Control of bear foraging

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

- Combination regeneration harvests/density management treatments

- Pruning

- Fertilization

- Genetics

Silvicultural Tools and Forest Management

Silvicultural practices are the tools available to achieve the desired future condition described in this FMP. 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).

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 include 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 sidebar boxes below.

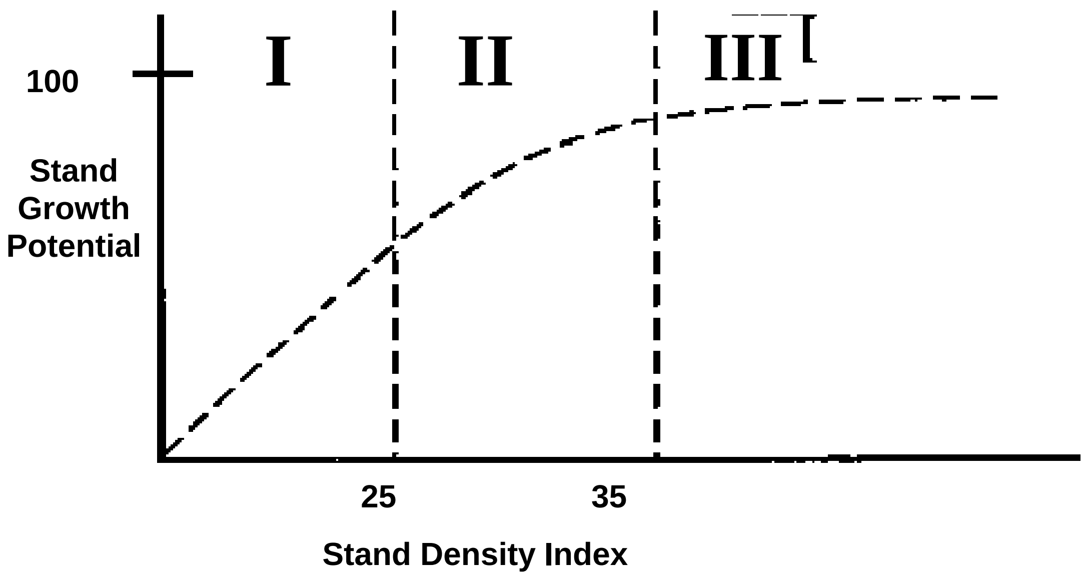
Stands with different structures develop differently after silvicultural treatments. Natural stands and plantations react differently. Existing plantations generally have less variability and less structure than natural stands. They are usually in more need of deliberate treatment to maintain stand vigor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

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 early structure. 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 intermediate structure. 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). SDI is a relative measure of stand density; converting a stand's current density into a density at a reference size. It is usually expressed in the equivalent number of trees that are 10 inches in diameter, e.g., 65 trees per acre that average 26 inches in diameter have the same SDI as 300 trees per acre that average 10 inches in diameter. This index is calculated from the stand's average diameter and the trees per acre:

$$\text{SDI} = \text{trees per acre} \times (\text{diameter}/10)^{1.6}$$

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 65 trees per acre and an average diameter of 26 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 maintain them at 35 to 55 percent during their growing years, and allow them to 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, cable corridor openings, etc.

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.

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 the Elliott State Forest, the most appropriate type to assure successful establishment of new trees is the clearcut or modified clearcut. A group selection harvest may be appropriate in some circumstances. The retention cut 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.

Clearcuts—On almost all sites in the Elliott State Forest, clearcuts will provide the best conditions for successful plantation establishment. In this FMP, clearcuts are modified to leave residual live trees, snags, or trees destined to become snags specifically for their biological or environmental values. 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. Trees left for biological or environmental values may be of significantly different species, condition, or location than trees left to help regeneration.

In other harvest methods, such as retention cuts and selection harvests, trees are left to help achieve regeneration, for example, as a seed source. However, in a modified clearcut, overstory trees, if alive and reasonably vigorous, will contribute to the overall stand stocking and may compete with the regeneration. Stand density may be approximated by calculating and summing the overstory and understory SDIs.

