KEY ELEMENTS FOR ECOLOGICAL PLANNING:

MANAGEMENT PRINCIPLES, RECOMMENDATIONS, AND GUIDELINES FOR FEDERAL LANDS EAST OF THE CASCADE CREST IN OREGON AND WASHINGTON

A Report to the
Interior Columbia Basin Ecosystem Management Project

Columbia River Bioregion Campaign
Science Working Group

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EXECUTIVE SUMMARY

This report was drafted by the Science Working Group of the Columbia River Bioregion Campaign. It provides principles, recommendations, and guidelines that should be incorporated into any planning alternative for federal lands east of the Cascade crest in Oregon and Washington (the "Eastside") that purports to be ecologically sound. Chapter summaries are provided below.

Chapter I. Terrestrial Species Conservation: Extensive loss of habitat due to logging, grazing, introduction of alien species, mining, fire suppression, and development has put numerous Eastside terrestrial species at risk of extinction or extirpation. This chapter contains standards and guidelines for 1) maintaining large or functionally significant populations of all native terrestrial species and 2) maintaining or restoring well-distributed populations across their historic range on federal lands. The chapter also addresses the limitations of the Interior Columbia Basin Ecosystem Management Project's ("ICBEMP") "coarse-filter" method for assessing species status. An alternative approach for assessing species status, both as part of the scientific assessment and as part of subsequent planning prescribed by the Environmental Impact Statement ("EIS") alternatives, is described. This approach employs a combination of "coarse-filter" and "fine-filter" methods, depending on the characteristics of the species and data availability. General management guidelines for ensuring sufficient habitat and connectivity to support viable and resilient populations across the landscape are also described.

Chapter II. Aquatic Conservation: Most Eastside watersheds have been severely degraded. The recovery of aquatic ecosystems and species will depend on the protection and active restoration of watersheds on federal lands. The aquatic conservation strategy proposed in this chapter contains guidelines for a regional aquatic reserve network comprised of Biotic Refuges, Riparian Areas, and Aquatic Diversity Areas ("ADAs"), within which natural diversity and biophysical processes should be largely unimpaired. Watershed assessment should provide the basic planning tool for future management. The first priority for watershed restoration should be to secure reserve areas from any existing or potential threats to their value as refuges for native biota. Ecological indicators of watershed recovery are identified in conjunction with management guidelines which severely restrict or prohibit human activities in aquatic reserves.

Chapter III. Landscape Prioritization and Reserve Design: Existing protected areas alone are incapable of maintaining biodiversity and important ecological processes on the Eastside. Although these areas play an important role, the system of biological reserves needs to be expanded if it is to protect and restore biological diversity at all levels of organization. Many Eastside ecosystems are either poorly represented or not represented in the current reserve system. An integrated reserve network on the Eastside is necessary to 1) maintain fully functioning ecosystems, 2) maintain well-distributed, viable populations of all native species, 3) provide representation of all natural communities and successional stages, and 4) provide refuges that are relatively resistant to biological invasions and human degradation. An integrated reserve system should act like an insurance policy – buffering species from the rest of the managed landscape. Reserves are necessary to act as controls in experimental implementation of ecosystem management. They can provide an important gauge of the success or failure of ecosystem management efforts. Landscape prioritization and reserve design are discussed in this chapter.

Chapter IV. Prescribed Burning: Carefully conducted, prescribed burning has the potential to improve significantly the ecosystem integrity of Eastside forests, where wildfires have been a dominant force shaping the species, communities, structures, and processes for at least the last several millennia. Fire suppression policies over the last century have changed historic fire regimes in some Eastside stands, particularly in the ponderosa pine and mixed conifer communities. These changes in the fire regime, in conjunction with logging, livestock grazing, and other human-caused disturbances, have adversely affected forest health and productivity. Guidelines for using prescribed burning as a tool for restoring the ecological benefits of fire are presented in this chapter. Prescribed burning programs should be carefully planned at the landscape-scale, should mimic natural fire regimes, and should include public information and outreach programs.

Chapter V. Thinning: There is an emerging scientific opinion that past forest management activities and fire suppression policies have led to the development of forests on some Eastside landscapes that are denser and more homogenous than under pre-settlement conditions. Although thinning treatments are being advocated by some as a tool for facilitating the development of forest conditions that more closely resemble those that would occur under a natural disturbance regime, thinning operations, even when properly conducted, can result in significant adverse ecological impacts. Thinning should be allowed on public forest lands on the Eastside only when the responsible land management agencies can demonstrate that proposed treatments will accomplish desirable ecological goals. The approach to thinning discussed in this chapter is designed to accomplish the presumed benefits associated with this practice while minimizing ecological risks by restricting areas where thinning is allowed and establishing management guidelines to ensure retention of important structures at the stand level.

Chapter VI. Post-Disturbance Logging: A conservative (i.e. non-manipulative) approach to post-disturbance management is clearly indicated for Eastside landscapes. This approach should emphasize natural recovery. The ecological consequences of removing "dead and dying" trees are described and areas in which post-disturbance logging should be prohibited are identified. The chapter also establishes standards for protecting ecosystem integrity in areas where post-disturbance logging is allowed to occur.

Chapter VII. Fire Fighting: Fire suppression should not be a goal of forest management, except when human life or private property is at stake. Fire fighting efforts often result in more ecological harm than benefit and are expensive in terms of both dollars and human lives. Instead of aiming to eliminate fire from the landscape, managers on the Eastside should focus on restoring over time ecologically beneficial fire regimes. Recommendations are presented for 1) minimizing ecological damage associated with fire fighting efforts, 2) determining areas where wildfires should not be actively fought, and 3) allowing for protection of human life and property.

Chapter VIII. Soil Conservation: Scientific literature, agency pronouncements, and the law all recognize soil as "the foundation of the ecosystem." Unfortunately, past Eastside planning and management practices have failed to protect adequately soils and their essential contributions to long-term productivity of terrestrial and aquatic systems. Ecological planning should provide substantially more conservative standards for protection of soil structure, organic matter, and productivity by controlling or eliminating activities on erosive soils and fragile sites, limiting compaction, retaining coarse woody debris ("CWD"), and maintaining complex soil food webs. Equally important, agencies should institute more effective inventorying and monitoring programs and ensure accountability for meeting standards and guidelines.

Chapter IX. Livestock Management on Forests and Grasslands: Over a century of livestock grazing has significantly damaged Eastside forests. Although recent increases in forest density and susceptibility to diseases and fire are usually attributed to fire suppression and selective logging, the scientific literature suggests that livestock grazing may be the primary cause. Cattle and sheep are alien herbivores which graze at higher densities and for longer time periods than native wildlife species. They have changed Eastside forests by 1) depleting the herbaceous layer which historically out-competed conifer seedlings and reduced tree density, 2) removing herbaceous biomass that would otherwise fuel low-intensity fires, 3) causing the replacement of native herbaceous species with alien and weedy species, and 4) reducing herbaceous cover and disturbing and compacting soils, thus leading to increased erosion, loss of topsoil, and damage to downslope riparian areas. All livestock grazing should be excluded from 1) old-growth forests and forests that have an open, park-like structure, 2) forests still vegetated to some extent by native herbaceous species, 3) forests to which low-intensity fire is to be restored, and 4) areas with steep slopes, fragile soils, and sensitive habitats such as wetlands, springs, and fish-bearing streams.

Chapter X. Prevention of Alien Plant Invasions: The progressive invasion of alien plants into Eastside ecosystems is a serious long-term threat to the maintenance of ecosystem health and biodiversity. This invasion causes significant resource and economic loss. Introduced alien species are a serious threat to rare native species – creating the second most important cause of species endangerment nation-wide. They disrupt ecological processes and natural food webs. Since control methods are only temporary, often ineffectual, and can cause serious environmental harm (e.g. effects of herbicides), prevention strategies represent the best method of stopping alien plant invasions. Alien plants primarily occupy disturbed habitats, and are most frequently found in Eastside forests and rangelands that have roads, logging, or excessive grazing. Prevention of further spread into unroaded, unmanaged, and relatively pristine areas is critical to the long-term conservation of ecosystem resources, as these areas still retain undisturbed native flora and natural resilience to management-induced disturbances. Attempts to control invasions should emphasize biological, cultural, and mechanical control measures. Herbicides pose a serious threat to human and ecosystem health and should not be used on public lands to control invasions.

Chapter XI. Road Management: Roads have been widely constructed to facilitate resource extraction and other land management activities throughout the Eastside. Although existing road systems were planned solely to provide human access, they have resulted in numerous and significant adverse impacts to soils, water quality, wildlife, and other biological resources. Recommendations are discussed in this chapter for 1) managing transportation systems on Eastside federal lands in a manner that does not result in significant and widespread adverse effects on terrestrial and aquatic ecosystems and 2) reducing road densities by closing/decommissioning roads that cause the greatest harm to biological resources.

INTRODUCTION

The forests and rangelands east of the Cascade crest in Washington and Oregon (the "Eastside") are recognized in the scientific community as among the most imperiled ecosystems in North America. Over a hundred years of logging, grazing, fire suppression, road-building, mining, development, and introduction of alien species has resulted in widespread degradation of much of the region's 12 million acres of public forest and rangeland. Still, significant areas, including wilderness areas and roadless areas where fire exclusion did not occur, remain less disturbed.

Concern over species viability and ecosystem integrity on Eastside public lands has led to efforts to conduct ecosystem-based planning at the regional scale. In July 1993, President Clinton directed the Forest Service "...to develop a scientifically sound and ecosystem-based strategy for management of eastside forests." The Chief of the U.S. Forest Service and the Director of the U.S. Bureau of Land Management cooperated to initiate an "ecosystem management" assessment and planning process on federal lands. This process – entitled the Interior Columbia Basin Ecosystem Management Project ("ICBEMP") – is scheduled to be completed in early 1996.

This report provides scientific principles and management recommendations for ecologically sound management of federal lands in eastern Washington and Oregon.[1] Any scientifically-based "ecosystem management" plan needs to incorporate these standards to achieve ecosystem protection. The principles and management recommendations are presented in separate chapters to facilitate their review and consideration. Nonetheless, the chapters are highly interrelated and should also be considered in an integrated manner. Although not addressed in its own chapter, water and how water influences and is influenced by ecological processes is a key element. Management alternatives should reflect the central importance of water and its associated ecological, economic, and social value.

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[1] The report was prepared for the Columbia River Bioregion Campaign, a coalition of 42 groups sharing a common goal: the ecological health of Eastside federal lands. The scope of this report is limited to the Eastside portion of the ICBEMP. Although the report may not fully represent the policy views of each member organization of the Columbia River Bioregion Campaign, it reflects their substantial agreement about the scientific principles that must be addressed in order to maintain the biological diversity, ecological integrity, and long-term productivity of these public lands.

CHAPTER I: TERRESTRIAL SPECIES CONSERVATION

OBJECTIVES

Management plans for Eastside public lands should meet the following key objectives for all native terrestrial species:

- maintain populations within the range of natural variability, at functionally significant or large population sizes rather than estimated minimum viable population sizes (see Shaffer 1987; Conner 1988); and
- maintain/restore multiple populations of each species such that they are well-distributed throughout the species' historic range on federal lands. All native species should have a very high (95-99%) probability of having well-distributed populations persist for 200 years or longer (Shaffer 1981 and 1987).

PRINCIPLES

Extensive loss of habitat due to logging, grazing, introduction of alien species, fire suppression, mining, road-building, and development has put numerous Eastside species at risk of extinction or extirpation. Over 750 species of plants and animals are considered to be of special concern by the U.S. Fish and Wildlife Service, the U.S. Forest Service, or the U.S. Bureau of Land Management (Interior Columbia Basin Ecosystem Management Project 1994). In addition, data is lacking for a significant number of species and taxonomic groups, such as soil invertebrates and fungi, that are not included in the species of concern list mentioned above but may be experiencing reduced viability, with potential serious consequences for overall ecosystem health and resilience.

