Chapter 4

Resource Management Concepts

Chapter 4 presents the resource management concepts underlying the management strategies to be implemented in the Elliott State Forest. Resource management is designed to generate an appropriate balance of economic, environmental, and social values from this state forest. The guiding principles listed in Chapter 3 embrace the concepts of “sustainable” and “integrated” that are fundamental to the management of the Elliott State Forest.

This chapter briefly explains the resource management concepts that were used to develop the strategies of the *Elliott State Forest Management Plan*. The concepts were derived from legal mandates and scientific research in the fields of geology, silviculture, forest ecology, fisheries and wildlife biology, and stream ecology. The full references for the scientific publications cited throughout the text are provided in Appendix B. Following the explanation of the conceptual foundation, the strategies of the FMP are presented in Chapter 5. The strategies provide the direction for achieving the goals and vision that were outlined in Chapter 3.

The main headings in this chapter are:

Introduction

Forest planning begins with overall policy (legal framework), guiding principles, vision, resource management goals, and landscape management strategies, and then proceeds through several steps to site-specific projects. Figure 4-1 shows the hierarchy of four planning levels, from strategic to operational.

The FMP provides the strategic framework for planning of the Elliott State Forest. The strategies are presented in Chapter 5. The proposed Elliott State Forest HCP develops more specific conservation strategies for fish and wildlife species of concern. The HCP is a separate document subject to approval by the USFWS and NOAA Fisheries. Issuance of an ITP, through an approved HCP, is considered a key tool for fully implementing the strategies described in this FMP over the long term.

Using the strategic framework in the FMP and HCP, the district IP is developed to achieve the FMP management goals and the HCP conservation objectives for a 10-year period, and move toward achieving the forest vision. AOPs describe site-specific projects and how those projects are designed to contribute to the goals of the FMP for a one-year period.

The four planning levels, shown on the next page and described in Chapter 1, provide a framework for adaptive management. Agency staff, through identified review and approval processes, can make changes as needed at the various levels, ranging from strategic landscape-wide changes to the FMP and HCP, to specific tactical changes at the district and project level.

STRATEGIC .... OPERATIONAL

FOREST MANAGEMENT PLAN

Oregon Constitution

Maximize Revenue to the Common School Fund Using Sound Techniques of Land Management

Harvest Objectives for Common School Forest Lands

Greatest Permanent Value (BOF Lands) (full range of benefits)

Resource Goals

Integrated Forest Management Strategies

Resource Management Strategies

Key Working Hypotheses

Land Base Designation

Land Management Classification System

Monitoring/Research Goals

Elliott State Forest HCP

Conservation Objectives (species-specific)

Conservation Strategies (species-specific)

Mitigation Measures

Monitoring/Research

Adaptive Management Process

Environmental Impact Statement

Implementing Agreement

10-YEAR IMPLEMENTATION PLAN

Current Condition

Desired Future Condition

Watershed/Basin Descriptions

Management Opportunities

Harvest Objectives for Board of Forestry Lands

Young Stand Management Objectives

Land Management Classification Maps

Recreation Plans

Road Plans

Monitoring/Research Plan

ANNUAL OPERATIONS PLAN

Timber Sale Plan

Young Stand Management Projects

Road Management Projects

Habitat Improvement Projects

Monitoring/Research Projects

Recreation Projects

Figure 4-1. State Forest Plans and Policies: Planning Hierarchy and Key Products

Basic Concepts for Managing the Elliott State Forest

The management approach for the Elliott State Forest synthesizes the knowledge from various disciplines, including forestry, fisheries, wildlife, geology, and hydrology. This approach to forest management seeks to meet the legal mandate for the land and achieve a broad range of resource goals that provide economic, social, and environmental benefits from the forest over time. In addition, this landscape approach manages forested ecosystems by utilizing silvicultural tools that emulate natural disturbances to provide forest products, maintain forest health, and retain significant social value.

The basic concepts for managing the Elliott State Forest in this FMP focus on:

- Sustainable economic and social benefit
- Sustainable forest ecosystem management
- Integrated resource management

Sustainable Economic and Social Benefit—Providing economic and social benefit is essential to sustainable management of the forest. The concept that economic, environmental, and social values of the forest are interdependent is basic to the design of the FMP. All three elements of sustainable forest management are woven throughout the FMP and within the strategies.

The basic concepts for sustainable economic and social benefit in this FMP focus on:

1. Legal mandates and trust obligations
2. Predictable and dependable products and revenues
3. Social benefit through forest management

Sustainable Forest Ecosystem Management—Sustainable forest ecosystem management is the application of silvicultural tools to attain the desired landscape condition, which will meet the resource management goals of the FMP. Specifically, it is designed to produce and maintain an array of forest stand structures and habitats across the landscape in a functional arrangement that provides for the economic, social, and environmental benefits called for in the management direction for these lands. These benefits include a high level of sustainable timber harvest and revenue, diverse habitats for native species, a landscape level contribution to properly functioning aquatic systems, and a forest that provides for diverse recreational opportunities.

The following five key concepts are the foundation for sustainable forest ecosystem management:

1. Recognize the importance of forest disturbance regimes and stand development processes.
2. Provide for biological diversity at the landscape level.
3. Provide for biological diversity at the stand level.
4. Provide for a diverse and healthy forest ecosystem through the principles of integrated pest management.
5. Maintain properly functioning aquatic systems.

These management concepts are discussed in the following pages; additional information is provided in Appendix C.

Integrated Resource Management—Integrated resource management involves the design and implementation of management practices, taking into consideration the effects and benefits of all forest resources such that the goals of the FMP are achieved over time and across the landscape. It does not mean that all resources are treated equally or that management practices must provide for all resources on every acre at all times. The key integrated resource management concepts for management of the Elliott State Forest are discussed at the end of this chapter; they include combining the landscape-level approach with site-specific strategies for other resource values.

Implementation planning is discussed in more detail in Chapter 6. The concepts, framework, and processes for monitoring and adaptive management are also described in Chapter 6.

Basic Concepts for Sustainable Economic and Social Benefit

The guiding principles outlined in Chapter 3 call for sustained economic and social benefit through active and integrated management of the Elliott State Forest over the long term. The terms “sustainable” and “integrated” recognize not only the complexity of forest management goals, but also the complexity of the systems and approaches necessary to meet them. Not all economic and social objectives can be maximized concurrently, however. Therefore, balancing partially incompatible goals through forest management practices is a major challenge. Environmental concepts are the third leg of sustainability and are addressed in other sections of the FMP.

The economic and social benefits of the Elliott State Forest will provide for both forest products and natural resource values.

The basic concepts for sustainable economic and social values in this plan focus on:

1. Legal mandates and trust obligations
2. Predictable and dependable products and revenues
3. Social benefit through forest management

Concept 1: Legal Mandates and Trust Obligations

A key planning principle for the Elliott State Forest involves the constitutional and statutory goals for the two types of forest land ownership.

The goal for Common School Forest Lands is the maximization of revenue to the Common School Fund in the long term, consistent with sound techniques of land management.

Approximately 90.5 percent of the Elliott State Forest and other lands managed by the Coos District are CSFLs. Revenue from these lands goes directly into the CSF, and a percentage of the investment income earned on the fund is distributed each year to support public schools.

The Oregon Constitution requires the State Land Board to manage CSFLs "with the object of obtaining the greatest benefit for the people of this state, consistent with the conservation of this resource under sound techniques of land management." According to a 1992 opinion of Oregon's Attorney General, the "greatest benefit for the people" standard requires the State Land Board to use the lands for schools and the production of income for the CSF. The State Land Board may take management actions that reduce present income if these actions are intended to maximize income over the long term. (See Appendix D for a summary of the 1992 Attorney General's opinion.)

The goal for management of Board of Forestry Lands is to secure the greatest permanent value to the citizens of Oregon by providing healthy, productive, and sustainable forest ecosystems that, over time and across the landscape, provide a full range of social, economic, and environmental benefits to the people of Oregon.

BOFLs constitute approximately 9.5 percent of the land managed by the Coos District. These lands were transferred to the state from the counties in return for a share of future revenue. Much of the counties' share of this revenue also is used to support public schools.

BOF guidance for managing BOFLs calls for maintaining them as forest lands and actively managing them in a sound environmental manner to provide sustainable timber harvest and revenues to the state, counties, and local taxing districts. This management focus is not exclusive of other forest resources, but must be pursued within a broader management context that includes other forest resource values such as fish and wildlife habitats, recreation, and protection of soil, air, and water. These concepts of sustainability are consistent with the goals for CSFLs.

Other legal mandates.

By agreement with the DSL for CSFLs, and by administrative rule for BOFLs, the ODF is directed to develop long-term management plans. The plans for CSFLs are to address ecosystem dynamics and revenue-producing capability. The plans for BOFLs are to be based on the best available science and contain specific elements, including guiding principles, resource descriptions, resource management goals, management strategies, guidelines for asset management, and guidelines for implementation, monitoring, research, and adaptive management. In addition, management plans for CSFLs are to be consistent with the administrative rule for management plans for BOFLs.

Management of the Elliott State Forest must also be consistent with a number of other state and federal laws, including federal and state ESAs and the Oregon Forest Practices Act (FPA).

The ODF will coordinate with the Oregon Department of Fish and Wildlife and Oregon Department of Agriculture in developing plans to comply with the state ESA, as long as the plans do not conflict with the constitutional mandate for Common School Lands.

Under the federal ESA, the prohibition of take of listed fish and wildlife species applies equally to non-federal and federal lands. The term “take” means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. The definition of “harm” includes actual injury or death directly traceable to habitat modification. On non-federal lands, compliance with the federal ESA can be achieved through actions to avoid take or through an ITP issued through approval of an HCP.

Under the federal ESA, take does not apply to plant species. Instead, the ESA prohibits the removal, damage, or destruction of endangered plants on federal lands, and certain other activities on non-federal lands when in violation of state law.

Activities on lands managed by the ODF are subject to the FPA, which addresses specific site and resource protection. The FPA declares it public policy to encourage economically efficient forest practices that assure the continuous growing and harvesting of forest tree species consistent with sound management of soil, air, water, fish, and wildlife resources, as well as scenic resources within visually sensitive corridors, and to ensure the continuous benefits of those resources for future generations of Oregonians. The ODF, through the FPA, is the designated management agency by the DEQ to implement the water quality standards of the federal Clean Water Act on forest operations.

Concept 2: Predictable and Dependable Products and Revenues

Though the Elliott State Forest constitutes a relatively minor percentage of forest land and harvest volume in the state of Oregon as a whole, the cumulative impact of all forest lands in the state is important to Oregon's forest economy. When examined in a local context, harvest volume from the Elliott State Forest is an important part of the economy. One MMBF of timber harvested from the Elliott State Forest generates 11 to 13 jobs in southwest Oregon, with an average wage of approximately $32,000, and generates additional proprietors' and property owners' income to owners of southwest Oregon businesses (Lettman et al. 2001).