Retention Cuts—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 the Elliott State Forest, but is not necessary to regenerate any of them. Because of its logistical difficulty and careful timing requirements, it will rarely be appropriate. The exception may be western hemlock stands where western hemlock regeneration is desired but the overstory trees are not considered sufficiently windfirm for a modified clearcut.

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 advanced structural characteristics is desired. With proper attention to vegetation management and reforestation, group selection methods should work with any tree species in the Elliott State Forest 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 generally will be by methods similar to clearcuts. Only minor acreages of these remain in the Elliott State Forest.

Comparison of Regeneration Harvest Methods—Regeneration harvests will have obvious impacts on stand structure. Selection methods will retain the most structure. Modified clearcuts will retain some structure. Regular clearcuts have the least structure and provide more limited opportunities for structural development in the future. Retention 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 (FPA) is not easy or automatic in the conditions found in the Elliott State Forest. 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.

A range of 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. Tree improvement programs are underway for Douglas-fir and western hemlock; most trees being planted today are from the tree improvement program. When improved seed is not available, seed is collected from local seed zones. 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 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 protection methods initiate tree growth in a positive manner and allow the trees 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 Elliott State Forest is a highly productive tree-growing area. However, it also supports very competitive native and introduced herbs, shrubs, and hardwood trees. Vegetation management is usually needed to allow conifers to reach full stocking within FPA 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, so as 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 six inches in diameter and larger. Control methods include feeding bears and/or trapping individual problem bears. Pruning, removing the lower live limbs, reduces the carbohydrate-to-terpene ratio of the tree’s cambium, rendering the trees less palatable to bears.

Status of Reforestation in the Elliott State Forest—ODF 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 required 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.

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 a 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, 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 performed 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, creation of gaps, and retention of unthinned areas within stands.

Regeneration Harvests and Density Management Treatments Combined

In the Oregon Coast Range, many stands are a mix 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.

ODF 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 they were regeneration harvested and converted at this time. Many future silvicultural options exist 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.

Pruning

Production of structural grade wood generally requires that knots be maintained at 1.5-inch 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. However, pruning is appropriate 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 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 performed to maintain a small diameter, cylindrical, defect core in the center of the tree. Pruned trees must maintain a minimum of 50 percent of their live crowns. 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) 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 early structure 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 nitrogen in urea. Response is better in thinned stands than in unthinned stands, and better on lower sites than on higher sites. Where intermixed red alder has added nitrogen to stands, conifer response to fertilization is less likely. The response of Douglas-fir is limited on site I soils. Fertilization of hemlock and western redcedar produce inconsistent responses. Response has been demonstrated for the period following stand closure up to approximately 80 years of age. Stand response past that age is unknown. Applications may be repeated, with similar responses, at four- to 8-year intervals. Application is usually by helicopter when enough moisture is present to quickly incorporate the fertilizer into the soil and minimize volatilization.

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 Oregon Coast Range. These stem defects are of serious concern for wood quality.

Genetics

Reforestation projects on state forest lands will take advantage of the highest quality seed to ensure 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 ODF 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 ODF'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 ensure 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 ODF 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 ODF 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 ODF 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.

Management Pathways

Sustainable Forest Ecosystem Management Strategies 1 and 2 state that the ODF will use active management to move stands toward the stand structure and landscape design goals. The following sections describe in detail how management will proceed. The management pathways described here are examples, not prescriptions. Silvicultural practices mentioned in this section, such as modified clearcuts, retention cuts, and group selection, are explained earlier in this appendix (under the heading "Silvicultural Practices").

Management Pathways for Achieving Stand Structure Types

Stand Type: Early

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

Stand Type: Intermediate

Pathways—Many of these stands originate from early structure stands that have reached crown closure. Some stands have been so densely stocked that virtually no understory exists; other 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. They may persist for a long time unless density management activities are carried out to produce stands with understory trees and shrubs, or regeneration harvest returns the stands to the early stage.

Stands in the intermediate 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 advanced structure; these same stands may have high value for timber production. Others will have greater potential to develop advanced structure 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 intermediate and advanced structures. The following text box provides an example of a decision process that could be used to develop silvicultural prescriptions for intermediate structure stands.