Conservation of multiple and well-distributed populations is necessary to achieve the goals of the Interior Columbia Basin Ecosystem Management Project ("ICBEMP") (Marcot 1994), to comply with regulatory requirements under the National Forest Management Act, to ensure a very high likelihood of population persistence over time (Shaffer 1981), to maintain ecosystem integrity (structure, function, and composition) across the landscape, and to verify the efficacy of ecosystem management. In order for federal agencies to ensure the continued existence of all native plant and animal species on federal lands, they must develop terrestrial species conservation plans which include realistic methods for protecting extinction-prone species, including adequate safety factors to account for stochastic events such as fires, disease, and other hazards that could threaten species viability (Wilkinson and Anderson 1987). The ICBEMP process should develop and propose a conservative approach to species viability that provides a very high likelihood (95-99%) of maintaining viable, well-distributed populations across the species' distributional range over the long-term (least 200 years) (Shaffer 1981 and 1987).[2]

The ICBEMP Terrestrial Team's method of assessing species status, which falls short of agency directives and legal requirements, will not adequately address species viability. Although the Terrestrial Team's charge is to assess "plant and animal species viability," defined in its documents as "the ability of a species to sustain itself," the Team is not actually conducting any viability assessments. In scientific terms, "population viability assessment" has a well-accepted definition: "a comprehensive analysis of the many *environmental* and *demographic* factors that affect survival of a population...." (emphasis added) (Meffe and Carroll 1994). Instead of conducting the necessary

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[2] Shaffer (1981) refers to the 95% standard as an example of high likelihood of survival, but goes on to define "minimum viable population" as 99% probability of viability over 1,000 years. 95-99% is used in this report as it has become the accepted standard in Population Viability Analysis ("PVA") (Clark et. al. 1990; Gilpin 1991; Fiedler and Jain 1992) and has been used in several endangered species recovery plans (Brussard and Gilpin 1989; Harris et. al 1989). Shaffer (1981 and 1987) refers to 100-1,000 years as the mid- to long-term time frame for viability analysis. 200 years is the bottom threshold utilized in this report because 1) it is commonly considered to be a preferred time frame (see FEMAT 1993: IV-43), and 2) it exceeds the 150-year time frame for initial development of old-growth characteristics on Eastside forests (USDA Forest Service 1993b; Henjum et. al. 1994).

quantitative analyses of environmental and demographic factors affecting species, the Terrestrial Team is currently using a "coarse-filter" approach which relies on a single indicator – habitat distribution – to infer species status.

There is widespread recognition among ecologists that "coarse-filter" habitat relationship models, such as the ones that the Terrestrial Team is using, have limited utility in predicting the status of many types of species, including those that are extinction-prone (Raphael and Marcot 1986; Verner et. al. 1986; de Becker and Sweet 1988; Ohmann 1992; Scott et. al. 1993). Problems with the habitat relationship model approach include 1) lack of consideration of demographic factors, environmental threats (anthropogenic and natural), and habitat quality, 2) invalid assumption of homogenous abundances in similar habitat types, and 3) reliance on coarse habitat classification systems. Unfortunately, the habitat relationship model approach is likely to yield the least accurate information for the species which are most threatened and, therefore, for which accurate information is most critical.

For species for which habitat relationship models are inaccurate, including rare, geographically isolated or locally endemic species, or species known to be declining, population viability analyses are needed to ensure that all species have at least a 95% probability of persistence over 200 years or longer (Shaffer 1981 and 1987). For species for which life history and/or population data are lacking, qualitative assessments leading to mandated mitigation measures should be conducted (see Species Analysis Team 1994). Priority species for in depth assessment and management include:

- extinction-prone species – which fit into one or more of the following categories: 1) top predators, 2) species which require specialized habitats (e.g. old-growth associated species), 3) poor dispersers, 4) migratory species, 5) species that have a low intrinsic rate of population growth, 6) species that are valued as commodities, 7) locally endemic species, and 8) species with low genetic variability.
- keystone species – which influence the occurrence or abundance of other organisms or play an important role in maintaining biological processes;
- indicator species – whose occurrence or abundance indicates changes in habitat or management activities; and
- mobile-link species – which influence more than one food chain, community, or ecosystem. (Henjum et. al. 1994).

A "coarse-filter" method that is being utilized by the U.S. Forest Service to assess Eastside habitat relies on the historic range of variability ("HRV") of forest structural stages as a benchmark for determining adequate habitat levels. Although the concept of HRV analysis is of theoretical interest, the HRV analyses that have been conducted on Eastside national forests as part of the interim management direction (U.S. Forest Service 1993a and 1994) have been inaccurate and have lead to erroneous conclusions (see DellaSala et. al. 1994; Natural Resources Defense Council 1994). An ecologically valid HRV analysis would have to be based on ecological data from time periods prior to intensive commercial management. These data are not currently available for much of the Eastside's public lands. HRV determinations also need to incorporate assessments at multiple scales. At a minimum, HRV should be analyzed at both the watershed and landscape levels, such that if a watershed is above HRV for a given biophysical environment/structural stage but the landscape is below, the watershed should not be considered in excess for management purposes. Similarly, even if a landscape is above HRV, management should be deferred in any of the landscape's spatial units that are below HRV.

In addition, determination of whether any biophysical environment/structural stage is above or below HRV should not be based on the lowest historical threshold for that type. Although short-term fluctuations in habitat availability and corresponding fluctuations in population sizes do not necessarily jeopardize populations in a dynamic system, restricting populations to lowest historical thresholds can reduce population sizes and induce genetic "bottlenecks," leading to inbreeding, greater likelihood of genetic drift, and diminished fitness. It can also increase susceptibility to demographic and environmental stochasticity that ultimately may induce extinction vortices in small populations

(Soulé 1983; Gilpin and Soulé 1986). Managers should not, therefore, equate lower thresholds within the HRV with the minimum amount of old-growth or other habitat that should be retained. Rather, sufficient habitat should be maintained such that fluctuations in habitat availability do not cause populations to decline below viable sizes. Habitat conservation standards must also include a reasonable margin for uncertainty and error in HRV estimates and habitat association information.

STANDARDS AND GUIDELINES

A conservative approach to managing terrestrial species should rely on a rigorous multi-pronged method of scientific assessment and conservation planning. The following procedures should be followed:

Assess the status of all native terrestrial species and develop regional conservation plans.

Although viability assessments for all native species should be standard protocol, rigorous interim approaches to assessment and conservation planning are needed for species for which currently there are not sufficient data for conducting a population viability assessment. Due to the great diversity of terrestrial species and the variability of existing knowledge of species' life histories and habitat requirements, a multi-pronged approach to assessing species status and designing management plans is required. The most appropriate approach to conservation strategies (e.g. "coarse-filter" versus "fine-filter") will vary depending on the characteristics of individual species and populations (e.g. widely distributed populations versus geographically isolated populations) (Menges 1990; Boyce 1992), as well as the availability of species status data. Utilization of a combination of "coarse-filter" and "fine-filter" approaches should result in viability probabilities with the least degree of uncertainty attainable given limitations in available data, analysis techniques, and project duration (Boyce 1992).

The basic approach used to assess and manage terrestrial species should depend on the species abundance, mobility, and data availability, as displayed in the following dichotomous key:

1. common species	assess species status with habitat relationship models *(Approach A)*
1. uncommon species	go to 2
2. non-mobile species	develop "survey and manage" protocols *(Approach B)*
2. mobile species	develop species conservation plans *(Approach C)*; go to 3
3. data are available	conservation plans based on quantitative viability analysis
3. data are not available	conservation plans based on qualitative viability assessment

A brief discussion of each of these approaches is presented below.

Common species

Approach A – habitat relationship models:

For the purpose of conducting species status assessments, common species are defined herein as Eastside plants and animals that are habitat generalists, are known to have large, non-declining population sizes, and have high reproductive rates. "Coarse-filter" wildlife-habitat relationship models (e.g. Grenfell et. al. 1982) can be relatively effective for correlating current and proposed vegetation conditions with the occurrence and abundance of common species. Specific models should be used to estimate habitat suitability, which can then be used to evaluate relative risks to species at the regional level. Validation of modeling results, through field surveys and risk assessments need to be conducted and presented (Raphael and Marcot 1986; Burgman et. al. 1993).

Uncommon species

For the purposes of conducting species status assessments, uncommon species should include Eastside plants and animals listed (or proposed or a candidate for listing) as rare, sensitive, threatened, or endangered by federal or state resource management agencies, tribes, or conservation organizations. In addition, uncommon species should include species, such as many invertebrates, lichens, and fungi, for which there are insufficient data to determine their status. These species should be removed from the uncommon list only after federal land managers have sufficient information to determine that they are common. The list of uncommon species identified thus far by the ICBEMP includes over 750 species (Interior Columbia Basin Ecosystem Management Project 1994). Plants and animals that are extinction-prone, keystone, indicator, or mobile-link species should be the highest priority for viability analysis and conservation planning (see Table 1 for examples of priority species).

"Coarse-filter" approaches, such as habitat relationship models, will not be adequate for uncommon species. Numerous studies have shown that these models are ineffective at predicting habitat suitability for a wide variety of uncommon species (i.e. those that are rare or localized, dependent on fine-scale habitat elements, and/or disproportionately influenced by spatial habitat patterns or intraspecific interactions) (Raphael and Marcot 1986; Verner et. al. 1986; de Becker and Sweet 1988; Ohmann 1992). Alternative strategies are required for evaluating viability of and conservation alternatives for uncommon species. The approach described here is dependent on species' home range size, vagility, and data availability.

Table 1: Examples of uncommon terrestrial vertebrate species that are of primary concern. Species included in this list, which is not comprehensive, are extinction-prone, keystone, indicator, or mobile-link species (see "Principles" section above for definitions). Status refers to administrative protection category (FE = Federal Endangered; FT = Federal Threatened; FC2 = Federal Category 2; BLMS = BLM Sensitive; FSS = FS Sensitive; FST = FS Threatened).

COMMON NAME	SCIENTIFIC NAME	STATUS
Bald eagle	Haliaeetus leucocephalus	FT, FST
Northern goshawk	Accipiter gentilis	FC2, FSS
Flammulated owl	Otus flammeolus	FSS, BLMS
Northern spotted owl	Strix occidentalis caurina	FT, FSS, FST
Boreal owl	Aegolius funereus	FSS, BLMS
Great gray owl	Strix nebulosa	FSS
Vaux's swift	Chaetura vauxi	
White-headed woodpecker	Picoides albolarvatus	FSS, BLMS
Three-toed woodpecker	Picoides tridactylus	FSS, BLMS
Black-backed woodpecker	Picoides arcticus	FSS, BLMS
Pileated woodpecker	Dryocopus pileatus	BLMS
Red-breasted nuthatch	Sitta canadensis	
Pygmy nuthatch	Sitta pygmaea	
Brown creeper	Certhia americana	
Golden-crowned kinglet	Regulus satrapa	
Swainson's thrush	Catharus ustulatus	
Hermit thrush	Catharus guttatus	
Townsend's warbler	Dendroica townsendi	
Pine Martin	Martes americana	BLMS
Fisher	Martes pennanti	FC2, FSS, BLMS
Wolverine	Gulo gulo	FC2, FSS, BLMS
Grey wolf	Canis lupus	FE
Grizzly Bear	Ursus arctos	FT, FST
Lynx	Lynx lynx	FC2, FSS
Mountain lion	Felis concolor	

Approach B – "survey and manage" for non-mobile species:

Develop "survey and manage" protocols for uncommon species that are non-mobile (e.g. plants) or have average home range sizes smaller than 5 acres (e.g. amphibians), similar to those adopted for federal lands within the range of the Northern Spotted Owl (FEMAT 1993). Active surveys to locate sites should be mandated for these species; surveys should not rely solely on known sites. Particular attention should be directed at developing "survey and manage" protocols for taxonomic groups, such as amphibians, plants (vascular and non-vascular), lichens, fungi, mollusks, arthropods, and non-volant mammals, for which little information is currently available. Lists of species requiring surveys and the degree of survey specificity should be developed for each national forest, building from those developed by state natural heritage programs, the U.S. Forest Service sensitive species program, and the expert panels on various taxonomic groups convened by the ICBEMP Scientific Integration Team ("SIT"). Mitigation measures that preclude deterioration of habitat suitability due to human causes should be mandated for all locations where uncommon species occur.