CSFLs are managed through an agreement with the DSL – the administrative arm of the State Land Board. The Elliott State Forest constitutes approximately two-thirds of the CSFLs in the state. The revenue from CSFLs accounts for, by far, the greatest amount of land-based revenue to the CSF (typically more than 75 percent of the fund's land-based revenue).

The major emphasis in producing predictable and dependable wood products and revenues will be the continued harvest of high-quality, high-volume stands followed by prompt reforestation. This will promote vigorously growing younger stands that progress through the early and middle forest stages as quickly as possible. This emphasis will require using the full range of silvicultural methods to promote rapid tree and stand development. These activities will also produce significant volumes of lower quality timber from young stands.

Some areas will be developed into advanced structure stands that will serve as habitat for species that use late successional forest areas (see the discussion of stand structures in the "Concept 1: Recognize the Importance of Forest Disturbance Regimes and Stand Development Processes" section of this chapter, page 4-15). Eventually, these stands will be regeneration harvested to provide products and revenue. The overall approach will produce a variety of stand structures across the landscape. Over time, this landscape approach will provide consistent employment in silvicultural operations and in the processing of forest products. It will sustain a constant labor force and a consistent supply of forest products, rather than the historic boom and bust cycles of large regions harvested within a short time. Managing for a diversity of stand types will produce a variety of products. Diversified treatments will produce a range of qualities, sizes, and species of logs to match market conditions, as well as special forest products such as mushrooms, berries, and greenery (Oliver 1992, 1994).

Concept 3: Social Benefit through Forest Management

Social values realized from forest areas are wide-ranging, depending on the values of the individual. They include both commodity and non-commodity values. Most people value a number of social benefits that forests can provide.

Providing a regular source of employment for the local and regional economy, producing products used by businesses, and providing revenue to support education or other public programs are important social values to be derived from forests. These benefits can be provided through sustainable commercial harvest of timber and other forest products.

Environmental values are also considered important social benefits by many people. These values include ecosystems with abundant plant, fish, and wildlife populations for hunting, viewing, and collecting. Clean air, water, and productive soils are important aspects of biological diversity that are highly valued by many people. Aquatic and riparian strategies that provide biological diversity and properly functioning habitats for salmonids and other native fish and aquatic life will also enhance recreational and commercial fisheries.

Recreational opportunities are key benefits of managing the Elliott State Forest, especially for local communities. Though visitors to the Elliott State Forest have a modest direct economic effect on the local economy, these effects measure only a part of the total economic contribution of recreational activity. Other economic changes credited to recreation activity include the indirect and induced economic activity generated in other southwest Oregon counties, the economic activity received by the visitors themselves, and the contribution that these visits make to Oregon’s economy because they add to the perception of enhanced quality of life (Lettman et al. 2001).

Basic Concepts for Sustainable Forest Ecosystem Management

The goals identified in Chapter 3 depend on the functioning of key ecological or ecosystem processes. Maintaining these processes is a fundamental goal for sustainable forest ecosystem management. Salwasser et al. (1993) note that, to conserve ecosystems, regardless of the specific goals and objectives, management must be ecologically viable (environmentally sound), must meet fiduciary obligations (be affordable), and be socially desirable (politically acceptable). Failure to devote adequate attention to any one of these three criteria will result in a system that cannot be sustained. Thus, the closer ecological, social, and economic considerations are in agreement, the greater the likelihood that both ecosystems and society will benefit.

However, ecosystems function sustainably only when they remain within normal bounds of their physical and biological environment. Thus, management of the ecosystem will be successful only when management decisions reflect understanding and awareness of ecological principles related to sustainability. Sustainable management incorporates ecosystem conditions, natural processes, natural disturbance patterns, and productive capabilities into decision-making processes so that human needs are considered in relation to the sustainable capacity of the system. The most scientifically sound basis for ecosystem management is to ensure that the variation characterizing ecosystems includes the range of conditions that are expected at various scales in ecosystems apart from human activities or influences. This approach would generally preserve all components of natural ecosystems, but is not intended to return all lands to a natural state.

Maintaining viable populations of native plant and animal species is a central theme of ecosystem management. This approach also addresses conservation of soils, aquatic and riparian systems, and water resources. It is intended to allow normal fluctuations in populations that could have occurred naturally. It should promote biological diversity and provide for habitat complexity and functions necessary for diversity to prosper.

Sustainable forest ecosystem management is designed to emulate many aspects of natural stand development patterns, as well as preserve portions of the forest for biological refugia. By anticipating future patterns of forest development, foresters predict the potential for individual stands to produce specific characteristics such as a multi-layered canopy. Foresters can then develop appropriate silvicultural prescriptions to emulate stand development and the types of structures, products, and habitats that forest stands will produce over the long term. The result is a forest landscape that more closely resembles historic variability and diversity in a much shorter time frame than that achieved if the existing stands were allowed to develop through natural influences.

Individual stand management will vary greatly under this plan. Some stands will be managed along pathways that focus on timber production, incorporating habitat structures such as snags and downed wood. Others will be managed to produce stands that emulate habitat conditions normally associated with older forests. These stands are also expected to produce high volumes of timber. Stands in conservation areas will be managed to enhance habitat features with minimal amounts of manipulation.

In the long term, many stands will move through all of the stand development stages, and will return to the early structure condition through a regeneration harvest. Thus, when the desired future condition is achieved, much of the landscape will consist of a dynamic mosaic of differently developing stands, but will remain relatively stable in quantities of early, intermediate, and advanced stand structures (see the Key Terms box below). Embedded within the mosaic will be a network of areas that develop into advanced forest structure conditions and then persist in a relatively unmanaged state.

Key Terms

For this FMP, a series of three stand structures have been defined that depict the typical progression of stand development following a natural or human-caused disturbance. These structures are more fully described in the "Concept 1: Recognize the Importance of Forest Disturbance Regimes and Stand Development Processes" section of this chapter.

Early Structure—Young stands with newly established trees, grasses, herbs, and shrubs.

Intermediate Structure—This stage begins when trees fully occupy the site and form a single, main canopy layer. As the trees grow, they compete for light, nutrients, and moisture, and eventually less competitive trees die. Near the end of the stage, small gaps form in the stand where understory trees, shrubs, and herbs begin to reappear. These stands may include sapling stands, unthinned stands, or thinned stands where the overstory still occupies most of the stand.

Advanced Structure—This stage occurs later in stand development. This structure is generally characterized by a relatively open overstory and the establishment of significant understory vegetation. Vigorous herb and shrub communities combine with tree crowns to create multiple canopy layers. Tree crowns and shrubs create a complex vertical structure from the forest floor to the tops of the tallest trees. Some advanced structure stands have structure typically associated with older forests, including large trees; multiple, deep canopy layers; substantial amounts of coarse woody debris; and large snags.

Outside Conservation Areas, stand density will be actively managed to accelerate stand development; this will be performed through periodic thinning and partial cutting. These techniques can be used to produce a variety of results. Some prescriptions will result in fast-growing, well-stocked stands with minimal understories. Other prescriptions will develop more advanced stand structures, with rapid tree diameter growth, enough sunlight on the forest floor to maintain understory plants, and a complex forest canopy. Thinning and partial cutting can also be used to create or maintain other important structural components, such as snags, downed wood, gaps in the canopy, and multiple canopy layers.

A diversity of stand structures will provide for a broad range of ecosystems and wildlife habitats, which will contribute to biological diversity. The structural components associated with the range of stand structures will benefit long-term forest productivity by maintaining the key linkages for nutrient cycling and soil structure. The high level of diversity should result in a resilient forest that will not be prone to large-scale damage from environmental or human-caused stresses.

Many researchers agree that no single, ideal stand structure serves as a panacea to the wildlife and biological diversity issues we face today. Thus, a diversity of stand structures across the landscape in varying amounts and arrangements likely is the most effective way to provide habitats for the broad spectrum of birds, small mammals, or wildlife in general (Oliver 1992, Hunter 1990, Hansen et al. 1991, Carey et al. 1996, Carey and Johnson 1995).

The basic concepts for sustainable forest ecosystem management in this FMP are as follows:

1. Recognize the importance of forest disturbance regimes and stand development processes.
2. Provide for biological diversity at the landscape level.
3. Provide for biological diversity at the stand level.
4. Provide for a diverse and healthy forest ecosystem through the principles of integrated pest management.
5. Maintain properly functioning aquatic systems.

Concept 1: Recognize the Importance of Forest Disturbance Regimes and Stand Development Processes

The dynamic attributes of a forest ecosystem are composition, function, and structure. Composition describes the proportion of various species, while function refers to the processes taking place in the system. Structure includes types and distribution of stand components such as trees, snags, and logs of various sizes and shapes (Franklin et al. 2002).

Stand Composition

As described in Chapter 2, the Elliott State Forest is in the western hemlock zone as defined in Franklin and Dyrness (1973). The forest is dominated by Douglas-fir, and also contains western hemlock and western redcedar. Red alder, Oregon myrtle, golden chinquapin, and Pacific madrone are hardwood species also commonly found on the forest.

Hardwoods play an important role by providing species diversity at both the stand and the landscape level. Depending on stand history and species of the tree, the amount of hardwoods present may range from a few scattered trees to most of the trees in the stand. Red alder can be found in almost pure stands or as scattered trees or small groups in openings in mixed conifer/hardwood stands. Alder, a relatively short-lived and shade-intolerant species, will persist in mixed stands when the crowns are in the upper canopy.

Stand Function

Relationship between Disturbance and Stand Development

Ecologically sustainable forest management is based in part on understanding the relationship between forest disturbances and the subsequent processes of stand development. Natural disturbance regimes and their interaction with climate and terrain determine the size, shape, location, and types of patches that provide heterogeneity in unmanaged forest landscapes (Lindenmayer and Franklin 2002). Recent applications of the principles of ecosystem concepts to forest management recognize the importance of disturbances, both natural and human, in the development of forest planning and operations. Although human disturbance regimes cannot duplicate the spatial complexity of natural disturbances, they can be designed to emulate important attributes of natural disturbances to maintain biological diversity and sustain forest productivity. Such approaches use natural ecological processes to define specific resource management activities (Attiwill, 1994; Grumbine 1994; Norris et al. 1992). The outcome should be the retention of more natural levels of ecosystem complexity and diversity than have resulted from the traditional forest plantation management approaches. Where lands are managed to produce various resource-based goods and services, ecosystem management assumes that greater similarities between the effects of a natural disturbance and effects of management activities lead to a greater probability that natural ecological processes will continue with minimal adverse effect (Rowe 1993).