Example: Developing Prescriptions for Intermediate Structure Stands

1. The stand offers good silvicultural potential for future wood growth or development of desirable stand characteristics. Prescribe for:
    - A. A pathway that does not head for advanced structure (retains biodiversity components such as snags, coarse downed wood, etc.); a pathway that heads for advanced structure (retains biodiversity components and develop multi-canopied structure); or general density management for vigorous growth that defers the decision on the ultimate stand structure for the given stand.
    - B. Regeneration harvest. Prescribe regeneration harvest to meet early structure goals or to realize timber value.
2. The stand does not offer good silvicultural potential. Prescribe for regeneration harvest in near future, unless other management priorities exist.

Stand Types: Advanced

Pathways—A broad range of stand conditions exists in this stage. Stands 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 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.
- The organization and structure of the living plant community is complex. Vertical layering of tree crowns, shrubs, and herbs is well developed.
- Plant communities are complex, layering is extensive, and snags, downed wood, tree litter, and soil organic matter are present.
- Further stand development features include large trees, canopy layering, snags, and substantial downed 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.

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 early and intermediate structures. Stands with more complex structural development may be managed to continue to produce advanced structure. The following text box presents some possible silvicultural prescriptions for advanced structure stands.

Example: General Prescriptions for Advanced Structure Stands

A. A pathway that does not lead to advanced structure (retains biodiversity components such as snags, downed wood, etc.).

B. A pathway that maintains current condition (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 acres in this type that are not necessary contributors for other structure types.

Managing for Key Structural Attributes of Forest Stands

Multi-layered forest canopies, herbs and shrubs, and canopy gaps are structural components present in natural forest stands that are also desired in managed stands to provide biological diversity. Each of these attributes is described in more detail below.

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 FMP, 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 (early) stage and accelerates the onset of the intermediate structure, 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 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 early to intermediate structure. Wildlife species that prefer the open habitats of the early structure 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 intermediate structure can create other important wildlife habitat elements. The intermediate structure stands can provide thermal, hiding, and escape cover, especially for big game mammals. For these reasons, it is important to have closed canopy stands as a part of the forest landscape.

As stand development progresses through the intermediate structure, 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 downed 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 (one-half to two 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 1987; 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).

Managing for Key Legacy Structural Components

Sustainable Forest Ecosystem Management Strategy 4 presents approaches for managing the key habitat components listed below, followed by the reasons for providing these habitat components within the managed forest.

- Residual live trees
- Snags
- Downed wood

Stand-level management for diversity requires managing the structural components of stands. 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 downed wood and tall snags. By 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 be required in specific locations within the district. However, on a districtwide 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 in which the location of a tree might require the relocation of a road to a less stable place, or that a substantially longer road be built to avoid the tree. Examples of situations in which a decision might be made to remove a residual tree, snag, or patch of trees include windthrow or other natural causes of downed trees, likely damage to improvements such as bridges or buildings, or potential 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 in which these components must be removed.

Remnant Old-growth Trees—Existing old growth in the district occurs as scattered individual trees, and occasionally as small isolated patches. Because the occurrence is limited, the ODF’s intent is to retain existing old growth, subject to operational and safety considerations, to provide this element of diversity in present and future stands. The discussion below regarding residual live trees also applies to remnant old-growth trees.

Residual Live Trees

Live retained trees provide important structure for several species of wildlife in different stages of stand development. Patches of live 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). Several bird species are positively associated with the retention of large live trees within harvest units, including the olive-sided flycatcher. In addition to providing raptor perches and foraging substrate for animals living in young plantations, residual live trees in regeneration harvest units may allow development of structurally diverse stands and landscapes in later stages of forest development (Zenner 2000). Retention of large trees within harvest units increases structural heterogeneity within the developing stand, and provides a legacy of structure that may provide habitat (primarily foraging and dispersal) for some species associated with late-successional conditions. As the stand develops, these trees add vertical diversity to stands, providing more habitat niches for wildlife, and potential future nesting sites for species such as northern spotted owls and marbled murrelets. Legacy structure, including residual trees, snags, and downed wood, has been found to be an important component of spotted owl habitat, particularly in younger stands.