Approach C – conservation plans for mobile species:

Individual species conservation plans (Thomas et. al. 1990; Suring et. al. 1992) should be developed for species that are not covered by the "survey and manage" requirement. In particular, conservation plans should be completed for all mobile species (i.e. average home range ≥ 5 acres) for which viability is an established concern. Species conservation plans should include a discussion of major threats to viability, mitigation measures that address these threats, and requirements for habitat protection (including minimum size, distribution, and connectivity of required habitat patches) in order to ensure that viable, well-distributed populations exist for species with identified concerns. Such plans should be based on the best available information on taxonomic status, distribution, life history, demography, sensitivity to disturbance, and habitat relationships. Viability should be assessed as follows:

a) Quantitative viability analysis.

Where sufficient data on species' habitat requirements and population factors are available, conservation plans should be based on the results of quantitative viability analysis. Several established modeling techniques provide a basis for quantitative viability analysis and subsequent development of habitat-based conservation strategies (e.g. Boyce 1992; Murphy and Noon 1992).

b) Qualitative viability assessment.

Where necessary data are lacking, interim qualitative assessments of species viability should be conducted until additional data can be obtained. These assessments should draw from and improve on the approach employed by FEMAT (1993) and the Tongass National Forest (Suring et. al. 1992). Qualitative species viability assessments should include environmental and demographic considerations, and should determine current status as one of at least four potential conditions: 1) well-distributed across its range within eastern Oregon and Washington, 2) locally restricted, 3) restricted to refuges, or 4) at risk of extirpation. Major threats to species viability, and management actions that could most effectively mitigate human-caused impacts, should also be identified. The basis for subjective judgments about viability, and the level of uncertainty involved in determinations, should be clearly articulated.

All available information from the scientific literature, interim results from ongoing research, and professional judgment of experts familiar with the species involved and habitat conditions on federal lands in the region should be reviewed and incorporated into these assessments and subsequent development of conservation plans. Additional research, statistical analysis of empirical data, and inferences drawn from studies of related species should be conducted to test and strengthen species management guidelines, using an adaptive management approach (Murphy and Noon 1991). When sufficient data become available, quantitative population viability analysis need to be conducted and species conservation plans modified accordingly.

General Guidelines for Conservation Planning

Although different assessment strategies are needed for different species types (as described above), some general guidelines for the management and conservation of viable populations have been developed that are widely accepted among specialists in the fields of ecology and conservation biology (e.g. Thomas et. al. 1990; Suring and Crocker-Bedford 1992; Noss and Cooperrider 1994). The following guidelines apply to the development of species conservation plans and overall management scenarios:

- Maintain habitat connectivity for all species requiring dispersal and migration habitat. Connectivity can potentially be satisfied by adopting one of two strategies (or a hybrid of both), depending on the species involved: 1) maintain/restore discrete habitat corridors, in spatial and dimensional configurations required to facilitate dispersal, migration, recolonization, and genetic interchange between core population centers of target species (Fahrig and Merriam 1985 and 1994; Harris and Scheck 1992) (see also Chapter III) or 2) implement land management guidelines that assure sufficient habitat conditions across the majority of the landscape for dispersal, migration, and recolonization between subpopulations for target species (e.g. Thomas et. al. 1990).

- Maintain the viability of interacting subpopulations within metapopulations (Gilpin 1990; Harrison 1991). The viability of metapopulations can depend on the viability of individual subpopulations and the interchange between them. For species exhibiting metapopulation dynamics, suitable dispersal habitat should be maintained between interacting subpopulations (Gilpin 1987; Hanson 1991; Hanski and Gilpin 1991).

- Anticipate natural variability and the potential for habitat loss and accommodate localized extinction caused by disturbance (e.g. catastrophic events) and environmental, genetic, and demographic stochasticity. Anticipating disturbance requires retaining sufficient ecological redundancy to maintain ecosystem resiliency (Walker 1992). In the context of species viability, this means retaining surplus habitat above estimated minimum levels and maintaining multiple, large habitat areas and populations distributed across the landscape (Soulé and Simberloff 1986; Suring and Crocker-Bedford 1992).

- Maintain potential recolonization habitat in the vicinity of metapopulations that experience frequent, localized extinction of subpopulations (e.g. amphibian metapopulations) (Gilpin 1987; Hanski and Gilpin 1991).

- Where appropriate, develop multi-species conservation plans that satisfy the needs of species exhibiting similar and overlapping habitat requirements (e.g. Suring et. al. 1992; FEMAT 1993).

- Maintain the ecological processes, such as fire and hydrologic regimes, that create and maintain habitat to support viable, well-distributed populations of native terrestrial species (Agee and Johnson 1988; Agee 1993; Grumbine 1994).

- Recover populations of species that are currently known to be declining due to anthropogenic causes.

- Reintroduce extirpated native species and translocate keystone species where necessary (Griffith et. al. 1989; Mills et. al. 1993).

- Control non-native species where these are out-competing or displacing native species (Everett et. al. 1994a) (see also Chapter X). Control measures should not include the use of herbicides.

- Develop and implement a program to monitor 1) indicators of biodiversity at multiple spatial scales and hierarchical levels of biodiversity (Noss 1990a), 2) indicators for ecologically meaningful functional groups (Korner 1993), and 3) sub-regional population trends of indicator species over time. Conservation plans should be updated to reflect new knowledge derived from monitoring, using an adaptive management approach (U.S. Forest Service 1992a; U.S. Congress Office of Technology Assessment 1992; Grumbine 1994).

- For areas where management activities are allowed, provide guidelines that follow principles of "ecoforestry" (Hammond 1992). Specifically, set standards for snag, greentree, and coarse woody debris ("CWD") retention, and canopy closure requirements.

Integrate species status assessments and planning/decision-making.

Management plans should be developed only after species status assessments have been completed. The ICBEMP SIT needs to provide an evaluation of the quality of the species status assessments and evaluate all regional management scenarios. Specifically, the SIT should:

- Present clear and appropriate recommendations to the ICBEMP EIS team, including a risk assessment of species viability.

  The ICBEMP SIT should clearly indicate to the EIS Team the limitations of each approach used to evaluate viability (i.e. habitat relationship models, quantitative viability analysis, and qualitative viability assessment) and should specify the level of accuracy in viability determinations that are derived from these approaches. They also should use the relevant confidence levels achieved to specify the implications and utility of the various types of viability evaluations for developing management plans. The basis for determinations about relative risks to viability (e.g. lack of important data) should be clearly articulated. The SIT should provide recommendations for developing regional management scenarios that are sensitive to the level of uncertainty associated with the species status assessments, such that more conservative approaches are used for species for which assessments are less accurate.

- Assess the probability of maintaining species viability under each proposed management scenario.

  Management scenarios should be evaluated based on their ability to ensure, at a minimum, at least a 95% probability of having well-distributed populations for longer than 200 years of all native terrestrial species across federal lands (Shaffer 1981 and 1987). All available empirical and theoretical evidence should be utilized and presented to support viability evaluations of proposed management scenarios. The implicit scientific uncertainties and potential consequences of implementing any management scenario should also be rigorously explored and clearly articulated.

Provide project level direction for species conservation.

Although viability assessments at the regional level are critical for developing species conservation strategies, project level consideration of the status of populations also will be necessary in order to maintain multiple, well-distributed populations of all native species. Regional species conservation strategies should stipulate project level mitigation measures and guidelines. The guidelines listed in the "General Guidelines for Conservation Planning" section above should be incorporated into project level plans. In addition, project level assessments will be needed to determine if additional provisions are needed to maintain population viability. EIS alternatives will have to prescribe general guidelines for conducting assessment of project impacts on populations. These guidelines should:

- Prescribe populations as the operative units for assessment of project level impacts.

  Although EIS alternatives assess and ensure viability of species at the regional level, they should prescribe populations as the operative units of ecological organization for project level impact assessments. Ruggiero et. al. (1995) point out that "the gross mismatch of scales between the geographical scale of management actions (e.g. a timber sale) and the scale of ecological responses (e.g. species viability) reduces the reliability of environmental assessments." Population level responses to management activities can be more readily assessed than species level responses.

- Prescribe general guidelines for population viability assessment during project planning.

  Population viability assessments at the project level may only be necessary for certain types of species, such as extinction-prone, indicator, or keystone species. Ruggiero et. al. (1995) present a six step process for conducting population viability impact assessments at the project level. This process includes delineating spatial areas of analysis that are relevant to 1) the viability of individual populations and metapopulations, 2) the direct impact of a particular management activity, and 3) the cumulative effects of management activities. Assessments should consider at a minimum 1) habitat connectivity, 2) degree of isolation, 3) successional and developmental stage of habitat, 4) patch size, 5) reproductive rates of populations, and 6) environmental conditions that may influence carrying capacity or increase variance in the growth rates of populations, thereby affecting persistence probabilities.

CHAPTER II: AQUATIC CONSERVATION

OBJECTIVES

The purposes of the following recommendations for management of aquatic ecosystems are to:

- protect and restore the ecological health of watersheds on Eastside federal lands;
- protect as refuges for biodiversity 1) the remaining relatively healthy watersheds and riparian ecosystems and 2) those parts of river systems with the healthiest habitat and the greatest concentrations of biological diversity ("hot spots");
- restore degraded watersheds by removing threats to aquatic refuges, restoring natural hydrologic and disturbance regimes, and improving management to expand and link functional areas;
- conduct watershed-level ecological assessments which provide the informational basis for planning and restoration; and
- establish connectivity between aquatic refuges by protecting riparian corridors.

PRINCIPLES

Most Eastside watersheds and riverine ecosystems have been severely degraded due to resource development including logging, road-building, grazing, and mining, as well as water diversions, agricultural practices, hydroelectric development, urbanization, extirpation of riparian species, introduction of non-native species and hatchery stocks, pesticide and herbicide pollution, and other causes. These practices have contributed significantly to the catastrophic decline of anadromous and native fish habitat in the region. A majority of watersheds in the region would benefit from active restoration.

Most of the Eastside's remaining watersheds of high biological integrity are located on federal lands. It is in the public's best interest to protect and maintain these remaining areas due to their value as habitat for rare biological communities, as repositories for, and sources of, natural species assemblages and diversity, and as benchmarks for the rehabilitation of riverine ecosystems nationwide. These watersheds and riverine ecosystems are of economic, aesthetic, ecological, educational, historical, recreational, and scientific value to the nation and its people and should be conserved and restored for future generations. Management actions taken to date by federal lands managers have not protected adequately or improved the condition of federally managed watersheds and riverine ecosystems in the region.

Significant problems with federal lands management policy include:

> "[o]veremphasis on production of non-fishery commodities, resulting in incremental losses of riparian and fish habitat; failure to take a biologically conservative or risk-aversive approach to planning land management actions when inadequate information exists about the relationship between land management actions and fish habitat; failure to include the best available scientific information in planning of project actions; planning actions on a site-specific basis, rather than based upon broader watershed and river basin conditions and capabilities; and reductions in the number, size, and distribution of remaining high-quality habitat areas (such as roadless and minimally developed areas) that serve as biological refuges for salmon subpopulations." (National Marine Fisheries Service 1995b).

Existing national forest management plans will not adequately protect aquatic and riparian resources because a comprehensive, landscape-level conservation strategy is lacking. Specifically, the plans fail to:

> "provide for a network of well-distributed watersheds containing high-quality spawning and rearing and readily restorable habitats and reduce risks to these habitats;
> prioritize restoration; plan activities and conservation strategies after landscape-scale analysis; and conduct implementation monitoring and begin gathering data for effectiveness and validation monitoring." (National Marine Fisheries Service 1995b).

The most effective strategy to ensure the long-term health of the region's watersheds and fish habitat is to protect biologically key areas including watersheds serving as ecological refuges, smaller biotic refuges, and riparian areas. Protection should include taking all necessary steps to prevent irreversible damage from ecologically harmful management activities which increase the occurrence and severity of landslides, mass erosion, sedimentation, wind drying, wind erosion, and temperature.

In short, an adequate aquatic conservation strategy would 1) identify and protect a system of aquatic and riparian reserves (referred to here as Aquatic Diversity Areas ("ADAs"), Riparian Areas, and Biotic Refuges), 2) restore watershed processes and functions across the landscape with priority on aquatic and riparian reserves, and 3) integrate planning and decision-making with watershed assessments.