Natural Disturbance

Disturbance regimes vary at different scales and are relative to specific locations and time intervals. Some locales may be more subject to wind, landslides, and flooding, while others are affected more by fire, insects, and diseases. However, both small- and large-scale disturbances caused by different agents can operate simultaneously in the same community or on the same landscape as a function of local climate, topography, and biota (Pickett and Thompson 1978).

Within a stand, small-scale disturbances primarily involve tree death or treefall and subsequent canopy gap formation. Such gaps occur when one to several large trees in the upper canopy die and/or fall over. The size and intensity of the local disturbance resulting from tree death or treefall are a function of the number and biomass of the tree(s) that fall.

Wildfire, wind, landslides, flooding, and certain other weather phenomena can act over large areas with varying magnitudes. Such catastrophic disturbances affect both healthy and weakened trees, and usually result in significant or complete mortality over wide areas. Large-scale disturbances such as wildfire generally return a stand to an earlier developmental state by killing many plants, thereby favoring the establishment of early seral species. Windthrown forests may be accelerated toward a later developmental state if shade-tolerant advance regeneration forms the bulk of the next stand (Spies and Franklin 1988).

Wildfires range from approximating the size of a canopy gap to covering hundreds of thousands of acres. Wind damage covers a spatial range similar to that of wildfire, from small gaps to landscape scales. Variations in impacts are due to meteorological conditions, topographic characteristics, stand and tree characteristics, and soil characteristics.

Potential consequences of landslides and flooding include major changes to the structure of surface materials and drainage channel systems. In nearly all cases, a similar ecosystem eventually develops on the site. Interactions between the abiotic disturbances of wind and wildfire and biotic disturbances of diseases and insects occur at a large scale as well.

Stand Structure Development

There are several models for stand structure development, but all have similarities (Oliver and Larson 1996; Peet and Christensen 1987; Franklin et al. 2002). Structural development in stands is continuous, rather than occurring in a series of discrete stages, with many of the processes occurring throughout the life of the stand. Specific processes may dominate or characterize stages of stand development, but are not necessarily unique to those stages. Individual stands may also skip developmental stages. Following a stand-replacing disturbance, the dominant developmental process generally operates uniformly over the entire stand. As stands develop, chronic disturbances create small gaps or openings where several stages of development are occurring in several areas within the same stand (Franklin et al. 2002).

Some models use several stages to further refine stand development, but four stages are common to all: stand initiation, stem exclusion, understory reinitiation, and old growth. Although the terminology varies and there is some overlap of developmental stages between models, the developmental processes are universal.

Early Stand Development, Legacies

Stand development after a disturbance is a result of conditions prior to the disturbance and the type and severity of the disturbance. The size, type, and severity of the disturbance; the amount, size, and species of live and dead material remaining; and the conditions immediately following the disturbance govern the starting point for stand development. The effects on stand initiation and pathway are striking when comparing the effects of disturbances. A stand experiencing a moderate severity fire may exhibit similar structural characteristics in 80 years to those found in a 200-year-old stand that experienced a high severity fire (Wimberly et al. 2000). Unlike fire, windstorms leave all of the organic material and may not destroy regeneration already present on site, resulting in much different conditions for stand initiation. The species and density of remnant legacy trees and other vegetation greatly influence the density and distribution of new seedlings. Large downed wood is one of the more persistent legacies, influencing the site for hundreds of years (Spies and Cline 1988). (See description of early structure in the text boxes contained within this section.)

Stand Initiation

A new generation of trees is established during this phase of stand development. The duration of establishment and ultimate pathway of the new generation varies widely. This period may range from five years to several decades (Oliver and Larson 1996). A number of factors that influence regeneration, survival, and growth may delay tree establishment and vary density. Grasses, forbs, and shrubs may dominate the site for 20 to 30 years, but dominance could last as long as 60 years (Spies and Cline 1988). Rapid stand establishment occurs when surviving advance regeneration is released from competition with the overstory after the disturbance (Franklin et al. 2002).

Stem Exclusion

Stands enter the stem exclusion stage when trees reoccupy all the growing space and exclude new plants from becoming established (Oliver and Larson 1996). Canopy closure caused by overlap among individual tree canopies increases inter-tree competition and causes major changes in understory vegetation. Reduced light levels, moderated temperatures, increases in relative humidity, and near-exclusion of wind affect the composition and function of the forest ecosystem. As conditions change, some species are suppressed or eliminated, while other species are favored. This stage is characterized by rapid tree growth and biomass accumulation, competitive exclusion of many organisms, density-dependent tree mortality or self thinning, natural pruning of the lower branches, and crown class differentiation (Franklin et al. 2002).

The time from stand establishment to canopy closure is dependent on the productivity of the site and tree density. Early in the stem exclusion stage, existing trees quickly reoccupy open growing space created by tree mortality or small disturbances. As the overstory trees mature, they cannot continue to fully utilize the growing space created by additional tree mortality or minor disturbances, causing changes in the understory environment. (See description of intermediate structure in the text boxes contained within this section.)

Understory Reinitiation

At this stage, the main cause of overstory tree mortality shifts from inter-tree competition to mortality from disturbance agents such as insects, diseases, wind, and other weather factors. The earlier density-induced mortality results in relatively uniform stands, while chronic disturbances tend to increase stand heterogeneity by creating a variety of patch sizes and gaps unevenly distributed throughout the stand. (See descriptions of intermediate and advanced structure in the text boxes contained within this section.)

Understory reinitiation may occur in Douglas-fir stands at 80 to 100 years, but may occur earlier with more shade-intolerant species or on poor sites (Oliver and Larson 1996). Depending on seed sources, site conditions, and the amount and type of competing vegetation, the time it takes for a shade-tolerant understory to develop can vary considerably.

This stage is characterized by minimum levels of downed wood; reestablishment or expansion of the understory plant community, including shade-tolerant species; shifting from density-dependent to density-independent causes of overstory tree mortality; and the development of defect and decay (Franklin et al. 2002).

Large, downed wood typically is minimal at this time. The large, downed wood resulting from the initial disturbance has decomposed, and most subsequent downed wood recruitment was from smaller trees. As the stand matures, larger size material is available for downed wood recruitment. Downed wood accumulates slowly for the first 100 years, increasing rapidly between 100 and 400 years (Spies and Cline 1988).

Old-Growth Stage

The old-growth stage of stand development is characterized by increasing structural complexity until the stand reaches a state where the trees that pioneered the site eventually die and are replaced by a diverse mosaic of younger trees, or the stand is replaced by a major disturbance. Under natural conditions, this stage of development can occur at approximately 200 to 350 years in Douglas-fir stands, and can proceed for several centuries.

The development of large overstory trees, increased decadence, accumulation of large downed wood, and the reestablishment of moss and lichen communities are characteristic of this stage (Franklin et al. 2002). Vertical and horizontal diversity develop as shade-tolerant trees grow into the overstory canopy, overstory crowns deepen, and gap formation increasingly affects the heterogeneity of the stand. Horizontal diversity is primarily a result of gaps in the tree canopy that are created or expanded. Small gaps are utilized by existing understory vegetation or regenerated by shade-tolerant species. Larger openings may be regenerated with shade-intolerant species. Within each gap, the process of establishment, thinning, and gap formation are repeated, but on a smaller scale (Peet and Christensen 1987). (See description of advanced structure in the text boxes contained within this section.)

Managing for a Diversity of Stand Structures and Complexities

Pacific Northwest forests follow the typical progression of stand establishment and development over time following a major stand-replacement disturbance. Historically, these large scale disturbances resulted from major windstorm events, large-scale insect and disease outbreaks, and wildfires.

For the purposes of this FMP, a series of three stand structures have been defined depicting the typical progression of stand development following a natural or human caused disturbance. This is a simplified model. In reality, a continuum of forest development stages exists, reached by a multitude of pathways. These stand structures apply to all stands regardless of species composition, including pure conifer, mixed conifer/hardwood, and pure hardwood stands.

The processes that develop stand structures are described below. The stand initiation process is represented by the early stand structure. The stem exclusion and early understory reinitiation processes are represented by the intermediate structure. Structural complexity and larger tree size inherent to the advanced understory reinitiation process are characteristic of the advanced stand structure. The term "old growth" is used to describe both a process and a structure. Old-growth stands are included in the advanced stand structure.

The stand structures correlate with at least four types of habitats. Open habitats occur during the early structural stage; closed canopy habitats are associated with intermediate structure stands. In the understory reinitiation stages, habitats have more horizontal and vertical diversity and a variety of habitat niches. Advanced structure stands provide habitats commonly associated with late successional forests.

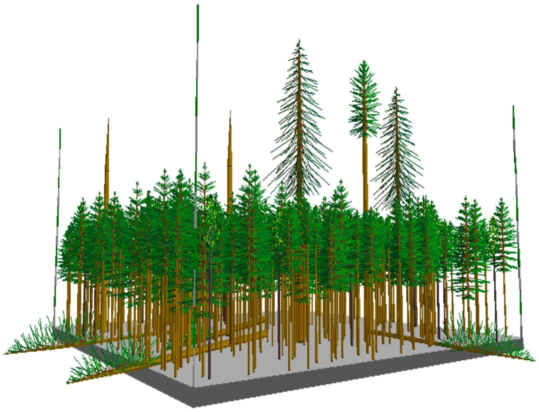
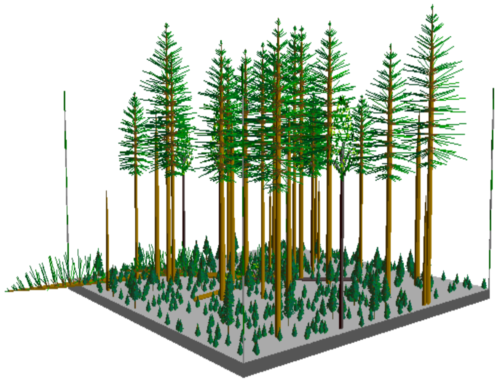
The figures below illustrate the possible appearance of these three representative stand structures following the typical stand disturbance, establishment, and development sequence. In addition, the figures describe stand characteristics, developmental stages, and the relative structural complexity.

Early Structure

Stand Development Process—Stand Initiation

Following a disturbance, an early structure stand develops through the stand initiation process. In the early years of this stage, new plants (trees, shrubs, and herbs) begin growing from seed, sprouts, artificial regeneration, or other means. The site is occupied primarily by tree seedlings or saplings, and herbs or shrubs. The trees can be conifers or hardwoods. Herbs, shrubs, and/or grasses are widespread and vigorous, covering 20 to 80 percent of the ground. This includes first-year regenerated stands, and continues to the stage when the trees approach crown closure. Snags, down wood, and residual live green trees are carried over or recruited from the previous stand.