In addition, live trees retained at harvest are a source of future downed wood and snags in a stand. This is particularly important in the intermediate structure stage, when the new cohort consists of small diameter trees and there is little mortality. During this stage, retained trees are the only source of large dead wood structures.

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 necessary for the stand and the landscape to develop multi-storied canopies. However, in some situations, individual scattered trees are more susceptible to windthrow.

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. Clumped leave trees often are more stable than individual scattered trees.

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.

Rationale for Number of Residual Live Trees in Regeneration Harvest— Sustainable Ecosystem Management Strategy 4 requires two to four live trees per acre to be retained in regeneration harvest units. These trees are to have a diameter greater than or equal to the stand average, ensuring that large trees are left in stands where they are available. When these larger trees are not available, four trees per acre would normally be retained. Minor species are retained as feasible and practical.

Having a range rather than a target allows flexibility while ensuring that a minimum are retained for any particular sale area. A range of two to four live trees per acre is consistent with the recommendation for providing habitat for the olive-sided flycatcher in open canopy stands developed by Partners in Flight (Altman 1999).

Modeling of the dynamics of snags and logs over time indicates that amounts of snags and downed wood recruited into a stand over time are enhanced by retention of live trees at initial harvest, particularly when minor species are retained (Kennedy et al. 2004). Minor species that are not of significant commercial value can provide a great deal of wildlife value throughout the rotation as well as contribute to stand complexity. Finally, larger trees are more likely to remain alive and standing for a longer period of time; and, if not, they at least will provide snags or logs of a large size to persist throughout the rotation (Kennedy et al. 2004).

Snags

Standing dead trees help to meet the habitat needs of cavity-using species and to serve as a source of future downed wood. Snags can be provided in all stand types, through a combination of existing snag retention, natural mortality in maturing stands, and artificial creation. For the purposes of this FMP, a snag is defined as a dead tree at least 15 inches in diameter and at least 20 feet tall. Neitro et al. (1985) reported that 10 of 11 species of cavity-nesting birds occurring in western Oregon and Washington used snags with diameters of 15 inches and greater. Data summarized by the USFS on its DecAID website indicate that 20 feet is the smallest mean tree height for nest trees measured by various studies of cavity-using species in the Oregon Coast Range (http://wwwnotes.fs.fed.us:81/pnw/DecAID/DecAID.nsf).

Snags are important components of wildlife habitat throughout stand development. In open canopy stands, snags provide habitat for species that require cavities in which to nest, such as purple martins, tree swallows, and western bluebirds. In mature and older stands, snags are used by species such as spotted owls, pileated woodpeckers, and Pacific fishers for nesting and denning. Pileated woodpeckers in particular, and other primary cavity excavators, create the cavities that other species (secondary cavity nesters) use for nesting. In fact, 55 species of wildlife require or frequently use snags for breeding, roosting, or denning in the Pacific Northwest (Weikel and Hayes

1999). Snags are also an important foraging resource, particularly for woodpeckers, throughout stand development.

In developing a strategy for providing snags in a managed landscape, taking into account how snags provide habitats through time is an important consideration. The following conclusions were derived from the results of a dead wood simulation model developed and summarized by Kennedy et al. (2004). The snags created or retained at the time of harvest provide most of the snag resource during the first ten years. There is little recruitment of new snags during this time. When these retained snags are large, they may persist on the landscape for decades. Many existing snags are felled during harvest operations for safety reasons. When live trees in addition to snags are retained at harvest, some of the live trees begin to recruit into snags between 10 and 60 years after harvest. In addition, some of the snags retained at harvest fall over and become downed wood, or become duff if they were initially soft snags. Both existing and recruited snags are important components of the snag resource during this time period. From 60 to 100 years, few of the snags retained at harvest remain standing. During this period, large snags are recruited from retained live trees (which by this time are probably quite large), as well as from large trees available in the new cohort.

Species that use snags in mature stands will also benefit from late successional habitats that have been retained on the landscape in reserves. In addition, snags occurring in riparian areas (which are not counted in this target) will contribute to habitat for mature forest species. However, these reserves in and of themselves are not likely to provide for viable populations of cavity nesting species, and managed, late-successional forests will also provide an important contribution to the habitats for these species.