Existing high-quality habitats functioning as refuges must be preserved.

The fundamental building blocks of any aquatic conservation strategy are the remaining areas of healthier habitat. The recovery of Eastside aquatic ecosystems depends on the protection and restoration of ADAs. The primary management goal within ADAs is the maintenance and restoration of the ecological integrity of riverine habitat and associated riverine-riparian species.

A growing body of literature supports the protection of existing refuges as an integral and necessary part of any aquatic conservation strategy (e.g. Sheldon 1988; Moyle and Sato 1991; Moyle and Yoshiyama 1992; FEMAT 1993; The Wilderness Society 1993; Henjum et. al. 1994; Rhodes et. al. 1994; Frissell et. al. 1995; National Marine Fisheries Service 1995a). Although individual fragments of suitable habitat have ecological value, refuges for aquatic species should be designed at the watershed level (Sheldon 1988; Williams et. al. 1989; Moyle and Sato 1991; Naiman et. al. 1992; FEMAT 1993).

Protection of headwater ADAs is required to prevent further habitat loss and secure the few remaining refuges for many remnant stocks and assemblages (Henjum et. al. 1994). Although protection of the headwater and small stream refuge areas identified as ADAs by the American Fisheries Society is critical, protection of those areas alone will not be adequate "...to sustain migratory populations or restore the productivity in eastside watersheds of native cold water species like salmon or bull trout (Henjum et. al. 1994)." Critical reaches and habitats on large streams and rivers must also be identified and protected based on criteria which recognize their high potential for restoration. These areas can then be targeted in subsequently developed restoration plans (Henjum et. al. 1994).

Riparian Areas, functionally defined, must be protected and restored.

Fully functional aquatic ecosystems are complex habitats that consist of floodplains, banks, channel structures (i.e. pools and riffles), water columns, and sub-surface waters. Riparian and upslope areas are an integral part of the aquatic ecosystem, providing sediment, large woody debris, and water (Pringle et. al. 1988; FEMAT 1993). Riparian Areas which are preserved in a natural, functional condition provide shade and organic debris and help regulate nutrients and sediments (O'Laughlin and Belt 1995). Disturbance processes, such as landslides and floods, help maintain the system by providing important delivery mechanisms.

Riparian reserves provide connectivity for the many terrestrial animals and plants that use riparian habitats as travel and dispersal corridors. They also play a role in protecting species that are dependent on the transition zone between riparian and upslope habitat (FEMAT 1993).

The protection and restoration of Riparian Areas would allow for the establishment and regrowth of riparian hardwoods, such as willows and cottonwoods, which provide a host of valuable ecosystem functions. Riparian vegetation provides shade and moderates water temperature. Woody root systems decrease erosion and provide bank protection during high flows. Rush and sedge communities provide fibrous roots which bind to finer particles in the flow (Elmore 1992), reducing sedimentation of the stream. Riparian vegetation produces mats which, in addition to providing off-channel habitat for aquatic biota, intercept sediments during high flow periods (Platts 1991) and allow for the accumulation of sediment and the building of banks (Elmore and Beschta 1987).

In degraded areas, watershed functions and processes must be restored.

Restoration strategies need to start at headwaters and work downstream in order to function effectively for watershed systems. It is ineffective to address problems at the reach scale alone. Existing conditions are inadequate to protect native species and, therefore, should not be considered a "baseline" or desired management condition (Reeves and Sedell 1992; FEMAT 1993; Beschta et. al. 1995; Frissell et. al. 1995; National Marine Fisheries Service 1995a). A primary goal of restoration must be to re-establish connectivity. In addition, natural disturbance patterns and self-regulating processes and functions both within and between watersheds should be re-established.

The interaction of the flood plain with the stream's high flow disturbance regime is essential to the recovery of aquatic ecosystems. In functional systems, where channel and floodplain are connected, floods naturally deposit sediment and debris on the floodplain, thereby replenishing the floodplain surface (Van Haveren and Jackson 1986). This process is required to establish vegetation on the floodplain and enable side-channel development over time. In degraded systems, where floodplain connectivity has been lost, sediment and debris are exported from the system. As connectivity and floodplain surfaces are restored, typical riparian species may be re-established (Elmore and Beschta 1987). In order to restore interaction with the floodplain, it may be necessary to remove roads and other obstructions (Henjum et. al. 1994).

Planning and decision-making should be integrated with watershed assessment.

Information on watershed functions and processes is necessary to determine whether the objectives of the aquatic conservation strategy are being met. This information can be provided by watershed assessment and analysis. Watershed analysis provides a practical analytical framework for ecosystem management using an ecologically relevant management unit (Montgomery et. al. in press). The specific goals of watershed assessment and analysis are to:

- determine and map the geomorphic, ecological, and hydrologic characteristics of specific watersheds with reference to neighboring watersheds and identified beneficial uses;
- determine the type, aerial extent, frequency, and intensity of watershed processes, including mass movements, fire regimes, peak and low streamflows, surface erosion, and other processes affecting the flow of water, sediment, organic material, or nutrients through a watershed;
- determine the distribution, abundance, life histories, habitat requirements, and limiting factors of fish and other riparian-dependent species;
- identify parts of the landscape (e.g. hillslopes and channels) that are either sensitive to specific disturbance processes or critical to beneficial uses and key fish stocks or species;
- interpret watershed history, including the effects of previous natural disturbances and land use activities on watershed processes;
- establish ecologically and geomorphologically appropriate boundaries of riparian areas, consistent with the minimum criteria set forth below;
- evaluate and monitor the reliability of watershed assessment procedures, the effectiveness of management standards applicable to riparian reserves, and the effectiveness of restoration measures;
- identify restoration objectives, strategies, and priorities; and
- recommend silvicultural and other management standards on lands which are not within designated riparian reserves. Such standards should, at a minimum, set appropriately long harvest rotation ages outside no-logging riparian reserves, withdraw unstable slopes and erosion-prone soils from the timber base, require

logging plans to be based on hydrologic designs, and identify and protect old-growth and mature trees and forests.

STANDARDS AND GUIDELINES

General Management Recommendations for all Federal Lands

All management activities on U.S. Forest Service or U.S. Bureau of Land Management lands within the planning area must be consistent with the conservation and recovery of aquatic and riparian systems and species. Management actions that do not maintain the existing conditions or lead to improved conditions in the long-term would not meet the intent of the conservation strategy and should not be implemented. Management activities should accomplish the following:

- Maintenance and restoration of the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations, and communities are uniquely adapted.

- Maintenance and restoration of spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refuges. These network connections must provide chemically- and physically-unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species.

- Maintenance and restoration of the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.

- Maintenance and restoration of water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality should remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits the survival, growth, reproduction, and migration of individuals composing riparian and aquatic communities.

- Maintenance and restoration of the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.

- Maintenance and restoration of instream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of natural peak, high, and low flows must be protected.

- Maintenance and restoration of the timing, variability, and duration of flood plain inundation and water table elevations in meadows and wetlands.

- Maintenance and restoration of composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply sufficient amounts and distributions of coarse woody debris ("CWD") to sustain physical complexity and stability.

- Maintenance and restoration of habitat to support well-distributed populations of native riparian-dependent plant, invertebrate and vertebrate species.

Management Recommendations for Aquatic Diversity and Riparian Areas

Identification and Designation Criteria of Aquatic Diversity Areas

Areas where native aquatic species are at risk and vulnerable to future disturbance, whole watersheds exemplify native aquatic ecosystems, or essential connecting habitats are required to support native fish populations should be protected as ADAs. 158 ADAs have already been identified on the eastside of Oregon by the Oregon Chapter of the American Fisheries Society (Oregon AFS 1993). With some modifications to ensure that all ecoregions are well-represented, these areas, and the criteria used to identify them, provide a starting point for the creation of an aquatic diversity network in both Oregon and Washington. Where ADAs have not yet been identified, ADA watersheds need to include the most intact riverine ecosystems. As long-term monitoring and control watersheds, ADAs would be useful for assessing the success of site-specific restoration activities in more degraded watersheds.

ADAs should be designated by watershed boundaries and must protect biotic communities at temporal and spatial scales sufficient to recover threatened fish and other riverine-riparian species. The following types of areas should be designated as ADAs (adapted from Oregon AFS 1993):

- Watersheds that support unique, sensitive, or key populations of aquatic species that may be vulnerable to disturbance and that require immediate protection to maintain genetic or life history diversity. These include critical areas for known sensitive species or stocks, narrow endemic populations, stocks known to have unique life history or genetic traits, populations near the extreme edge of the range of a more widely distributed species, or highly abundant populations that may be critical for sustaining production or seeding habitats within a watershed or in adjacent areas.

- Watersheds which contain unique, sensitive, or otherwise important aquatic assemblages or ecosystems, including the best remaining representatives of native assemblages and aquatic ecosystems in the region (e.g. the last or best remaining watershed or unfragmented old-growth forest in a large basin). Areas meeting this criteria would include but not be limited to 1) areas with high numbers of native species or watersheds relatively unaffected by species introductions or stock transfers which might serve as important genetic refuges for indigenous fish assemblages; 2) habitats or streams important to the watershed's ecological functioning (e.g. critical to maintaining water quality or optimum temperatures); and 3) corridors that provide vital connections between rearing and spawning areas, disjunct or potentially disjunct populations, or existing areas that are relatively undisturbed by management activities (e.g. wilderness areas or roadless areas).

- Watersheds which are a source for valuable baseline data, a benchmark for future monitoring, or a life history/ecology research site for a species or assemblage.

- All existing reserve areas, including national parks, wilderness areas, federally managed portions of the wild and scenic rivers system, national wildlife refuges, recreation areas, and monuments.

- The Eastside watersheds identified as ADAs by the watershed classification subcommittee of the Oregon chapter of the American Fisheries Society (Oregon AFS 1993).

Identification and Interim Definitions of Riparian Areas

Riparian Areas must be identified throughout the planning area. According to the functional definitions below, the size of Riparian Areas should vary with topographic and on-site conditions. However, unless and until the site-specific information is available to define Riparian Areas ecologically, riparian reserves should include at least 300 foot buffers for all perennial streams, as measured horizontally from the edge of both channels and at least 150 foot buffers for all ephemeral or intermittent streams, seeps, springs, and wetlands.

Streams: All streams, permanent and impermanent, should be designated as Riparian Areas based on functional, rather than fixed or arbitrary, widths. The full extent of the stream's riparian area must be included – from the edge of the active channel (or edge of the braided channel area) to the top of the inner gorge or to the outer edge of either the 100 year flood plain, riparian vegetation, the zone of control of stream area microclimate, the habitat areas of aquatic, semi-aquatic and riparian dependent terrestrial or avian species, or the top of stream-adjacent moderately unstable or unstable slopes. Particular attention should be given to defining Riparian Areas for streams so that connectivity between groundwater and surface water is maintained. Therefore, Riparian Area boundaries should be drawn with due regard to flood plain hydrologic features, recharge areas, and hyporheic zones. In addition, Riparian Areas should function as significant corridors for migration or dispersal of species or propagules and should be designated in a manner which protects those functions.

Springs and Seeps: Riparian Areas should be designated around all springs and seeps. They should be configured to protect the microclimate, the seasonally saturated soil, and the connectivity with the aquifer, so as to maximize the retention and possible recovery of structural and functional integrity.

Wet Meadows: Riparian Areas should be designated for wet meadows such that "areas where grasses predominate" and areas that are "waterlogged within a few inches of the ground surface" are included (FEMAT 1993).

Lakes: The designated Riparian Area for lakes should include the body of water and the area to the outer edges of either the riparian vegetation, the extent of seasonally saturated soil, the extent of moderately and highly unstable areas, or a distance equal to the heights of two site-potential trees.

Ponds, Reservoirs, Estuaries, and Wetlands: The designated Riparian Area for ponds, reservoirs, estuaries, and wetlands greater than one acre should include the body of water (the maximum pool elevation of reservoirs) or wetland and the area to the outer edges of either the riparian vegetation, the extent of seasonally saturated soil, the extent of moderately or highly unstable areas, or a distance equal to the height of one site-potential tree.