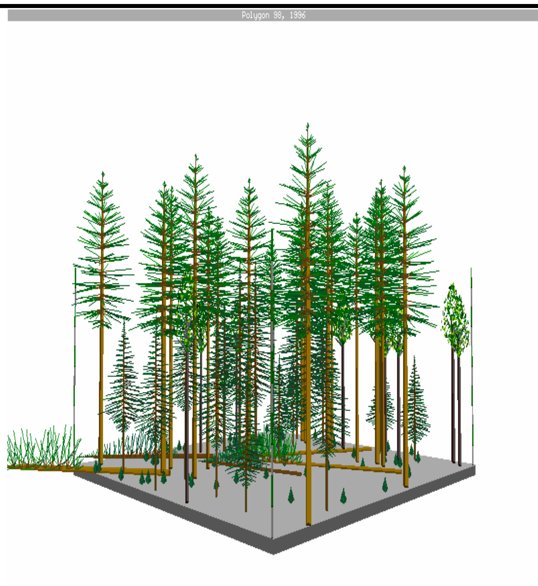
In the later years of this stage, increasing crown closure shades the ground, and herbs, shrubs, and grasses begin to die out or lose vigor. At this point in stand development, the stand transitions from an early stand initiation stage to an intermediate stem exclusion stage. Early structure stands also include stands that are thinned and/or pruned until the average stand diameter is six inches, and an understory exists which meets the definition of an intermediate structure stand.

Intermediate Structure
Stand Development Processes—Stem Exclusion and Understory Reinitiation

As early structure stands develop and transition into the stem exclusion stage, trees fully occupy the site and form a single, main canopy layer. The stem exclusion process begins when new trees, shrubs, and herbs no longer appear and existing ones begin to die, due to competition for light, nutrients, and moisture. Later in the stage, shrubs and herbs may essentially die out of the stand altogether. The shrub and herb layers may be completely absent, or may be short and dominated by one or two shade-tolerant species, such as sword fern, Oregon grape (*Berberis aquifolium*), oxalis (*Oxalis oregana*), or salal. The trees begin to show decreasing diameter growth rate and crown length. Later, less competitive trees die. Root diseases may kill additional trees. As some trees die, snags and down wood begin to appear in the stand. The surviving trees grow bigger and have more variation in height and diameter. Near the end of the stage, enough trees have died and the living trees have enough variation that small gaps form and understory trees, shrubs, and herbs begin to reappear. These stands may include sapling stands, unthinned stands, or thinned stands where the overstory still occupies most of the stand.

The understory reinitiation process begins when enough light and nutrients become available to allow forest floor herbs, shrubs, and tree regeneration to again appear in the understory. The amount of brush and herbaceous species is minimal at the beginning, but increases to a substantial part of the stand by the end of the stage. In all understory reinitiation stands, the shrub and herb layers are likely to continue to diversify and maintain or improve their vigor. Adequate light reaches the ground to allow shade-tolerant and intolerant herb and shrub species (e.g., Oregon grape, sword fern, blackberry (*Rubus spp*.), huckleberry, twinflower (*Linnaea borealis*)) to flourish. Tree canopies may range from a single-species, single-layered, main canopy with associated dominant, codominant, and suppressed trees, to multiple species canopies. However, significant layering of tree crowns has not yet developed in the intermediate structure stands. The least developed stands in this category consist of a single-species, single-layered, main tree canopy with a limited understory of shrubs and herbs. Depending on the intensity and timing of density management activities, stands could shift back and forth between the stem exclusion and understory reinitiation stages over time.



Advanced Structure

Stand Development Process—Understory Reinitiation and Old-Growth Processes

The understory reinitiation process continues after enough light and nutrients become available to allow herbs, shrubs, and tree regeneration to grow and develop in the understory. The new understory may grow very slowly at higher stand densities. The vertical structure of advanced structure stands is more developed than that of intermediate structure stands in the understory reinitiation stage. Tree crowns show significant layering from the tallest trees to the forest floor. Shrub and herb layers are diverse, in terms of species and in vertical arrangement. More advanced structure stands have a mixture of shade-tolerant (e.g., western redcedar, western hemlock, bigleaf maple) and intolerant tree species (e.g., Douglas-fir); and shrub and herb species (vine maple (*Acer circinatum*), huckleberry, rhododendron, Oregon grape, prince's pine (*Chimaphila umbellata*), oxalis). The plant community provides a wide range of habitat niches from the forest floor through the canopy.

Advanced structure stands that are highly diverse may develop structural characteristics typically linked with older forests or old growth. These stands will not necessarily emulate all the processes and functions of very old forests. However, they provide habitat for species commonly associated with older forests.

Old Growth

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

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

In the Elliott State Forest, large disturbances or timber harvest eliminated almost all old-growth stands. Currently only scattered old-growth trees and a few remnant patches of old growth are known to exist on the forest. Some residual old-growth trees remain following the Coos Bay Fire. Specific stands will be identified in this plan as old growth. In the future, old growth will likely occur on state forestlands in areas managed for special purposes, such as conservation areas or riparian areas.

Advanced structure stands are the managed stand type that is intended to emulate some, and possibly many, of the structures and functions of old growth. As the Elliott State FMP is implemented, scientific research and monitoring will be necessary to determine if advanced structure stands can provide the functions of old growth, or if the characteristics of advanced structure stands should be modified to better emulate specific old-growth functions.

Distribution of Stand Structures

The stand structures are not an end in themselves. To determine an appropriate array of stands, forest managers examined the diversity of stands historically associated with conifer forests in the Oregon Coast Range. Studies have been conducted on the historical distributions of older stand types (old growth) in the Oregon Coast Range (Teensma et al. 1991). At the province scale, research suggests that the percentage of older stands 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 (Wimberly et al. 2000).

The desired future condition is designed to emulate the diversity of stands historically associated with conifer forests in the Oregon Coast Range, recognizing that the actual quantity and distribution of these early, intermediate, and advanced structure stands was highly variable through time. Within this context, the quantity and arrangement of stands described in this FMP must therefore be viewed as adaptive, subject to periodic review, and possible revision throughout the life of this FMP. Once a desired array of stand structures is achieved, individual stands on the landscape will continue to change. For example, thinning can reduce tree density and transform an intermediate structure stand into an advanced structure stand more quickly than an unmanaged stand. Some advanced structure stands will continue to persist, while others will be harvested and returned to an early structural condition. Developing intermediate structure stands will replace these harvested stands. However, the relative abundance of the different stand structures is expected to remain reasonably stable. At some point, a dynamic balance of stand complexity will be achieved in a desired array, and individual stands will move in and out of the various developmental stages at a relatively even rate.

Ranges of Stand Structures—The planning team decided to use ranges for the desired future condition instead of setting exact percentages for early, intermediate, and advanced structure stands. First, the stand structures, as defined, do not always appear on the landscape as distinct types. The exact point at which an intermediate structure stand should be classified as advanced is open to individual interpretation.

Second, there is no single correct answer for the appropriate balance of the stand structures. Historically, the stand structures present in the Elliott State Forest have varied greatly. Large wildfires that resulted from Native American burning and subsequent European settlement (Coos Bay Fire and others) reduced the diversity of stand structures within specific watersheds or regions. Wildlife populations always fluctuated in accordance with the amount of available habitat, as well as from other natural factors.

There is currently no research that supports one specific, idealized array of stand complexity optimal for all species. However, because native species coevolved with historical disturbance regimes and the forest conditions that resulted, it is reasonable to conclude that providing meaningful contributions to the habitat needs of all native species will require producing all habitat types or surrogates.

For all these reasons, a precise desired future condition is unnecessary for the differing stand complexities, 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 providing the full array of habitats for native species (see Table 5-1 in Chapter 5).

Silvicultural Practices to Develop Stand Structures

Traditional silvicultural techniques may be used to produce a wide range of stand structures that meet a broad array of objectives. Many of these techniques were developed to enhance wood production. However, their use can be applied to develop forests, stands, and trees with characteristics desirable for multiple objectives (Curtis et al. 1998). Until recently, most of our silvicultural practices have simplified the composition and structure of our stands. Although this is appropriate in some cases, the management objectives of some stands require more diversity and complexity. Many of the components of advanced stand structures are carried over from the previous stand or developed early in the new stand’s life. Management practices can be modified to accommodate this need. The retention and development of these older forest characteristics in younger stands makes it possible to manage stands having structural components and supporting biological processes generally occurring in older stands (Newton and Cole 1987).

Management of a stand does not alter the natural direction of forest development, because no single obligatory direction occurs. However, within limits, the time a stand spends in any stage can be prolonged or shortened with appropriate management (Oliver and Larson 1996). Thinning has the potential to increase structural diversity in young stands, and to accelerate development of habitat for birds associated with late-seral conditions (Hager 2003). Inducing heterogeneity into homogeneous canopies has positive effects on diverse biotic communities and ecosystem function in stands managed with thinning and legacy retention. However, using only legacy retention or only thinning does not seem to produce communities typical of late-seral forests (Wilson and Carey 2000). Other elements, such as shade-tolerant conifer and deciduous understory and decadence have the potential to increase heterogeneity (Carey 2003).

Once the location and types of stand structures desired across the landscape are established, foresters develop silvicultural prescriptions that will place a forest stand on a pathway expected to meet these objectives. A pathway is the anticipated progression of stand development toward an expected condition. The pathway may be long term, starting before timber harvest and continuing through the development of an older, advanced structure. The pathway may also be relatively short term for older stands that are close to meeting management objectives. There is not a true endpoint in stand development. However, for this plan, the desired future condition is used as an endpoint, realizing that the forest is a dynamic system and will continue to change. Depending on present stand conditions and desired outcome, a range of treatments may be necessary to keep a stand moving along the desired pathway. Because of the requirement to anticipate a regime of treatments, the pathway is designed to be dynamic, and changes are expected as new or better information becomes available. Depending on existing stand characteristics and management objectives, management activity may range from relatively passive to intensive.

Foresters use an array of silvicultural practices to maintain desired pathways while providing timber and revenue. Depending on how a silvicultural practice is applied, it may increase or decrease complexity and diversity of a stand primarily through the manipulation of stand structure and composition. The size, amount, and arrangement of vegetation on a site characterize structure. Composition is characterized by the different species of vegetation on a site.