Rationale for the Number of Snags—The snag management guidelines presented in this FMP are designed to provide nesting, roosting, foraging, perching, and denning habitat for the various species of wildlife that use snags in the Elliott State Forest. Sustainable Forest Ecosystem Management Strategy 4 requires a minimum of three hard snags per acre to be retained in regeneration harvests. When this target has not been achieved within one year after harvest, 0.5 snags per acre are created within the stand, using live trees larger than 20 inches diameter breast height.

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 sufficient snags exist to provide nesting habitat for the target species, sufficient foraging habitat will be 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 likely inadequate, and that foraging resources also need to be considered. An adequate prey base cannot necessarily be supported when providing only for nesting trees.

The DecAID Decayed Wood Advisor (Mellen et al. 2003) is a summary, synthesis, and integration of published scientific literature, research data, wildlife databases, forest inventory databases, and expert judgment and experience. The information presented on ranges of snag and downed wood amounts under natural and current conditions is based on forest inventories, research studies, and other sources. Information is presented on wildlife species use of snags and downed wood based entirely on scientific field research rather than on modeling the biological potential of wildlife populations. This tool can provide a perspective on the quantities of snags and logs present in plots measured for wildlife studies as well as in vegetative inventory plots in various forest types and regions. Although these quantities may not be appropriate for stand-level targets, they do provide a picture of how dead wood is distributed on the landscape.

The ODF's approach is to manage for snags at levels approaching known historical levels. Spies et al. (1988) characterized snags and downed 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 two to four snags per acre greater than 20 inches diameter breast height and more than 16 feet tall. 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 ODF strategy is to retain all existing snags wherever possible and to provide hard snags across the landscape. Existing snags are very valuable for wildlife in that they may already have usable cavities; from an economic standpoint, they are of little or no value. The most critical issue with existing snags is safety. In practice in the Elliott State Forest, the majority of existing snags within harvest units are felled for safety reasons. Hard snags (decay class I–II) provide a unique foraging and nesting substrate; some species only forage on or nest in these recent snags. In addition, more recent snags will persist longer on the landscape than those that are already in a more advanced state of decay.

When the target of three snags per acre is achieved, and snags are distributed appropriately, this level of snag retention should provide habitat for western bluebirds in open canopy stands (Altman 1999). If the retained snags are large, they are likely to remain standing for long periods of time. Over time, additional snags will be recruited from retained live trees, and eventually from the new cohort as it develops. When few snags are retained at initial harvest, stands may undergo significant periods of time without any large snag habitat available until the new cohort develops trees large enough to provide functional snags (Kennedy et al. 2004). Large snags retained at harvest and maintained over time may provide habitat for other cavity-using species in intermediate and some advanced structure stands. Retained live trees also are an important source of large snags over time. However, the most likely source of snags in future advanced structure stands are trees from the new cohort (Kennedy et al. 2004).

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 1992; Zarnowitz and Manuwal 1985; Bull et al. 1997). Larger trees may be more likely to persist for a longer period of time, and for this reason receive more use over time. Some species require a minimum size snag for nesting, so a larger snag will provide opportunities for more species than a smaller one.

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

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.

Downed Wood

Downed wood on the forest floor provides many important functions in forested ecosystems. Some of the identified functions are mineral cycling, nutrient mobilization, moisture retention, maintenance of site productivity, natural forest regeneration (nurse logs), substrates for mycorrhizal formation, shade, cover, and nesting, denning, and foraging habitats for wildlife species in all stand structure types.

Wildlife use downed 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). Logs may have a particular importance to some wildlife species when stands are in an early structure stage. At this stage, the absence of tree and shrub cover means that downed wood may be the only available source of shade and moisture retention. 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 downed wood (Corn and Bury 1991; Bury and Corn 1988; Aubry 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 downed wood and understory vegetation development appeared to play important roles in the observed differences.

Wildlife species have also shown preferences for different attributes of downed 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 downed wood, though the use of particular size and decay classes of debris varied among salamander species (Welsh and Lind 1991).

Downed wood is an integral component of the structure of advanced structure 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 downed 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), and 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 downed 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 downed wood can be substantially less than in natural stands, due to the loss of downed logs from salvage during harvest and site preparation activities, and the lack of large trees left as a source of future downed wood (Spies and Cline 1988; Carey and Johnson 1995). Downed 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 downed 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 downed wood, as the self-thinning processes found in natural stands are reduced in the managed stand.