Management Goals for Aquatic Diversity and Riparian Areas

Within ADAs and Riparian Areas, the primary management goal is the maintenance (where conditions are optimum) and restoration (where conditions are sub-optimum) of the ecological integrity of riverine habitat and associated riverine-riparian species. Specifically, these areas need to be managed to achieve the following objectives:

- maintenance or restoration of water quality to the level necessary for stable and productive aquatic ecosystems, as measured by water quality parameters including, but not limited to, the timing and character of temperature, sediment, and nutrients, biochemical oxygen demand, turbidity, and the absence of anthropogenic pollutants;
- maintenance or restoration of stream channel integrity, channel processes, and the sediment regime under which the riparian and aquatic ecosystems developed (elements of the sediment regime include the timing, volume, and character of sediment input and transport);
- maintenance or restoration of instream flows to support desired riparian and aquatic habitats, the stability and effective function of stream channels, and the ability to route flood discharges;
- maintenance or restoration of the natural timing and variability of water table elevation in meadows and wetlands;
- maintenance or restoration of the diversity and productivity of native riparian plant communities;
- maintenance or restoration of riparian vegetation to 1) help achieve rates of surface erosion, bank erosion, and channel migration characteristics equal to those under which the desired communities developed, 2) provide adequate summer and winter thermal regulation within the aquatic and riparian areas, and 3)

provide and distribute large woody debris characteristic of natural aquatic and riparian ecosystems;
- maintenance or restoration of habitat to support well-distributed populations of native plant, vertebrate and invertebrate species; and
- maintenance or restoration of riparian and aquatic habitats as necessary to foster the unique genetic fish stocks that evolved within the relevant geo-climatic ecoregion.

Standards for Aquatic Diversity and Riparian Areas

- Subject to valid existing rights, all federal lands located in ADAs and Riparian Areas should be withdrawn from 1) entry, appropriation, or disposal under the public land laws, 2) location, entry, and patent under the mining laws, and 3) disposition under federal mineral and geothermal leasing laws.

- No logging (including removal of fuel wood or dead trees) should be permitted in ADAs or Riparian Areas, except where wood removal is necessary for human health or safety reasons (e.g. existing navigation) or to attain aquatic conservation management objectives. All such management exceptions should be determined based on site-specific interdisciplinary analysis.

- Removal of downed large woody debris (including from stream channels) should be prohibited in ADAs and Riparian Areas, except where necessary to allow the re-connection of a stream and its flood plain, or to protect human health and safety (e.g. for navigation).

- Heavy equipment including road-building equipment should be excluded from ADAs and Riparian Areas except if either specifically approved for road obliteration, construction, or maintenance or an interdisciplinary team determines that the proposed activity is needed to meet aquatic conservation management objectives.

- New recreation facilities (e.g. trails) should not be developed within ADAs and Riparian Areas unless compatible with the management objectives stated above. Existing facilities should be evaluated for compatibility with these objectives. Those which are incompatible should be modified to conform or their impacts should be reduced to the extent practicable through facility modification, changes in maintenance practices, education, use limits, or closure.

- Issuance of any license, permit, or exemption for any dam, diversion, electrical generation, water resources project, or similar facility should be prohibited in ADAs and Riparian Areas.

Identification and Management of Biotic Refuges

In addition to the protection of refuges at the watershed level, the intensely fragmented nature of Eastside aquatic systems requires the protection of small, isolated relic refuges which support biodiversity within otherwise degraded basins. Biotic Refuges may not necessarily exhibit the natural hydrologic regime or other aspects of aquatic ecosystem integrity (e.g. active hydrologic management may be required to maintain species) but should be important for maintaining genetic resources. Biotic Refuges should be identified during watershed analysis.

No activities should take place in Biotic Refuges that threaten or are inconsistent with protecting the remaining elements of the native biota. Biotic Refuges should be designed and managed with respect to the critical contributing area or the Refuge's relationship to the rest of the watershed.

Identification and Management of Roadless Areas

Roadless areas must be protected and integrated into the system of aquatic and riparian refuges (FEMAT 1993;

Henjum et. al. 1994; Technical Working Group for the Upper Grande Ronde Anadromous Fish Habitat Protection, Restoration, and Monitoring Plan 1994). New road construction and logging must be prohibited within existing roadless areas that are either 1,000 acres or larger or biologically significant regardless of size. Because roadless regions contain the least-disturbed forests and stream ecosystems on the Eastside, they are currently serving as reservoirs of ecological diversity and benchmarks for restoring ecological health in more disturbed areas. These areas must be protected from the fragmentation caused by pervasive road-building across the rest of the landscape (see Chapter XI for road management standards).

Watershed Assessment

Watershed assessment needs to be the basic planning tool for future management. The agencies should assess the rates, patterns, and intensities of natural disturbances and identify human-caused risks to Eastside watershed ecosystems. Results of the assessment would provide the informational basis for:

- evaluating cumulative watershed effects;
- establishing watershed restoration goals and priorities to remove sediment sources and other threats to the integrity of riverine-riparian ecosystems;
- developing and implementing watershed restoration plans on a site-specific basis;
- monitoring annually the effectiveness of standards, guidelines, and restoration treatment plans; and
- refining or expanding the network of ADAs, Riparian Areas, and Biotic Reserves identified through the regional planning process.

Products of the assessment must include at least:

- delineation of high productivity areas both in the aquatic and terrestrial components of the watershed;
- delineation of critical areas for ecosystem functions (e.g. unconstrained valley bottoms and tributary junctions are critical areas for hydrologic and sediment processes and also tend to be the most biologically diverse areas; wetland and pond areas are critical for water storage and metering as well as a diversity of terrestrial and riparian wildlife; certain types of geology and landforms are potentially unstable, highly productive, or insensitive to particular disturbances);
- identification of risks and hazards to critical ecosystem areas and specific land management recommendations to reduce these hazards;
- identification of riparian reserve areas based on hydrology, vegetation, channel morphology, landforms, species diversity, and potential impacts from upslope and upstream areas; and
- identification of specific criteria for evaluating and addressing the role of primary processes and disturbance trends when assessing the validity of restoration and management projects. These criteria should be aimed at regaining ecological function and biodiversity within the watershed as a whole and should ensure that projects are linked together in space and time. Criteria may also indicate priority areas for restoration, suggest time frames for project completion, and indicate where projects should be clustered to take advantage of time and money. Because the National Environmental Policy Act specifically requires cumulative effects analysis, the criteria need to provide a framework for assessing the cumulative impacts of all restoration projects in a watershed.

Watershed Restoration

For watersheds degraded by past or current management activities, watershed restoration plans should be developed based on a restoration needs assessment. Restoration plans should provide the following:

- spatially explicit objectives for restoration, including the specific measures needed, the techniques to be used, a recommended sequencing for implementing these measures, and a description of how the work will be accomplished, including,

a) a proposed long-term (2-20 years) monitoring plan which encourages and establishes cooperation of local, state, and federal participants; and

b) prioritization of restoration activities based on 1) presence and condition of at-risk salmonids, other fish stocks, or riparian-dependent species, 2) restoration potential of the habitat, 3) ecological importance of the habitat, and 4) resources necessary to execute the restoration plan;

- elimination or minimization of priority sediment sites and other threats to the ecological integrity of ADAs and Riparian Areas and an update of maps of land use history and disturbance to vegetation, soils, and streams;
- reforestation of ADAs and Riparian Areas according to site-specific needs for the introduction of native vegetation with priority given to areas adjacent to and immediately downstream from watersheds designated as ADAs and Riparian Areas;
- placement of large downed trees at ecologically appropriate places, pending the recovery of natural sources of downed trees as a result of riparian reforestation;
- identification of priorities for reintroduction of native fish and wildlife; and
- estimation of costs so that restoration plans can be accurately evaluated during agency budgeting procedures.

Ecological Indicators for Management and Recovery

Ecosystem-based indicators are needed to determine the condition (degraded v. functional) and trend (declining v. recovering) of aquatic and riparian systems within watersheds. These indicators should be used to implement land management standards, to guide restoration efforts, and to defer or curtail management activities. Such indicators should be capable, collectively, of accurately reflecting the aggregate effect of land use activities on ecosystem processes and functions at the watershed level. To this end, indicators should be developed to assess the condition and trend of the following aquatic and riparian habitat characteristics: 1) riparian vegetation; 2) channel substrate (e.g. sediment levels and cobble embeddedness); 3) channel morphology (number and volume of pools and large woody debris abundance); 4) water quality (temperature and levels of other pollutants); and 5) water quantity and timing.

Quantitative habitat standards are not recommended for each of these five categories. However, because the habitat needs of anadromous salmonids are relatively well-known, and because certain habitat characteristics of these species are partial indicators of overall watershed conditions and suitable habitat for other aquatic species, quantitative habitat standards based on the needs of salmon are suggested for aspects of three types of indicators: channel substrate, water temperature, and bank stability (Rhodes et. al. 1994). As stated by Rhodes et. al. (1994), "[i]t is recommended that where these standards are not met, any activity that can potentially delay improvement in habitat condition should be deferred or curtailed until the habitat standard is met or a statistically improving trend is documented through monitoring over at least five years."

Riparian/Aquatic Indicators:

- Riparian vegetation. Improved density of vegetation increases the ability of a channel to recover by contributing to resiliency and restoration of overall ecosystem functions. Although presence of riparian vegetation is a critical indicator of "recovery," it alone does not indicate a functional system. Channel recovery will likely take much longer than vegetative recovery (Kondolf 1993).

- Channel substrate. The presence of sorted bed material substrates, including decreased fine sediment among coarser material, is an indicator of the recovery of fish-bearing streams (Platts 1979). When cobbles are excessively embedded in fine sediments, fish reproduction is severely hampered. Substrates influence food production, as larger substrates provide a surface to which insects can cling (Wesche 1985). A decrease in cobble embeddedness may result from reduced erosion following improved management practices, high flows, and the presence of woody debris which allows fine sediment to be flushed out but retains coarser sediment (Beschta and Platts 1986).

a) Surface fines. Recovered watersheds should have surface fine sediment levels that average less than 20% in spawning habitat. There should be no increases in surface fine sediment levels in spawning habitat where it averages less than 20% (Rhodes et. al. 1994).

b) Cobble embeddedness. Cobble embeddedness should average less than 30% within rearing habitat. There should be no increase in cobble embeddedness in rearing habitat where it averages less than 30%.

- Channel morphology. Improvements in channel morphology indicate improved watershed function and fish habitat and include increased abundance and volume of pools, woody debris abundance, and bank stability (Rhodes et. al. 1994). For salmonids, increased pool volume is an essential morphological characteristic of the stream (Beschta and Platts 1986; Rhodes et. al. 1994). These pools tend to be created or improved by channel narrowing, subsequent turbulence, and water flow over logs and woody debris. Channel narrowing usually follows the moderation of flow, decreased sediment from soil disturbance, and recovery of riparian vegetation (Beschta and Platts 1986). These conditions may also result in increased sinuosity and channel complexity. Point bars – accumulations of relatively coarse-grained materials on the inside of a bend – are associated with the increased presence of deep pools (Beschta and Platts 1986). Increased numbers of riffles – important areas of fish food production (Beschta and Platts 1986) – form as trees mature and fall into or across streams (Platts 1991).

a) Pools. Pool volumes and frequencies should be monitored for trends, but should not be managed according to a numeric standard. Rather, watersheds should be managed to decrease fine sediment volumes in pools and increase residual pool volumes.

b) Large woody debris. Large woody debris retention should not be managed according to a numeric standard. Rather, natural large wood recruitment systems should be fully protected in riparian reserves (see "Standards for Aquatic Diversity and Riparian Areas" above). In highly degraded areas, active restoration to re-establish tree stocking is necessary. Large woody debris should be monitored for trends.

c) Bank stability. At least 90% of channel banks on all streams in a recovered watershed should be stable. Bank stability should be maintained where it is greater than 90%. Where stability is less than 90%, or shows a decreasing trend, activities which could decrease stability or forestall recovery should be eliminated until the standard has been reached or a statistically significant ($p < 0.05$) improving trend over at least five years has been documented through monitoring. Where an improving trend has been established but the standard is not met, activities should only be allowed if continued improvement in bank stability is not impeded. Suspension of riparian grazing is a key strategy for restoring bank stability (Rhodes et. al. 1994).