Silvicultural practices are used to meet management objectives and provide diversity among and within stands by:

- Providing a range of stand densities and structure types across the landscape
- Providing a range of thinning densities across the landscape, including variable density thinning
- Adapting thinning prescriptions to maintain or create dense patches of trees and gaps

- Manipulating tree density to encourage desirable tree characteristics, e.g., branch size, crown lengths, diameter growth, and understory development
- Retaining snags, downed wood, and defective live trees
- Promoting decadence by retaining trees that are damaged, show visible signs of rot, or have other characteristics of complex habitat
- Addressing goals of understory vegetation structure and composition during thinning operations
- Retaining patches of shrubs, hardwoods, and conifer reproduction
- Providing for multiple tree species, both conifer and hardwoods
- Maintaining an array of size and age classes in the stand
- Planting shade-tolerant species underneath the thinned overstory
- Promoting stand stability with early density management (Wilson and Oliver 2000)
- Utilizing salvage harvesting, balancing short- and long-term economic returns with the benefits that dead trees contribute to meeting landscape objectives

The differences among complex forests are a result of multiple developmental pathways. These differences contribute to ecological diversity through every stage of forest development (Spies 2003). A full range of stand structures will be maintained across the landscape. Some stands will be placed on a high intensity pathway with strict tree density control, intensive control of competing vegetation, and shorter rotations. Silvicultural treatments are designed to keep tree density at relatively high levels, utilizing most of the available growing space. These stands tend to be more uniform, with little or no understory development, are managed primarily for timber production, and will generally produce early and intermediate structure stands. At the other end of the spectrum, stands may be on a pathway emphasizing diversity, and will be retained for longer periods on the landscape. Trees in these stands may never occupy all the available growing space; or may occupy all of the available space for only short periods during stand development. These stands tend to originate after a disturbance with a supply of snags, down wood, and residual green trees, and generally produce advanced structure stands. The stands are open-grown throughout most of their early life, allowing shrubs and trees to develop in the understory (Tappeiner et al. 1997). Although there will be stands on each of these pathways, most stands on the Elliott State Forest will be on pathways somewhere in between.

Concept 2: Provide for Biological Diversity at the Landscape Level

Managing for Biological Diversity

Forest management for biological diversity is implemented at two scales: a forest stand and the forested landscape. The stand may be defined as a patch of forest distinct in composition or structure or both from adjacent areas (Lindenmayer and Franklin 2002). Silvicultural treatments are applied at the stand level. The landscape may be defined as many sets of stands that cover an area ranging from many hundreds to tens of thousands of acres (Lindenmayer and Franklin 2002). This section discusses some of the concepts behind landscape level management for diversity. The next section discusses some of the concepts behind stand level management for diversity.

Managing for biological diversity requires managing at various levels of biological organization: species, genetic variation within species, communities of organisms, functional diversity, ecosystem diversity, and associated diversity of processes. Managing for diversity also requires recognition that certain concepts and many details of managing ecosystems require further testing and refinement. Thus, an adaptive management approach is required that integrates management, research, and monitoring.

There is no one size of landscape for all classes of wildlife because each organism scales the landscape differently. Planning for biological diversity at the landscape level requires consideration at a range of spatial scales. Landscape management for diversity is based on the following principles:

- Manage for a variety of seral stages, stand structures, and patch sizes across the landscape, emulating natural patterns (Concept 1).
- Manage the arrangement and quantity of seral stages, stand structures and patch sizes to provide functional habitats and connectivity among habitats for native wildlife species.
- Maintain habitats of individual species or groups of species at particular risk of extinction.
- Maintain unique ecosystems, such as riparian areas, springs, wetlands, rock outcrops, and talus slopes.

Sustainable Forest Ecosystem Management Concept 1 described the concepts behind managing the forest for a variety of seral stages and stand structures. The following discussion focuses on how these stand structures are arranged on the landscape.

Functional Arrangement of Stands

How stand structures are arranged on the landscape, including the size of patches, how close similar patches are to one another, and what types of structures are adjacent to other types, determines in part the functionality of the different habitats for wildlife and other species. While some species are associated with the diverse, high-contrast edges between stands, other species have negative associations with these areas and select interior habitats that are not influenced by high-contrast edges. In addition, the degree to which habitat patches are connected across a landscape influences the distribution of some species.

Disturbances drive landscape composition and pattern, which in turn influence the distribution and abundance of wildlife species. The arrangement of habitat to allow movement of individuals between habitat patches describes the concept of landscape connectivity. Movement of organisms through a landscape shapes the distribution and abundance of a species. When a landscape provides connectivity for a species, habitat patches are more likely to be occupied, chances for long-term persistence are enhanced, and the ability of the species to recolonize a landscape after disturbance is improved (Lindenmayer and Franklin 2002). Thus, the pattern as well as the composition of habitat patches on the landscape is an important consideration in managing forests for wildlife.

Landscape connectivity is a species-specific concept. The connectivity of a landscape will be perceived differently by organisms with different dispersal abilities and habitat requirements. A species with limited dispersal capabilities may not be able to move across an area of the landscape that does not contain the habitat elements it requires, and so requires habitat patches to be adjacent. These species are thought of as having limited gap-crossing abilities. Other species, particularly highly mobile species, are able to cross gaps in their habitat and thus do not require patches to be adjacent, but within some distance of each other. Species that are abundant in well-connected landscapes may not have evolved well-developed dispersal mechanisms and thus may be vulnerable to landscape change (Lindenmayer and Franklin 2002; see Appendix C for a more detailed description of the concept of landscape connectivity).

In this FMP, approaches to providing habitat connectivity include:

- Applying landscape level habitat goals for structures and habitat conditions
- Incorporating areas managed primarily for conservation goals (conservation areas) throughout the forest
- Including functional patches of habitat outside of conservation areas
- Managing for stand structural complexity across the landscape

In this FMP, connectivity for species using late successional habitats was addressed in part through the designation of target percentages of advanced structure across the Elliott State Forest landscape, as well as in the individual management basins (see Sustainable Forest Ecosystem Management Strategy 1 in Chapter 5). Connectivity for species using late successional habitats also is addressed through the designation of conservation areas (see Sustainable Forest Ecosystem Management Strategy 2 in Chapter 5). Conservation areas facilitate connectivity by acting as stepping stones between larger reserves on adjacent federal lands, as well as contributing to biological diversity in their own right by providing important habitats for some species. Conservation areas protect aquatic and semi-aquatic ecosystems; provide refugia for organisms that subsequently provide offspring for colonizing surrounding forest; maintain landscape heterogeneity; provide nodes for restoration and expansion of key habitats; and increase protection for habitats, vegetation types, or organisms poorly represented in large ecological reserves (Lindenmayer and Franklin 2002). The arrangement of these structures within a management basin will also be an important consideration in providing functional habitat patches outside of conservation areas (see Sustainable Forest Ecosystem Management Strategy 3 in Chapter 5). Finally, connectivity for wildlife was also a primary consideration in setting goals for retention of structural features such as snags and logs (see Sustainable Forest Ecosystem Management Strategy 4 in Chapter 5). Managing for these structures across the landscape will provide connectivity for some species that rely on these structures as important components of their habitats.

Maintaining habitats for species at risk and maintaining unique ecosystems

Maintaining habitats of individual species or groups of species at particular risk of extinction involves identifying these habitats and ensuring they are maintained on the landscape. The most obvious way to ensure maintenance of specific habitats is through protection in conservation areas; another is through ensuring that the habitat type is maintained on the landscape over time through management. In this FMP, habitats for particular species at risk were identified and included in threatened and endangered species core areas (see Chapter 5). Riparian areas are protected through the aquatic and riparian strategies, and unique ecosystems were identified and are included in conservation areas.

Concept 3: Provide Biological Diversity at the Stand Level

Sustainable forest ecosystem management involves more than achieving a specific range of early, intermediate, and advanced structure stands. Managing for diversity and landscape planning are necessary to provide for a functional arrangement of the stands, and the stands must also have key structural components.

The landscape-level principles address this broad distribution of forest stands over the landscape and through time. Site-specific principles address managing stands to contain key structural components. Stand-level management deals with the structure and function of the individual stand, which differ with seral stage, ecosystem, and disturbance history. Within individual stands in all structure classes, important structural features for maintaining diversity include:

- Large and old trees
- Dead and dying wood (snags, wildlife trees, and downed wood)
- Understory vegetation

Legacy Components—Stand Level Management for Biological Diversity

Investigations of the effects of natural disturbances on forests underscore the importance of these events in ecosystem development. Results from these studies emphasize the importance of biological legacies (surviving organisms as well as stand structural components) to the rapid reestablishment of ecosystems that have high levels of structural, functional, and compositional diversity. Based on these results, the creation and maintenance of structurally complex managed stands is becoming the primary approach to managing forests for multiple, complex objectives, including commodity production (Franklin et al. 1997).

The most apparent changes caused by natural and human disturbances are in the type and distribution of structural components in the stands. Stands can be characterized as simple to complex based on the amount and distribution of the structural components. Active management to maintain structural complexity is vital to prevent the decline and eventual loss of key structural attributes (Lindenmayer and Franklin 2002).

Key structural attributes include the size of standing live and dead trees; the condition of those trees; and the size, amount, and condition of down wood on the forest floor. The canopies and boles of standing trees provide important habitats for a variety of wildlife. Down wood provides habitat and a long-term source of nutrients. It also fulfills many important roles in stream ecosystems by forming pools and backwaters, providing nutrients, dissipating the energy of flowing water, and trapping sediment. This structural complexity provides the basis for much of the variety and richness of species, habitats, and processes.

Approaches proposed to create structurally complex managed stands include silvicultural treatment of established stands to create specific structural conditions, and the retention of structural features at the time of harvest. Neither approach is mutually exclusive, although each has specific circumstances where it is particularly appropriate.

Active management outside of conservation areas may contribute to complexity on the landscape and habitat connectivity by retaining certain structures important to wildlife. Stand structures important for wildlife include large living trees and snags, large diameter logs, vertical heterogeneity—canopy layers, canopy gaps or antigaps—and thickets of understory vegetation (Lindenmayer and Franklin 2002; Bunnell et al. 1997). Providing these structural features in managed stands provides within-stand heterogeneity that allows some animals to persist in the managed areas and others to disperse across the managed area that otherwise would be prevented from doing so. In addition, these structures provide structural enrichment that allows a harvested stand to return more quickly to habitat suitability (Lindenmayer and Franklin 2002). These structures are described in more detail below.

Large Trees and Defective Trees—Large diameter trees are often characterized by large-diameter branches, complex branching systems, and bark habitats. These structures provide habitats for many organisms. When these large trees also contain defect and/or decay organisms (e.g., broken tops, heart-rot decay, mistletoe), they provide unique habitats and foraging opportunities for an even wider array of species. Often, these living trees with decay provide many of the same functions as snags, but remain on the landscape for a longer period of time. In addition, large trees and defective trees provide a potential source of future snag and downed wood structure.

A key structural component of advanced structure stands is the presence of large trees. One way to sustain this structural component within a managed forest is to retain enough residual green trees in regeneration harvest units to provide the required level of large trees when the stand develops the other characteristics associated with these stands.

Large trees and defective trees are preferred for retention in regeneration harvest units.