In developing a strategy for providing downed wood in a managed landscape, it is important to consider how logs provide habitats through time. The following conclusions were derived from the results of a dead wood simulation model developed and summarized by Kennedy et al. (2004). When very little downed wood is present after regeneration harvest, downed wood levels, while increasing over time, tend to remain at low levels. Large logs tend to persist for long periods of time, and when retained at harvest continue to provide large log volume over time. When high levels of live trees and snags are retained at harvest in addition to retained logs, there is a consistent increase in large log volume over time.

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 diameter breast height (Spies and Cline 1988). The size of downed 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. Because 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 FMP contains strategies to replicate old forest conditions that include requirements for the size of downed 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). Because decomposition of this material is gradual, downed logs in natural stands are present in a variety of decay stages. These stages are classified as decay classes I through V. The distribution of total downed 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 downed wood occurs in decay class III (the intermediate class), with the remainder of the downed 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 downed 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 downed wood, a wide range of downed wood should be maintained, by retaining or creating logs in a diverse array of size classes and decay stages. Replicating old forest structural patterns of downed wood is a logical strategy for maintaining a diverse wildlife community.

Rationale for the Downed Wood Target—In regeneration harvest units, where the average diameter breast height of the trees to be harvested is 20 inches or more, an average of at least 300 to 600 cubic feet of hard downed wood per acre will be retained. At least 50 percent of this volume should be in conifer logs. There is also a requirement for two logs per acre to be a minimum of 26 inches diameter at the large end where these logs are available.

Currently, there is no scientific quantification of the exact amount of downed 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 downed 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 downed wood needed to maintain all these groups of wildlife.

The DecAid Decayed Wood Advisor (Mellen et al. 2003) presents information on ranges of snag and downed wood amounts under natural and current conditions based on forest inventories, research studies, and other sources. Information is presented on wildlife species use of snags and downed wood based entirely on scientific field research, rather than on modeling the biological potential of wildlife populations. This tool can provide a perspective on the quantities of snags and logs present in plots measured for wildlife studies as well as in vegetative inventory plots in various forest types and regions. Although these quantities may not be appropriate for stand-level targets, they do provide a picture of how dead wood is distributed on the landscape.

The DOF's approach is to manage for downed wood at levels approaching known historical levels. Spies et al. (1988) characterized snags and downed logs in fire-originated stands in western Oregon and Washington, offering a view of what the historical condition of downed wood 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 downed wood per acre, with an average of 1,700 cubic feet per acre in mature stands. In their inventories, Spies et al. (1988) included downed wood in all decay classes, from very decayed wood, to downed logs that showed little evidence of decay. Approximately 20 percent of the downed wood measured was in early stages of decay and considered hard downed wood (T.A. Spies, personal communication. 1996.). Twenty percent of 1,700 is 340 cubic feet per acre. It may take many years or even decades to develop downed wood that is very decayed. The DOF's strategy involves protecting existing downed logs wherever possible and supplementing existing downed wood by providing additional logs during harvest entries.

The range of 300 to 600 cubic feet per acre of hard logs approximates the percentage of hard logs available in mature stands in the Oregon Coast Range (Spies et al. 1988). The requirement for two logs per acre to be at least 26 inches diameter at the large end recognizes the need for providing large logs that will function as valuable wildlife habitat and persist over long periods of time. The requirement for half of these logs to be conifer recognizes that conifer logs will persist longer on the landscape, while also allowing hardwood logs to be left in areas where hardwoods are predominant in the harvested stand. Hardwood logs, while less persistent through time, still provide an important function in providing shade, moisture retention, cover, and a substrate for insects.

In some cases, regeneration harvests will occur in stands that contain smaller diameter trees, and providing 300 to 600 cubic feet of hard logs may not be operationally practical. Recognizing that downed wood is still an important component to have retained at regeneration harvest, logs are required to be retained, but at a level of three to six logs per acre, without an associated volume range. Live trees retained in these harvests will provide a larger wood contribution in these stands in the future.