- Water quality – temperature and other pollutants. High summer stream temperatures resulting from lack of shading and wider channels put salmonids at great risk (Rhodes et. al. 1994). Current degradation has allowed for upstream propagation of warm water fishes. Thus the downwater migration of warm water fauna resulting from decreased water temperatures may indicate partial aquatic ecosystem recovery. The return of cold water fauna to restored areas may indicate that habitat has improved, as such fauna generally demand the highest quality habitat (Li and Castillo 1994). Increased vegetative cover and the narrowing of stream channels moderate stream temperatures year-round (Elmore 1992) and allow for increased oxygen availability (Noss and Cooperrider 1994).

a) Temperature standard. Watershed recovery is indicated by increases in the downstream extent of summer water temperatures that are suitable for salmon. As stated by Rhodes et. al. (1994), "[w]here daily maximum summer water temperatures in excess of 60°F exist in historically usable spawning and rearing habitat for salmon, passive restoration measures should be taken to reduce water temperature and active restoration should be undertaken, where it is likely to be effective in speeding the natural recovery of water temperature. Activities that have the potential to increase water temperatures or forestall the recovery of natural water temperatures should not be allowed on any stream."

b) Other pollutants. The presence of chemical pollutants is detrimental to salmon and other aquatic biota. As with temperature, existing state and federal water quality standards for pollutant parameters may not be sufficient to protect and restore sensitive aquatic biota such as salmon. Where these standards are inadequate, appropriate standards should be set and used as indicators of watershed condition. The presence of certain toxics, for example, indicates that mining activities are not being managed appropriately and/or that restoration of abandoned sites is needed.

- Water quantity and timing. As riparian conditions improve, hydrologic features and processes necessary for the maintenance of sensitive aquatic species (e.g. soil water holding capacity, flow moderation, and flood plain interaction) begin to return. The capacity of stream systems to retain water increases as riparian vegetation recovers (Wissmar et. al. 1994). As the capacity of stream systems to store water increases, streams may reappear and ephemeral streams may change (Elmore 1992). Decreased soil temperatures indicate increased soil moisture. Improved hydrologic function also includes moderated high flows and enhanced or prolonged base flows, which are evidence of functional interaction between surface flows and increased groundwater storage (Van Haveren and Jackson 1986).

  Velocity is an important parameter in determining distributional patterns of aquatic invertebrates (Wesche 1985). Swift water facilitates oxygen renewal in the stream and the production of invertebrates on which fish feed. Large organic debris from woody vegetation dissipates stream energy and provides slow velocity areas needed by fish (Beschta and Platts 1986).

Upland Indicators:

Because total system recovery is the ultimate objective, recovery in uplands should also be measured. Indicators of upland recovery include increased vegetative cover, the return of natural disturbance regimes, improved hydrologic processes, decreased abundance and distribution of alien plant species, and increased abundance and distribution of native plant species.

- Increased vegetative cover. Upland recovery is indicated by the return of natural patterns and assemblages of native vegetation communities, increased forage production, diversified age class distribution of plants, increased availability of microgermination sites as a result of reduced soil compaction, increased plant vigor, increased availability of seed sources, and the return of natural fire regimes.

- Return of natural disturbance regimes. Western ecosystems evolved with and in response to fire. Fires are a part of the pattern of disturbance and recovery that provides a physical template for biological organization at all levels. However, management practices have dramatically reduced the presence of fire over the last 100 years. The return of disturbance regimes benefits not only the ecosystem, but also ungulate vitality, as fire can increase forage production tenfold.

- Improved hydrologic processes. Recovery of aquatic ecosystem hydrologic processes may be hastened by improved upland hydrologic processes including reduced overland flow, reduced surface erosion, improved infiltration, and increased abundance of seeps/springs.

CHAPTER III: LANDSCAPE PRIORITIZATION AND RESERVE DESIGN

OBJECTIVES

The objective of this chapter is to provide recommendations for creating a system of new reserves on the Eastside to protect and restore native biological diversity at all levels of organization (genes, species, ecosystems, landscapes, and landscapes) and the ecological and evolutionary processes associated with each of these levels. More specifically, an integrated reserve network on the Eastside is necessary to:

- maintain/restore fully-functioning ecosystems (including a complete array of native plant communities and wildlife habitats);
- maintain well-distributed, viable populations of all native species;
- provide representation of all natural communities and successional stages across their natural range of variation;
- provide refuges of native flora and fauna that are relatively resistant to biological invasions of exotic organisms, and can act as source pools for dispersal into adjacent habitats;
- provide areas of adequate size, number, and connectivity to allow for inevitable environmental change due to natural disturbances and long-term climatic shifts; and
- accommodate uncertainty.

In addition to protecting biodiversity, reserves are necessary as control areas in experiments with ecosystem management (Walters and Holling 1990; Noss 1991a).

PRINCIPLES

Development of an interconnected system of reserves, restoration areas, and linkage zones within the larger matrix of federal lands is the only reliable way to ensure that the ecological integrity and sustainability of Eastside ecosystems are not permanently lost. Any ecosystem management strategy for the Eastside which seeks to maintain regional biodiversity must incorporate a system of reserves, designed to protect relatively large, natural areas where native plant and animal communities and their associated ecosystem processes predominate. Comparison of natural landscapes in reserves with more intensively managed areas can provide an important gauge of the success or failure of ecosystem management plans (Kaufmann et. al. 1994). Since ecosystem management activities are experimental, widespread, and affect large landscape areas, control areas (i.e. reserves) for these experiments also need to involve large, well-distributed areas on the Eastside.

The following principles underlie the need and foundation for developing a regional reserve system on the Eastside:

Reserve-based conservation strategies are at least as indicated for Eastside landscapes as they are for other regions.

Some authors have suggested that reserve-based conservation strategies are inappropriate for disturbance-prone landscapes, such as those found on the Eastside (Oliver 1992; Lippke 1993; Covington et. al. 1994; Everett et. al. 1994b). One frequently proposed argument is that past human management activities on the Eastside (e.g. fire suppression, logging, and grazing) have created ecosystem conditions that are unsustainable and, therefore, should not be protected in reserves. Although Eastside forests and rangelands have undoubtedly been degraded by past management and may be in a relatively unstable condition, protection of those areas that remain in a high-quality condition is critical. Widespread and repeated degradation of ecosystems in the region only reinforces the need to 1) protect those areas that have not yet been heavily degraded and 2) manage a large percentage of the landscape in a manner that is most likely to restore ecosystem stability and biodiversity (Angermeier and Karr 1994; Henjum et. al. 1994).

It must also be emphasized that designation of an area as a reserve should not preclude active management. Rather, reserves should be areas where management (active or passive) is directed at maintaining and restoring biodiversity and ecosystem patterns and processes (Carroll and Meffe 1994). Biodiversity conservation in reserves can be facilitated by decommissioning roads, eliminating exotic species, and limiting recreational impacts. Active management may be important for restoring currently degraded, unstable areas of any proposed reserves. Appropriate restoration management guidelines should be developed, as described at the end of this chapter. These guidelines should reflect the dynamic nature of ecosystems in the region and encourage (not prevent) the restoration of disturbance regimes that sustain biodiversity and are characteristic of specific ecosystem types. For example, considerable management effort needs to be directed toward restoring natural fire regimes in existing protected areas and new reserves that are outside the historic range of variability for fire frequency.

Other authors (Botkin 1990; Degraaf and Healy 1993; Everett et. al. 1994c; Johnson et. al. 1994) have argued against the establishment of reserves reasoning that since many vegetation types are subject to frequent and/or large disturbance events, reserves are not likely to be effective at preserving specific desired ecosystem conditions (e.g. old-growth forests). Neither the influence of disturbances in general nor the "non-equilibrium paradigm" in particular invalidate reserve-based conservation strategies. Proper recognition of ecosystem dynamics simply leads to the conclusion that larger and more reserves are required in order to ensure the protection of regional biodiversity and ecological integrity (Baker 1992; Pickett et. al. 1992; Fiedler et. al. 1993; Angermeier and Karr 1994; DellaSala et. al. 1994).

The concept of "emphasis areas" in place of reserves has recently been promoted (Everett et. al. 1994b). These are conceived of as areas with "soft" boundaries and a management focus on the maintenance of certain species or ecosystem elements. This concept has significant shortcomings. First, the concept, as presented, focuses conservation efforts on individual species and ecosystem elements. Everett et. al. (1994b) described by way of example an "emphasis area" for protecting a population of rare *Delphinium veridescens* in a small watershed. This "single species" focus through special management of a small area has merit in certain situations but does not offer a viable alternative to conservation of regional biodiversity where populations of hundreds of sensitive, threatened, and endangered species are at stake. Larger reserves, which provide habitat and protection for diverse assemblages of species and ecosystems, are superior. Although there may be a continuing need to alter the boundaries of reserves based on new information and objectives, the implementation of flexible or "soft" boundaries (FEMAT 1993; Everett et. al. 1994b) is likely to lead to economically-driven decisions that adversely affect biodiversity protection.

Existing reserves are inadequate for protecting regional biodiversity and ecological integrity on the Eastside.

Although some wilderness areas, national parks, and other protected areas have been established on the Eastside, these areas were selected primarily for aesthetic, recreational, and socio-economic reasons. Ecological principles were not typically employed in their design, and biodiversity conservation was not the primary objective of their establishment. As a result, they suffer from a number of inadequacies in their ability to sustain biodiversity. The most widely recognized shortcomings of existing protected areas include:

- domination by high-elevation environments, which tend to be unproductive and support fewer species than more mesic sites (Harris 1984);
- failure to protect adequately all communities and ecosystem types representative of the region – particularly those with high commercial value (Noss 1990b);
- reliance on closed, static (rather than open, dynamic) models of ecosystems, resulting in loss of resiliency and adverse external influences (White and Bratton 1980);
- designation of areas that are too small and isolated to sustain viable populations of native species and important ecological processes (Grumbine 1990; Shafer 1990);
- allowance of human development activities that may be incompatible with biodiversity protection (e.g. fire

suppression, widespread livestock grazing, mining, and in some cases roads) (Schonewald-Cox and Buechner 1992); and
- lack of congruence between the administrative and ecological boundaries of protected areas (Kushlan 1979; Newmark 1985).

As a result of these inadequacies, existing protected areas alone are incapable of maintaining biodiversity and important ecological processes. An expanded reserve network, designed according to ecological criteria, is needed to ensure that all elements and processes associated with native ecosystems on the Eastside are sustained. Although existing protected areas alone are inadequate for a representative and viable reserve system, they nevertheless represent some of the least disturbed areas on the Eastside and contribute to the habitat needs of a subset of the Eastside's species. Existing protected areas play a significant role (as part of an expanded reserve system) and must continue to be protected.

Ecologically-based criteria for identifying areas of high conservation value and designing reserve systems have been well developed by the scientific community.

Reserve design and conservation evaluation have been the subjects of considerable research and discussion within the scientific community over the last 15-20 years. Experience from numerous empirical case studies and application of ecological theory have led to the development of some systematic guidelines about how best to locate and design reserves for biodiversity conservation. These guidelines, as articulated by Diamond (1975), Soulé and Simberloff (1986), DellaSala et. al. (1994), Meffe and Carroll (1994), and Noss and Cooperrider (1994), should form the foundation of reserve identification and design efforts on the Eastside.