Snags—Snags help to meet the habitat needs of wildlife species, and also serve as a source of future down wood. Snags can be provided in all stand types, through a combination of existing snag retention, natural mortality in maturing stands, and artificial creation. Large snags are particularly important structures because their size allows them to be used by a wider range of species and because they tend to stay standing on the landscape for longer periods of time.

Standing dead trees are important to many species of wildlife, including woodpeckers, other cavity-nesting birds, raptors, bats, marten, bear, and many other birds and mammals. Snags provide nesting, roosting, foraging, perching, and denning habitat for various species of wildlife in the Elliott State 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, maintenance of site productivity, natural forest regeneration (nurse logs), substrates for mycorrhizal formation, and provision of diverse habitats for wildlife species. Downed wood is an integral component 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. Large diameter logs are important to wildlife because their size allows them to be used by a wider range of species, and because they remain on the landscape for long periods of time.

Sustainable forest ecosystem management requires managing the structural components of stands, as well as arranging early, intermediate, and advanced structure stands on the landscape. Through careful planning of the spatial arrangement and temporal occurrence of stands and structural components on the landscape, managers can find reasonable approaches to develop the desired forest structural characteristics for wildlife and biological diversity.

Understory vegetation –Understory vegetation contributes a variety of functions to the forest stand including providing shelter and food for many species of wildlife, substrate for other organisms such as bryophytes and macrolichens, nutrient cycling, and structure and compositional diversity. Shrubs provide food directly to insects which in turn are food for many species of birds and mammals. In addition, shrubs provide food for ungulates such as deer and elk, and berry or mast-producing shrubs provide food directly to birds and mammals. Understory vegetation also provides shelter and nesting sites for various species of birds and other wildlife (Muir et al. 2002).

Forest management can affect the structure of understory vegetation. Thinning dense forests can promote biodiversity and abundance of understory plants. Since some plants do better in relatively open conditions while others thrive in more closed-canopy forests, thinning prescriptions that incorporate variable density practices may maintain more diversity of understory vegetation than uniform prescriptions (Muir et al. 2002).

Concept 4: Provide for a Diverse and Healthy Forest Ecosystem through the Principles of Integrated Pest Management

The desired forest condition is one in which biotic and abiotic influences do not threaten resource management objectives now or in the future. Biotic influences, such as insects, diseases, and vertebrates, are integral parts of the forest ecosystem. These disturbance agents, which can damage or kill trees, are for the most part native species that have been functional parts of the Elliott State Forest ecosystem for thousands of years. (A few agents, such as white pine blister rust, have been introduced and have become naturalized). Abiotic factors, such as weather extremes, drought, fire, climate change, and pollution, are often unpredictable or uncontrollable, and history shows that they too can cause severe damage.

When disturbance agents damage or kill trees, they affect the structure and composition of forests. These effects can be either positive or negative, depending on management objectives. Birds and other animals use dead and/or decayed trees for nesting, shelter, and foraging. Selective killing of certain tree species or individuals contributes to diversity by creating canopy gaps that provide space, light, and nutrients for a variety of plant and animal species. When forests experience large-scale insect outbreaks or disease epidemics, catastrophic and unwanted changes to the forest can occur.

A general principle of forest management is that greater biological diversity provides stability and resiliency to the forest, especially with regard to pests. A diversity of tree species provides some assurance that pest outbreaks will not kill all of the trees, because most native pests have some degree of host specificity. Structurally and compositionally diverse forests also will contain habitats and conditions suitable for the many natural factors that help keep pest populations and levels of damage within acceptable levels.

Strategies to reduce the undesirable impacts of insects, diseases, and other agents must consider the characteristics of individual stands, situations, management objectives, and the landscape or regional context. Management objectives for the Elliott State Forest vary over the landscape and often differ from one stand to the next. These various objectives help determine the desired future condition of the forest, which in turn drives stand management activities. Management actions must consider the effects of disturbance agents, which are a permanent part of the forest ecosystem. Integrating forest health strategies with management ensures the widest availability of options as forest management is adjusted and adapted in the future.

The most effective way to maintain a desirable forest condition is to prevent an undesirable condition from occurring. This is accomplished primarily through active management of stands. Prevention strategies involve establishing tree species and genotypes that are well-suited to the site, ensuring a diversity of species to avoid catastrophic losses, manipulating stand density to avoid stress that may predispose trees to pest injury, and manipulating stand structure and composition to create unfavorable conditions for pests.

Rather than elimination or eradication of pests on state forestlands (except in the event of an introduced exotic pest), the aim is on managing the forest such that pest effects are within acceptable ranges (which vary over time and space with changing objectives and constraints). The undesirable effects of these various influences can be mitigated through several prevention and suppression strategies. Many of these strategies involve applying existing silvicultural treatments and technologies. However, new approaches to management should be explored, and existing methods monitored to ensure that the best strategies are used. The forest health strategies apply to both upland and riparian areas.

In some cases, pest populations and associated damage can exceed the desired levels, and thus suppression might be appropriate. Any suppression activities on state forest lands must adhere to the principles of IPM. This approach uses the most appropriate of all reasonably available means, tactics, or strategies, blended together to minimize the impact of forest pests to meet site-specific management objectives. IPM techniques may include the use of natural predators and parasites, genetically resistant hosts, environmental modifications, and, when appropriate, chemical pesticides or herbicides.

Concept 5: Maintain and Enhance Properly Functioning Aquatic Systems

Riparian and aquatic habitats will be managed to maintain and enhance key functions and processes of aquatic and riparian systems. Because streams are tightly linked to the landscapes through which they flow, riparian and aquatic conditions depend on the interrelated components of the entire landscape. For this reason, this FMP uses a blended approach that applies the concepts of landscape ecology to manage riparian and aquatic habitats at the landscape level and through site-specific prescription. This type of two-tiered approach was cited by the Independent Multidisciplinary Science Team as necessary to achieve a high likelihood of providing properly functioning aquatic systems (Independent Multidisciplinary Science Team 1999).

The structural components in a landscape include the physical habitat occupied by salmonids and other organisms, along with the structures and processes that maintain the integrity of that habitat. Functional interactions include the flows of energy and materials within the ecosystem. Landscapes are dynamic: both structure and function change across time and space. Even with change, stability is ensured so long as ecosystem structure and function are maintained within certain bounds and all required components remain within the landscape (Independent Multidisciplinary Science Team 1999).

Management for Proper Functioning of Aquatic Systems

The functioning of natural riparian and aquatic areas depends on the interaction of three components: vegetation, landform and soils, and hydrology. Riparian-wetland areas function properly when adequate vegetation, landform, or large wood are present to: 1) dissipate stream energy associated with high waterflows, reducing erosion and improving water quality; 2) filter sediment, capture bedload, and aid floodplain development; 3) improve flood-water retention and ground-water recharge; 4) stabilize streambanks; 5) develop ponds and channels of sufficient depth and duration to provide fish habitat; and 6) support biological diversity (USDI Bureau of Land Management 1993, revised 1995). In determining what constitutes "properly functioning aquatic systems," the overall approach in this FMP is based on the following key concepts:

- Native aquatic species have coevolved with the forest ecosystems in western Oregon.
- High quality aquatic habitats result from the interaction of many processes, some of which have been influenced by human activity.
- Aquatic habitats are dynamic and variable in quality for specific species, through time and across the landscape.
- No single habitat condition constitutes a "properly functioning" condition. Rather, providing diverse aquatic and riparian conditions over time and space would more closely emulate the natural disturbance regimes under which native species evolved.

The biological and ecological objectives of the strategies in this plan are to maintain and enhance the key ecological functions of aquatic, riparian, and upland areas that directly influence the freshwater habitat of aquatic species, within the context of the natural disturbance regimes that created habitat for these species.

Riparian Area Management

Properly functioning aquatic habitats must occur through two major approaches:
1) management towards a desired future condition in specific riparian areas; and
2) management to support targeted functions and processes in specific riparian areas.

Understanding the role of riparian vegetation is fundamental to understanding the importance of riparian management. Natural disturbance regimes, including floods, debris flows, and beaver activity, historically determined the temporal and spatial distribution of the range of riparian characteristics (Teensma et al. 1991, Wimberly et al. 2000). Although significant areas of old growth are likely to have occurred along riparian areas, variability in the intensity, timing, and location of disturbance events created a diverse mosaic of riparian vegetation characteristics.

The complex interactions between aquatic plants (primary production of nutrients), salmon biological processes, and stream temperature result in a variable response to increased levels of sunlight to the stream. A riparian forest may reduce the amount of sunlight reaching the stream, thus helping maintain or reduce stream temperatures. Long-term management must provide the appropriate range of conditions to ensure appropriate water quality conditions in the riparian and aquatic systems so that they are biologically productive.

The massive network of roots growing from vegetation near the stream bank helps stabilize the soil and slow erosion. Large trees growing in the riparian area are the source of LWD that creates complex fish habitat. Leaves and other organic matter falling into the stream provide an energy source for this ecosystem (Forest Practices Advisory Committee Issue Paper on Riparian Function, November 1999).

A more detailed explanation of these approaches is presented in Chapter 5, under the heading, “Strategy 6: Management of Aquatic and Riparian Systems.”

Management strategies within riparian areas should be consistent with achieving or maintaining the desired conditions specified for the water body. For areas that do not meet the desired condition, management strategies should be designed to move the stand toward these conditions. Riparian areas that meet the desired conditions should be maintained in that state with limited or no management activity.

Desired Conditions

Fish-bearing Streams (Type F) and Large/Medium Non-fish-bearing Streams (Type N)—The goal of management along fish-bearing streams and larger non-fish-bearing streams is to grow and retain vegetation so that, over time, riparian and aquatic habitat conditions are maintained as, or become similar to, those associated with mature forest stands. Generally, the conditions associated with conifer stands of approximately 80 to 100 years of age or older are sites conducive to conifer production. Mature hardwood stands are the desired condition in sites where hardwoods are expected to be the natural plant community. This plant community is often more common on riparian sites because of the presence of saturated soils (high water table) or the effects of periodic floods. Mature forest conditions should support functions and processes associated with properly functioning aquatic habitats.

Small Non-fish-bearing Streams (Type N)—Along small non-fish-bearing streams, the overall goal of riparian vegetation management is to grow and retain vegetation sufficient to support important functions and processes within the various streams, and to contribute to achieving properly functioning conditions in downstream fish-bearing waters. The functions of these streams will be maintained by the influence and contributions of adjacent stands managed to meet the landscape-level stand structure desired conditions, and by vegetation retained in riparian areas during harvest activities. Management strategies should be designed and implemented to maintain and enhance water quality, supplement wildlife habitat, and contribute to the overall supply of instream large wood within a watershed.