Because native biodiversity is not uniformly distributed, identification of portions of landscapes that have the highest potential for conserving regional biodiversity is the first and most important step in the design of a reserve network. Landscape prioritization involves the integration of "coarse-filter" biological and physical factors into a model that predicts the overall value of various segments of the regional landscape to a reserve network (e.g. Develice et. al. 1993; Scott et. al. 1993; Stine and Luciani 1994). Decision rules that apply to the development of a landscape prioritization model include:

- landscape units that have high species diversity and/or provide habitat for multiple rare, sensitive, threatened, or endangered species have high priority;
- landscape units with high levels of endemism are of high value;
- natural areas (especially in forest systems) that are unfragmented by logging, roads, and other forms of human disturbance are of higher priority than fragmented areas;
- rare communities and successional stages (e.g. old-growth forests) and communities that are under-represented in existing reserves are prioritized over communities that are widespread and/or relatively well-protected;
- landscape units where native flora and fauna are relatively uninfluenced by alien species have high priority;
- undeveloped watersheds that provide high-quality water to aquatic ecosystems and act as refuges for native fish and other aquatic organisms have high priority; and
- wetlands and riparian areas (because of their relatively high diversity, productivity, and decline from historical abundance) generally are of high priority.

Results of landscape prioritization should provide the basis for the selection of areas to be included within a regional reserve system.

A regional reserve system should be developed using the design principles presented by Noss and Cooperrider (1994) and briefly summarized below. All of these principles are interrelated and must be considered in conjunction. For example, decisions regarding matrix management and proximity of reserves influence decisions about reserve size, shape, and ability to absorb disturbances.

Reserve Size. Large reserves are generally considered to be more effective at conserving biodiversity than small reserves. Large reserves capture a larger number of species, as documented in the well-known species/area relationship (MacArthur and Wilson 1967). The ability of a reserve to provide adequate habitat to maintain minimum viable populations for target species should also be one of the primary considerations in determining reserve size (Soulé and Simberloff 1986; Thomas et. al. 1990). The size needed to maintain minimum viable populations is a function of home range size and population density of target species, habitat quality within the reserve, proximity and connectivity to adjacent suitable habitat, the character of surrounding matrix lands, and the autecology of the target species. Often, reserves are considered to be isolated islands, surrounded by hostile environments to target species. Although this is sometimes the case, reserves can also be surrounded by habitat adequate for migration and dispersal. Isolated reserves surrounded by hostile environments need to be significantly larger than reserves located within a less human-disturbed matrix (Harris 1984; Janzen 1986).

Representation and redundancy. Representation of the entire range of successional stages and ecosystem types is a key objective in designing a regional reserve network. In a region as large and diverse as the Eastside, providing protection for all ecosystem-level diversity patterns necessitates many reserves well-distributed throughout the region. Vegetation types that have declined dramatically from their historic abundance due to human activities deserve special consideration. On the Eastside, old-growth forest stands, wetlands, and native grasslands are currently much reduced from historic levels and, therefore, should be a high priority for protection (Henjum et. al. 1994).

Redundancy in representation of the elements of biodiversity within reserves is also of great importance in any plan attempting to maintain/restore ecological integrity (Murphy and Noon 1992). Redundancy helps ensure that ecosystems and their associated species are well-distributed throughout the region – ideally across their complete elevational, latitudinal, and environmental ranges – thereby reducing the risk of extinction and loss of biodiversity elements due to catastrophic disturbances.

Natural heterogeneity within reserves. Spatially heterogeneous reserves are generally more successful than homogeneous reserves at capturing and maintaining diversity (Meffe and Carroll 1994). This principle stems from the observation that overall biodiversity of a given area is a function of both alpha (within habitat) and beta (between habitat) diversity. More naturally heterogeneous areas usually have higher beta diversity. Natural patch heterogeneity dampens disturbances better than homogeneous landscapes (Perry 1991), and may be important in controlling metapopulation dynamics (Murphy et. al. 1990). Spatially heterogeneous reserves also provide for the diverse habitat needs of many species which require a variety of habitats at different seasons or at different life stages (e.g. grizzly bears).

Ability to withstand short- and long-term change. It is imperative that reserve networks be designed to accommodate natural disturbances and climate change without loss of species or habitats. This is most likely to be accomplished by incorporation of large landscapes with broad environmental gradients which allow for species to shift their distributions in response to environmental change (Graham 1988; Hunter et. al. 1988). Incorporation of large landscapes allows natural disturbance processes to operate without jeopardizing all available habitat for target species (Baker 1992).

Reserves can also accommodate disturbances by incorporating ecological elements that confer resiliency. These include: riparian fire breaks; abundant, older, fire-resistant trees; intact duff layers to trap moisture; within-stand structural and compositional diversity; and abundant populations of insectivores, parasitoids, and fungivores that help reduce the frequency and magnitude of insect epidemic events (DellaSala et. al. 1994). While the likelihood of high-intensity disturbance has increased in some areas on the Eastside, resiliency within reserves would dampen the intensity, reduce the frequency, and limit the spread of fire and epidemic insect outbreaks. As mentioned above, a reserve system that incorporates sufficient ecological redundancy would ensure ecological persistence and function in the face of potential habitat loss due to catastrophic disturbance. Reserves should thus be designed to incorporate redundancy of functional groupings, multiple populations of individual species, and multiple representation of each community type and seral stage. In lower-elevation, ponderosa pine ecosystems, restoration of high-frequency, low-intensity fire regimes would reduce the likelihood of stand-replacing disturbance. This would facilitate restoration of an equilibrium in the dynamic representation of seral communities, such that habitat converted through major disturbance would equal habitat replacement through stand maturation.

Ideally, reserves should be at least as big as their "minimum dynamic area" – the smallest area that allows for a natural disturbance regime while maintaining internal recolonization sources and hence minimizing extinction (Pickett and Thompson 1978). Some authors have concluded that reserves should be large enough to incorporate landscapes many times the size of the largest natural disturbance (White 1987; Baker 1992). Reserves of this size are not always feasible, but some of their most important features may be provided by designing around the significant Eastside opportunities (e.g. in the Eastern Cascades, Blue Mountains, Salmon-Selway Mountains) for large, interconnected reserve complexes.

Proximity, connectivity, and matrix management. Allowing for migration and dispersal of organisms between units in a reserve network is critical to meeting long-term biodiversity conservation objectives (Noss 1991b; Taylor 1993). The ability of organisms to move between reserve units is dependent on the proximity of the units, the degree of habitat connectivity present, and/or the management of the matrix in which the reserve units are embedded. Protection of discrete linkage zones can ensure the continuance of migration and dispersal of many organisms between reserves, provided the linkages are of sufficient width and quality to satisfy dispersal habitat requirements (Beier and Loe 1992; Harrison 1992; Mcuen 1993). Alternatively, matrix management which provides habitat conditions suitable for migration and dispersal of target species may also allow for the movement of organisms through the landscape (Thomas et. al. 1990).

RECOMMENDATIONS FOR DEVELOPMENT OF A REGIONAL RESERVE SYSTEM

The following step-wise method is recommended for designing a reserve system on the Eastside, using Geographic Information Systems:

Step 1 - Assemble "coarse-filter" data on biological and physical attributes of the study area.
Step 2 - Derive additional data layers for specific variables relating to biodiversity.
Step 3 - Evaluate biodiversity values across the region and prioritize areas for protection.
Step 4 - Delineate boundaries of a regional reserve system, including reserves, restoration areas, and linkage zones.
Step 5 - Develop general management objectives and guidelines for maintaining/restoring biological diversity and ecological integrity within the reserve system.

Each of these steps is briefly outlined below.

Step 1 – Assemble GIS data layers of biophysical attributes. The first step in conducting a GIS-based landscape prioritization of the Eastside is the assembly of digital data layers which accurately portray important biological and physical attributes relating to biodiversity across the region. These should include:

- Vegetation data which accurately reflect the current condition of plant communities in the study area. Wherever possible, this data should categorize vegetation to the plant community level and contain information on current vegetation conditions and potential natural vegetation, for both forested and non-forested plant communities.
- Detailed forest cover data which contain specific information on canopy cover, successional stage, age, size, site class, and human management history of all forest stands.

- Detailed hydrography data with stream segments attributed according to the Strahler ordering system. Ideally, this should be a network coverage.
- National Wetlands Inventory data. This information can be supplemented with additional finer-scale data where available.
- River Information System data – similar to the Washington River Information System (WARIS) program data or the American Fisheries Society database on Aquatic Diversity Areas ("ADAs") in Oregon.
- Major watershed and sub-watershed boundaries.
- Natural Heritage Program data – fine-scale information on known occurrences of rare, sensitive, threatened, and endangered species.
- Distribution maps for vertebrate species.
- Population status maps for sensitive, rare, threatened, and endangered species.
- Landsat thematic mapper satellite imagery for base reference purposes.
- Digital elevation data. 90 meter resolution is adequate for a regional analysis.
- Soils and geology data.
- Landform structural classes (e.g. glacial troughs, mesas, and cliffs).
- Detailed transportation system data compiled from all available sources.
- Human population centers and population density (U.S. census data).

Step 2 – Derive additional data layers relevant to determination of biodiversity values. The data listed above should be used as the basis for deriving data layers which reflect more specific dimensions of the landscape relating to biodiversity value. These derived data layers should be assembled to provide input into a raster-based GIS model depicting biodiversity value. The following derived layers are important elements of this surface model:

- <u>Degree of mature and old-growth forest development.</u> Forest condition data should be analyzed to provide information on mature and old-growth forest conditions within the study area. This grid should be smoothed with a 500-meter mean filter to reflect the average degree of development of mature and old-growth forest characteristics in the landscape. The resulting surface should then be weighted to reflect the degree to which mature and old-growth forests contribute to regional biodiversity.

- <u>Distribution and fragmentation of unmanaged forest.</u> The best existing data sources should be integrated to create a unified forest cover layer which reflects the current status of managed and unmanaged forests in the study area. Forest fragmentation can then be evaluated through determination of patch size and area/perimeter ratios of unmanaged forest patches. Resultant forest patches should be weighted; large patches with low perimeter to area ratios should receive the highest rank.

- <u>Patch size evaluation of mature and old-growth forest stands.</u> The above GIS layer on mature and old-growth forests should be used to calculate patch size, connectivity, and proximity of mature and old-growth forest stands. A GIS grid should be created which is weighted by stand size, configuration, and proximity to other stands.

- <u>Vegetation rarity and representation evaluation.</u> The overall rarity and representation of each vegetation type within existing protected areas (e.g. gap analysis) (Scott et. al. 1993) should be evaluated across the study area. A GIS grid should be developed which reflects both the relative rarity and degree of protection for each vegetation type in the study area. This grid should be weighted so that rare, under-represented communities receive the highest weighting and common, well-represented communities receive relatively low scores.

- <u>Road density analysis.</u> A continuous surface model of road density should be developed for the study area. The road density surface should be designed to reflect the landscape-level impact of transportation systems in the study area, and should be weighted using a negative exponential distribution weighting.

- Road proximity analysis. A continuous surface model of road proximity should be developed for the study area. This should be weighted with a negative exponential distribution weighting. The resulting surface model should give higher value to areas in the interior part of larger roadless/undeveloped regions.

- Roadless/undeveloped region determination. All areas over 200 meters from a road and over 400 hectares (approximately 1,000 acres) (Henjum et. al. 1994) in size that have not been significantly and actively altered by human management (other than fire suppression and grazing) should be delineated as roadless/undeveloped regions. Roadless/undeveloped regions should be identified through analysis of composite road and land use coverages assembled from the best current data sources for the study area. They should be weighted by size using an exponential distribution weighting, such that overall value increases with area.

- Biological effect of major streams and rivers on terrestrial species. A grid portraying proximity to perennial streams and rivers should be developed, where the first 100 meters adjacent to a watercourse is given the highest weighting. The weighting of the rest of the landscape should be determined using a negative exponential distribution, with areas over 1 km from a watercourse receiving no biodiversity value for this variable.

- Biological effect of elevation. Low-elevation lands are generally more productive and biologically diverse than adjacent higher-elevation areas. A GIS grid should be created to reflect this pattern where weighting is inversely proportional to elevation.

- Distribution and density of rare, sensitive, threatened, and endangered species. A GIS grid should be developed that depicts the distribution and average density of element occurrence records of rare, sensitive, threatened, and endangered species. Remote, unsampled areas should receive a regional average weighting to reduce the bias created by sampling intensity.