This FMP recognizes that a variety of small Type N streams exist across the forest landscape, and that these streams may differ in their physical characteristics, dominant functional processes, and contribution to watershed-level processes. As a result, the strategies for these Type N streams should vary according to which functions and processes are dominant within an individual stream. Riparian vegetation retention should be designed to maintain these dominant functions. The following section summarizes the key functions and processes that are considered important for different small Type N streams.

Perennial Streams—These streams are characterized in terms of function by their potential ability to influence water temperature in downstream reaches. Steeper gradient streams may also periodically transport large wood and coarse sediments to downstream reaches. Fine sediment and leaf litter (nutrient) storage processes are somewhat limited in the steeper streams primarily because past practices removed retention structures. The presence of large wood may enhance nutrient storage processes, and affects the morphology of steep channels primarily through the storage of coarse sediments. These streams are also often recognized as providing important habitats for certain sensitive amphibian species.

Lower gradient perennial streams generally lack the hydrologic force necessary to transport large wood or coarse sediments, but they possess the ability to transport fine sediments during normal storm events. These streams are often the sites where large wood and coarse sediments settle out and are stored during flood events. Fine sediment and leaf litter (nutrient) storage processes are dominant in these streams during most times of the year. The presence of large wood enhances these processes, and can directly influence channel morphology in non-confined reaches.

Riparian vegetation on these streams plays a key role in protecting stream bank stability, providing leaf litter input, and maintaining water temperature to provide cool water sources to downstream reaches. Water temperature protection should be focused in the downstream portions of these streams where the greatest influence on fish-bearing stream temperatures is most likely to occur. Vegetation retention should also be prioritized on reaches that may support amphibians. Management should be designed to provide a source of large durable wood for recruitment to these channels. In steeper streams, the wood will function as localized sites to sort and store coarse sediments, and as a potential supply of large wood for downstream reaches during periodic transport events. In all channel types, large wood enhances fine sediment and leaf litter (nutrient) storage and routing processes. Instream material to support these processes is provided by adjacent riparian stands, and may be delivered from steeper, upstream reaches.

Seasonal High energy Streams—The presence of a relatively wide active channel on these seasonally flowing streams indicates that periodic high flows can be a prevalent channel-forming feature. The relatively steep gradient, in combination with the potential for high flows, indicates a capacity for these streams to potentially transport coarse sediment and large wood. Where the influence of large wood is lacking, segments of these channels are often observed to have scoured to a bedrock-dominated form. With large wood, these channels commonly exhibit a stepped profile as a result of coarse sediment storage. The presence of large wood can change the morphology of these channels. Large wood transport events are assumed to be limited to infrequent high flow events and debris flows. The lack of perennial flow minimizes the influence of these streams on water temperature in downstream fish-bearing reaches.

Management along these streams should focus on providing a source of large, durable wood to maintain a stepped profile channel form, and to create habitat beneficial to aquatic species. The wood will function as sites that sort and store coarse sediments within the stream, and to provide a large wood supply for downstream reaches during periodic transport events. Large wood in these streams will also trap smaller materials, which will enhance the storage and processing of leaf litter (nutrients). Riparian vegetation should also be managed to protect stream bank stability, and provide leaf litter input. Because these streams do not flow perennially, management has little potential to affect water temperature in downstream reaches, or to moderate near-channel riparian micro-climate.

Seasonal Potential Debris Flow Track Reaches—The physical setting and characteristics of these streams indicates a high probability of large wood delivery to downstream fish-bearing waters in the event of slope failure. The morphology of these channels is conducive to transporting large wood during debris flows. The presence of high landslide hazard locations near these channels indicates a potential that debris flow events could occur. During these events, it is assumed that vegetation retained along the debris flow track will either reduce the energy of the event and cause the materials to become temporarily stored within the channel, or become entrained within the debris wedge for delivery to downstream reaches. Management should focus on maintaining vegetation that has a high probability of interacting with debris flows along this track. The emphasis should be on maintaining large trees that can provide the functional habitat-forming elements of these natural disturbance events.

The presence of vegetation along these channels supports stream functions and processes during the period when debris flow events do not occur. Riparian vegetation provides nutrient (leaf litter) input. Large wood recruited to these channels sorts and stores coarse sediments and influences channel morphology. This material also enhances nutrient storage and processing functions. The lack of perennial flow minimizes potential influences on summer water temperature in downstream fish-bearing reaches.

Other Seasonal Streams—Individually, these streams are assumed to have limited overall influence on watershed-level aquatic conditions due to their small size, flow pattern, and morphological characteristics. Their small size and seasonal flow pattern limits their individual potential to influence downstream water temperatures. The size, morphology, and physical setting of these streams also indicate a lower probability that large wood transport to downstream reaches is a significant function. The major functions of these waters are assumed to be the recruitment, routing, and processing of leaf litter, and transport, sorting, and storage of fine sediments.

The Blended Approach—A Landscape-Level Approach Combined with Site-Specific Strategies

Aquatic ecosystems interact closely with the surrounding terrestrial systems, both at the landscape scale and at the scale of stream reaches and riparian zones. Therefore, the health of the aquatic system depends on forest management practices that recognize, maintain, and enhance the functions and processes that compose these terrestrial-aquatic interactions at a variety of scales.

Historical Conditions, Disturbance Regimes, and Riparian and Aquatic Habitats

Conditions over the landscape are dynamic. Aquatic and riparian habitats in western Oregon have always represented a continually shifting mosaic of disturbed and undisturbed habitats. At any particular point in time, some streams offer better habitat conditions for specific species than others (Independent Multidisciplinary Science Team 1999).

Historically, forest stands in the Elliott State Forest ranged from dense mature or old-growth conifer forests to sparsely forested open conditions created by fire, floods, wind, or other disturbance factors. It is estimated that, from 1850 to 1920, approximately 50 to 70 percent of forest stands in the Oregon Coast Range were in the mature or old-growth stages, defined as greater than 100 years of age (Teensma et al. 1991). More recent modeling efforts have estimated that historic levels of old growth ranged from 30 to 70 percent at the province scale. At smaller scales, the variability was even greater, ranging from 15 to 85 percent of the landscape at any point in time (Wimberly et al. 2000). Streamside forests likely had similar proportions of old and young forests, although there may have been more hardwood stands and young stands near large streams because of more frequent disturbances, including floods, debris flows, beaver activity, and related competition with shrub species. The riparian areas of smaller streams were more likely to be dominated by conifer stands.

Mature forest conditions likely dominated the landscape from 1850 to 1920. Instream habitat conditions varied in response to periodic catastrophic disturbances and variations in forest conditions across a watershed. In the Elliott State Forest, for example, a fire in 1868 burned more than 90 percent of the forest.

It is becoming increasingly evident that riparian and aquatic ecosystems are maintained over the long term by periodic upland and hydrologic disturbances. For example, wildfires left burned forests with structural elements such as snags and fallen trees, many of which were ultimately delivered to stream channels through landslides or other mechanisms. Natural disturbances such as wildfires, windstorms, and floods have affected and created Oregon’s forests for millennia. Native flora and fauna evolved with these disturbance events. There is considerable debate about the frequency and magnitude of these events, and it appears that forest disturbance frequencies vary considerably throughout Oregon’s forests based on location, climate, and ecosystem. The typical disturbance pattern in an area is known as the disturbance regime.

In the past, forest managers often did not recognize the structural needs of the streams and forests and the processes that created these structures. In the rehabilitation of the Columbus Day Storm, salvage logging was performed before new trees were planted. Historic timber harvesters did not attempt to maintain large conifers and fallen trees in riparian and aquatic habitats. Because of concerns about fish passage and floods, large wood was deliberately removed from stream channels. Thus, past management activities have contributed to the current low levels of large wood in most stream channels in the Elliott State Forest.

More specific analytical efforts are necessary to accurately describe the current conditions of riparian and aquatic habitats, including the levels of structural components such as large wood and large streamside conifers. This information will be the basis for site-specific prescriptions that use both active and passive management strategies to produce the desired conditions. Although active management can potentially produce the desired results several decades sooner than passive management, it also has some short-term risk. Prescriptions must balance the benefits and risks based on site-specific conditions.

Thus, in developing a set of strategies to support properly functioning aquatic systems, it is necessary to apply principles of landscape ecology to manage habitat at both the site-specific and landscape level. This type of a blended approach seeks to emulate disturbance patterns in both upslope and riparian areas (Independent Multidisciplinary Science Team 1999).

Slope Stability

Many watershed events can affect aquatic and riparian areas. Slope stability and landslides are a particular concern. The main issue is the potential effect of management activities on naturally occurring geologic processes.

Landslides are part of the natural geologic process in mountainous terrain, and are natural in western Oregon forests (Pierson 1977; Burroughs 1984; Burroughs 1985a; Burroughs 1985b; Benda 1988; Benda 1990; Benda 1994). This erosion process should be recognized as natural and geologically controlled over the long term. A “no-risk” option does not exist with landslides because of the very nature of the erosion process. Risk can be described as a function of both probability and consequence (Remboldt 1997). Management decisions related to this natural geologic process must be risk-based because of the uncertainty and complexity of geologic variation and the limits of scientific knowledge.

Landslides can substantially change habitat and stream environments in the short term, for years after the impact (Beschta 1981; Benda and Dunne 1987; Benda 1994). Channel-scouring landslides remove all gravel and structure that produce fish habitat. The deposition of debris (clay, silt, sand, gravel, and wood) from landslides buries fish habitat. Because of the devastating impacts to the immediate environment, landslides typically have been perceived as negative, and the prevention of landslides has been the goal of many engineering and land management efforts (Koler 1998).

Key Terms

Landslide—The dislodging and fall of a mass of earth and rock. There are many types of landslides, including debris slides, earthflows, rock block slides, slumps, slump blocks, and slump earthflows. The different types of landslides vary tremendously in how they occur, how far they move, the type of materials, etc.

Debris Torrent—Rapid movement of a large quantity of materials, including wood and sediment, down a stream channel. This generally occurs in smaller streams during storms or floods, and scours the stream bed.

Earthflow—Movement of material, both sediment and vegetation, down a slope. Earthflows are typically large, but move only a few centimeters each year.

Headwall—The steep slope or rocky cliffs at the head of a valley.

Rock Block Slide—Type of landslide in which the weakness and initial breaking is in the underlying rock rather than the soil.

Scour—The powerful and concentrated clearing and digging action of flowing air, water, or ice, especially the downward erosion by stream water in sweeping away mud and silt on the outside curve of a bend or during a flood.

Slump—Type of landslide in which a coherent mass of rock or unconsolidated material moves downslope along an upwardly curved surface, i.e., the slide tends to be spoon-shaped.

The latest scientific understanding is that landslides are the natural source for many key habitat structures (large wood and backwater) and as such, initiate hot spots of habitat and aquatic life. Over time, landslides are a major natural source of structure and habitat variation in mountain streams. Fish species are adept at occupying these locations, and it is a natural process for different fish species to inhabit the stream at different times, as the stream's structure and habitat change over decades and even centuries. In managed forests, the most damaging aspect of landslides may be the lack of wood in landslide deposits from timber harvest units. The management challenge then is to maintain near-natural landslide rates and composition of landslide deposits.

Landslides of many sizes and classifications occur on western Oregon forest lands. The landslide usually considered of most significance is the debris slide or debris torrent (Varnes 1977, Benda and Miller 1991) because of the common perception that forest management is most significant at altering rates and probability of failure for these smaller landslides (Pyles and Skaugset 1998). However, slumps, block slides, slump earthflows, and earthflows are also of concern in western Oregon forests, particularly in relation to forest road location and design (Beschta 1977).

Debris slides and debris torrents originate as shallow (typically three-foot depth), translational (slip surface parallel to the natural ground surface), steep slope landslides. They are small (typically less than 500 cubic yards), but often grow in volume through scour and undercutting until they cause major impacts in stream systems. They can travel great distances downstream as debris torrents, dam-burst floods, or migrating organic dams (Benda et al. 1997). The downstream effects of intense storm events and landslides are complex and difficult to predict. Prediction of initiation sites is only possible in the probability sense (Hammond et al. 1992). Prediction of run-out distance and deposition are possible (Benda and Cundy 1990), but predicting downstream impacts is difficult at best.

Forest management's effect on the rate of occurrence of these landslides is often divided into two categories; road-related landslides and in-unit landslides (Prellwitz and Koler 1994). Road-related landslides are somewhat more predictable and manageable. There are commonly accepted best management practices (BMPs) that can be associated with costs and levels of risk for managing this type of landslide (Koler and Neal 1989). There is even a relatively accepted track record of geotechnical input and environmental protection (e.g., Reilly 1989). This category of landslides contains no absolutes; however, there is reasonable agreement and theoretical rationale for existing design mitigation.

The second category of in-unit landslides is much less predictable and manageable. Numerous studies using aerial photography have attempted to quantify the rate of increase for specific areas due to harvesting (specifically clearcut harvesting). See *AEG Oregon Case Histories* (Skaugset and Pyles 1998) for a complete scientific review of the research. BMPs are much more limited and uncertain for in-unit slides than for road-related slides. For in-unit slides, it is appropriate to apply risk-based management that matches BMPs with the values at risk, and accepts the uncertainties and nature of the science (Michael 1997).

There are two basic conceptual concerns with timber harvest in relation to slope stability. The first and most commonly cited concern is root strength, defined as the ability of vegetation roots to reinforce the soil and add strength against slope failure (O'Loughlin 1974; Swanston 1974; Ziemer and Swanston 1977; Burroughs and Thomas 1977; Ziemer 1981; O'Loughlin and Ziemer 1982; Greenway 1987). Root strength is a difficult factor to evaluate, as it is complicated by the site-specific location of the root within the soil in relation to the potential slip surface. It is reasonably certain that rooting through the soil matrix into the underlying fractured rock or subsoil provides a buttressing effect, but this is difficult to quantify.

Another case is the lateral blanket effect of roots that do not penetrate the entire soil mass, or do not extend below a predicted potential slip surface. This lateral blanket effect is impossible to quantify by the usual analysis. The value of strength to be assigned is unclear even if the tensile strength of the individual root is known. The effect, however, is not less likely, but simply more complex.

The second theoretical concern for slope stability after vegetative removal is the effect of water. This factor is often termed interception and evapo-transpiration. Vegetation has a complicated role in relation to the groundwater pressures in the naturally marginal slope stability setting (steep slope and shallow landslide potential). The effect of vegetative removal on groundwater pressures has often been dismissed on a theoretical basis because the slope movements (debris slides) occur during intense storms in the winter. However, the most recent research (Dietrich 1997) and some conceptual thinking from forest geotechnical specialists leave the possibility of significance open for future research. If the mechanism for increased instability is misunderstood, the implication for environmental protection is significant. Leave areas that may stem to mitigate increased rates of landslides may actually have little or no real effect on those rates. Conversely, harvesting of some gentle ground that seems insignificant to slope stability might be exacerbating the natural risks.

The use of leave areas as a mitigation to slope stability risk must be studied in the context of the uncertainty that exists in the risk management decision. The ODF uses leave areas to mitigate the risk to public safety, in compliance with statute, and requires geotechnical professional design for all but the most basic leave area boundary decisions. This deferral or leave area approach is best understood as removing the potential (temporary) exacerbation of the probability of failure from the forest operation.

The USFS has attempted to use leave areas on a broad scale for habitat and stream protection purposes, on the Siuslaw National Forest in Oregon (Mapleton Headwall Leave Area). The OSU Engineering Department conducted a study of these leave areas, and found slightly higher rates of landslide occurrence in the leave areas than in apparently equivalent clearcut-harvested headwalls. This scientific perspective should not imply that managers “do nothing” (conduct business as usual), but it should be recognized in the management decision process. The applied science of vegetative management (leave areas) as a mitigation to slope stability risk should be seen as a work in progress or experimental.

Watershed Analysis

Watershed analysis must be a critical process in refining and planning management activities related to implementation of this FMP. With a greater understanding of the interrelated processes occurring in watersheds, plans and activities can be better structured, potential consequences better anticipated, and communication and resource understanding improved.

There is a need on state forestlands to employ a goal-driven process to characterize the watershed features of its management basins. These features include the riparian, aquatic, terrestrial, and cultural conditions, processes, and interactions that affect the overall watershed character and response to management activities. To assess these components so that they provide insight into management effects and resource potential, a relatively high-level assessment has been applied forestwide.

Successful implementation of watershed analysis can provide qualitative and quantitative information useful to managers as they develop plans and set objectives for their management basins. Watershed analysis is a tool in guiding management and policy decisions to sustain use of a watershed's resources, and in ensuring that the broader goals of restoring and/or maintaining watershed health and providing for properly functioning aquatic systems are achieved.

To be successful, a watershed analysis must provide relevant, understandable, and logical information to managers and policy makers to improve actions and plans. Prioritization of analysis issues and data collection should be directed toward this goal. To be most effective, information and recommendations from watershed analyses should be processed through the adaptive management framework and processes developed for implementation of this plan, so that proposed changes are implemented in a timely manner, and review and approval take place at the appropriate levels.

Basic Concepts for Integrated Resource Management

The guiding principles outlined in Chapter 3 rely on the integrated management of forest resources through active management of the Elliott State Forest, taking into consideration a wide range of forest values. Not all resource objectives can be maximized concurrently, however. Therefore, balancing partly incompatible goals through integrated resource management is a major challenge.

Coarse Filter – Fine Filter Planning

An operational approach to manage for biological diversity is the "coarse filter/fine filter" concept proposed by The Nature Conservancy (1982), and described in Hunter (1990). The coarse-filter component is based on the premise that maintaining a range of seral stages, stand structures, and sizes, across a variety of ecosystems and landscapes will meet the needs of most organisms. Sustainable forest ecosystem management provides the framework for the coarse-filter management of biological diversity. Individual species or habitats that require special consideration, such as species with unique or limited distributions (not addressed using the coarse filter), are managed specifically under a fine-filter approach. Fine-filter management superimposes specific management actions in addition to those required under the coarse-filter management. Collectively, coarse- and fine-filter management maintains and enhances biological diversity.

Coarse-filter/fine-filter planning for the Elliott State Forest will be accomplished at the landscape level through implementation planning. Planning at the implementation level can effectively integrate the two approaches to maximize compatibility between coarse- and fine-filter planning efforts.

Integrated resource management promotes the coarse-filter benefits of sustainable forest ecosystem management while providing the fine-filter provisions for special resource values. Integrated resource management will permit multiple resource objectives to be met concurrently while ensuring the protection of special resource values where necessary.

The basic concept of integrated resource management in this plan focuses on combining the landscape-level approach with site-specific strategies for other resource values.

Concept 1: Combine Landscape-Level Approach with Site-Specific Strategies for Other Resource Values

Integrated resource management brings together knowledge of various natural resource disciplines to understand and promote land management actions that consider all forest values. Active management practices are applied over time in conjunction with conservation areas to achieve both landscape-level and site-specific forest resource goals. Management practices are not applied to every acre every year. The approach promotes the compatibility of most forest uses and resources over time and across the landscape.

Integrated resource management provides the means for assessing resource values, compatibility of resource objectives, and necessity of additional planning or mitigation. It is best described as differing levels of management emphasis that adjust as the compatibility of resource values change.

The first level of integrated resource management occurs when all forest resources are integrally managed according to the landscape-level or coarse-filter concepts.

The second level of integrated resource management occurs when the FMP specifies a higher level of management emphasis for a designated resource value. In these instances, the resource will be managed according to site-specific strategies documented in the FMP. This management emphasis might mean supplemental planning before conducting management activities to assess effects, and design approaches that will maintain, protect, and enhance the specific resource. Management in these areas might also require management practices to be modified. In most cases, the FMP and/or legal requirements will list the site-specific management requirements for the resource.

The third and final level of integrated resource management occurs when the management of a resource does not permit the landscape strategies to be used. In these instances, the resource is managed exclusively according to site-specific strategies. The landscape strategies in these areas may not be applicable because of: 1) legal requirements such as the FPA; 2) goals, strategies, and prescriptions in the FMP; or 3) dominant resource values that cannot be protected, maintained, and enhanced using the landscape strategies. The landscape strategies will be severely restricted and may be prohibited in some cases. Management of other forest resources may also be restricted or prohibited if it will have a significant long-term adverse effect on resource values. Goals, strategies, and prescriptions in the FMP, legal constraints or requirements, and the dominance of certain resource values will determine the level of management emphasis needed. One example of a site-specific resource value taking priority over the landscape strategies is the presence of a Native American village or burial site. In this example, preservation of the site would take precedence over other resource values.

Where more than one forest resource in a specific area requires site-specific emphasis, each of the resources will be managed according to the strategies for the specific resource. Where overlaps occur, the management approach will seek to achieve the goals for all of the identified resources to the maximum extent practicable. Where a forest resource in a specific area requires site-specific emphasis and another resource in the same area requires a higher level of consideration, the resource requiring the highest level of protection will determine the management approach. One example of overlapping resource values is the Native American site mentioned above being located adjacent to a fish-bearing stream. In this example, both the historic site and the fish-bearing stream require special emphasis; however, preservation of the site would still take precedence over other resource values. In addition, because of the possibility of stream channel migration, additional consultation with the State Historic Preservation Office might be necessary to prevent degradation of the site.

It is important to remember that integrated resource management activities should lead to achieving the goals of the FMP. Therefore, the values and needs of forest resources, as described in the FMP goals and strategies, are the determining factors in planning and conducting management activities.