- Aquatic diversity. The status of important aquatic species, including anadromous and resident fish, amphibians, and keystone aquatic invertebrates should be evaluated based on watershed assessment (see Chapter II). Watersheds with high aquatic diversity or the presence of rare, sensitive, threatened, or endangered species or stocks should be given the highest weightings. Other factors influencing watershed weightings include 1) fish habitat quality, 2) level of human disturbance, 3) sensitivity to disturbance (i.e. erosion hazard), 4) habitat connectivity value, and 5) genetic purity of fish stocks.

- Geologic/Geomorphic rarity and representation. Endemic and unusual flora and fauna are often related to unusual geologic/geomorphic conditions. A rarity and representation evaluation of geologic substrate and landform should be developed in a similar fashion to that described above for vegetation.

- Site productivity, forest suitability, and erosion hazard. Soil information for the study area should be compiled and used to develop two GIS data layers relevant to landscape prioritization and reserve design. The first data layer should reflect the relative potential of individual landscape units to provide sustained commodity outputs, with areas of higher productivity receiving higher weighting. The second data layer should reflect the relative surficial and mass erosion hazard of each landscape unit. These two data layers can be used to identify areas of high biodiversity where little resource conflict exists.

Step 3 – Evaluate biodiversity values using a GIS model. A GIS-based landscape prioritization model integrating all of the biodiversity value layers described above should be developed and used to identify those areas with high value for protecting biodiversity across the region. Weights and integration algorithms should be adjusted in an interactive GIS grid environment to achieve scientifically defensible results. The end product should be a surface model of the landscape that ranks all areas on a scale from relatively high to low biodiversity value, which then should be used as the foundation for designing a reserve network.

Step 4 – Design the regional reserve network. The biodiversity surface model described in the preceding steps should provide practical direction for defining the boundaries of a system of reserves, restoration areas, and linkage zones, using the design principles outlined earlier in this chapter. Restoration areas should be those areas which are adjacent to reserves and have the potential to contribute greatly to regional biodiversity but have been degraded by past management and are in need of restoration activities. Linkage zones should be areas of varying size and type that provide spatial linkages in the reserve network but do not qualify as reserves. The concept of minimum dynamic area should be employed when designing the integrated reserve network. An interactive GIS environment should be used to aid biologists in developing and evaluating several alternative reserve system options.

Step 5 – Develop management objectives and guidelines. Developing ecologically-based management objectives and guidelines for the various land designations should be a critical step in developing a regional ecosystem management plan. Since conditions vary greatly across the Eastside, management guidelines should be tailored to match specific vegetation types and objectives. Some initial management objectives and guidelines for the proposed land designations are listed below:

Management objectives of the reserve system

- Maintain/enhance habitat quality for rare, sensitive, threatened, and endangered species.
- Restore native plant communities from damage associated with livestock grazing and other human disturbances.
- Maintain/restore mature and old-growth forests.
- Maintain/restore aquatic habitat for anadromous and resident fish and other elements of aquatic biodiversity.
- Restore vegetation/landscape structure characteristic of natural disturbance regimes.
- Maintain high-quality habitat for wide-ranging mammals currently or formerly present, including elk, woodland caribou, moose, lynx, cougar, wolverine, fisher, grizzly bear, and gray wolf.
- Maintain characteristic diversity of native flora and fauna.
- Maintain well-distributed, viable populations of all native species.

Management guidelines for the reserve system

Reserves:

- Natural disturbances allowed to occur (e.g. fire, insects).
- No new mining or road construction permitted. Prompt closure of unnecessary roads with obliteration and revegetation of roadbeds with native plant species.
- Prescribed fire permitted as primary tool for restoring/maintaining forest ecosystem health (see management guidelines related to prescribed fire presented in Chapter IV).
- Trail systems and other access regulated (follow typical wilderness area standards).
- Collection of plants or other materials for commercial purposes prohibited.
- No logging of unmanaged forests permitted. Thinning permitted only in plantations and other recently logged areas in order to facilitate development of old-growth forest characteristics, restore natural forest structure and composition, or reduce fuel loads (see thinning guidelines presented in Chapter V).
- Alien species eliminated or reduced, as feasible without use of herbicides (see recommendations for alien plant control presented in Chapter X).
- Fire suppression permitted on a case-by-case basis, but generally discouraged (see Chapter VII).
- Environmentally-sensitive, low-impact recreation, environmental education, and non-manipulative research

permitted.

Restoration areas:

- Thinning permitted in order to facilitate restoration of natural forest structure and composition (as described in Chapter V).
- No new road construction or reconstruction permitted.

Linkage zones:

- No logging of existing old-growth forests permitted.
- Some level of timber cutting permitted, but emphasizing previously managed stands, selection logging techniques (Swanson and Franklin 1992), long (200+ year) rotations, and other silvicultural systems that seek to emulate forest stand and landscape patterns created by natural disturbance regimes.
- Restoration forestry and sustainable forestry experiments allowed. However, experimental treatment must retain at least a minimum canopy closure, determined for each forest type on the Eastside, based on capability, natural disturbance regime, and other factors. In addition, experimental testing and monitoring of restoration techniques should take place on small areas and should be determined to be effective at achieving its objectives while protecting ecological values before any large-scale application is allowed.
- Road density reduced to or maintained at no more than one mile per square mile. New road construction is prohibited except when shown to be necessary for a larger program of partial or complete road obliteration.
- All riparian areas and other sensitive sites identified by landscape or watershed assessment conducted prior to any new management activity, protected.

CHAPTER IV: PRESCRIBED BURNING

OBJECTIVES

Carefully conducted prescribed burning has the potential to improve forest ecosystem health significantly in Eastside ponderosa pine and mixed conifer forests. The objective of prescribed burning is to use surface fires to mimic natural disturbance regimes on stands historically maintained by low-intensity, high-frequency fire regimes. Prescribed burning should be conducted to accomplish one or more of the following goals:

- reduce fuels/break up horizontal fuel continuity;
- prepare seedbeds for regeneration;
- maintain/improve wildlife habitat;
- achieve the effects of understory thinning;
- control some forest insect pests and pathogens; and
- encourage nutrient release.

PRINCIPLES

Scientists and forest managers are increasingly aware of the importance of fire for maintaining forest ecosystem health on the Eastside (e.g. Agee 1994; Mutch 1994). Wildfires have been a dominant force shaping the species, communities, structures, and processes of many Eastside forests for at least the last several millenia. Historically, fires have helped maintain ecosystem integrity by releasing a steady supply of nutrients into the soil, helping to control populations of forest pests, and limiting stocking levels, thereby reducing resource competition (Agee 1994). Many of the Eastside's plant species have evolved in fire environments and are dependent on fire for germination and recruitment (Kauffman 1990). In addition, stand structural characteristics that are the result of fire provide habitat for a variety of mammals, birds, and other taxa.

The influence and effects of fire vary by community type. In dry forest types, the historic fire regime of frequent, low-intensity burns maintained primarily open stands of old, large-diameter trees (e.g. Agee 1994; Everett et. al. 1994a; Langston in press). Higher-elevation fir-dominated communities have a longer interval historic fire regime. Fires in these types historically often were (and continue to be) intense stand-replacing fires. Moister riparian areas and north slopes are also less prone to frequent fires.

Fire suppression policies over the last century have changed historic fire frequency, intensity, and extent, particularly in Eastside ponderosa pine and mixed conifer communities (Agee 1994). These changes in the fire regime, in conjunction with logging, site conversions, livestock grazing, and other human-caused disturbances, have adversely affected the ecosystem integrity and productivity of some stands. Some formerly open, park-like stands have developed thickets of shade-tolerant firs. In these stands, trees may be stressed from overstocking, potentially increasing susceptibility to attack by insects and pathogens. Where there are abnormally high rates of tree defoliation or mortality, fuel loading can be especially high, potentially contributing to increased incidence of high-intensity, stand-replacing fires that historically did not occur frequently in this forest type.

Although some stands may have abnormally high stocking levels and fuel loads, this condition does not exist uniformly on Eastside forests. In fact, Forest Service data indicate that tree mortality as a percentage of stocking on national forests has not increased in the Interior West and has decreased in the Pacific Northwest over the past four decades (U.S. Forest Service 1992b). In addition, tree mortality, insects, and diseases are natural, essential ecosystem components. Areas of high mortality may provide essential habitat for species which rely on standing and downed dead wood (Hutto in review).

Prescribed fire is a tool for re-establishing the historic fire regime of forests that have been adversely influenced by fire suppression. In addition to reducing fuel loading and continuity, prescribed fire may decrease pest outbreaks, provide germination sites for shade-intolerant species, release nutrients, and create wildlife habitat (Brennan and Hermann 1994). However, there are significant ecological risks associated with its widespread application. These risks are compounded by 1) the lack of information about the effects of various fire intensities on ecosystem components and 2) current fuel conditions which may increase significantly the probability of crown fires in some Eastside forest stands. Ecological damage potentially associated with fires that burn at high-intensity includes: erosion, nutrient loss, loss of duff and soil wood, damage to tree roots (Thomas and Agee 1986), increased susceptibility to bark beetles (Fellin 1979), smoke hazard, and damage from escaped fires. Although managers are beginning to recognize the importance of reintroducing fire, prescribed fire is not used commonly except for removal of slash piles.

STANDARDS AND GUIDELINES

- Prescribed burning should be conducted primarily in areas that are currently outside the historic range of variability for fire frequency (i.e. have missed more than 1 fire return interval). Prescribed burning generally should not be conducted in forest types that have long-interval fire frequencies (> 100 years) and, therefore, have probably not experienced significant ecological change due to fire suppression.

- Priority for prescribed burning should be given to 1) ecologically sensitive areas, such as oak woodlands and native grasslands, that are likely to disappear without fire (Agee 1994), 2) low-elevation or south-facing forests that have been most transformed by fire suppression, 3) areas where landscape-scale benefits of fuels reduction are high, and 4) the environs around developed areas.

- Although prescribed burns should be conducted at the stand-level, they should be planned at the landscape-scale in order to be effective at restoring ecosystem integrity and resiliency (Mutch 1994).

- Prescribed burns should be conducted at frequencies and intensities similar to the natural fire regime.

- Introduction of prescribed fire may need to be carried out in conjunction with pruning of lower limbs, raking litter away from large boles, or thinning treatments that reduce ladder fuels.

- Prescribed burning should be conducted in the fall – the natural fire season – whenever feasible. Spring burning generally is discouraged because of potential damage to soil organisms, depletion of water retention in soils before the summer season, and threats to vulnerable birds and burrowing mammals.

- Managers should plan to re-burn within a ten year period; in moister areas, it may be necessary to re-burn several times to reduce fuels gradually (U.S. Forest Service 1992c).

- Control of prescribed fires should comply with standards and guidelines for fire fighting (as described in Chapter VII).

- No new roads should be constructed for prescribed burning programs.

- Where land ownerships are mixed, federal land management agencies should establish policies to address conflicts between re-establishment of natural disturbance regimes on federal lands and the protection of private property (Beschta et. al. 1995).

- Negative public perception of prescribed burning due to "escaped" fires and reduced air quality should be addressed through public outreach and careful timing of burning so as to avoid significant short-term degradation of air quality.

CHAPTER V: THINNING

OBJECTIVES

The objectives of thinning recommendations as part of an ecologically-based approach to national forest management on the Eastside are to:

- enhance the development of stand conditions that are generally characteristic of each forest type under a natural disturbance regime;
- reduce tree stocking associated with significantly abnormal susceptibility to insects and pathogens;
- reduce fuels that significantly increase the abnormal likelihood of stand-replacing fires;
- encourage the maintenance of older, large-diameter early seral trees; and
- maintain/restore variability at both stand and landscape levels while maintaining wildlife habitat and other ecological values.

Owing to its potential to cause serious environmental damage, thinning should be allowed on public forest lands on the Eastside only when the responsible land management agencies can convincingly demonstrate that proposed treatments are consistent with these objectives, and will comply with the standards and guidelines that follow.

PRINCIPLES

There is an emerging scientific opinion that past forest management and fire suppression policies have led to the development of forests on some Eastside landscapes that are denser and more homogeneous than under pre-settlement conditions (Covington et. al. 1994; Gast et. al. 1991; Henjum et. al. 1994; Lehmkuhl et. al. 1994). The increased density of shade-tolerant trees, particularly in forest types formerly characterized by frequent, low-intensity fires, has been linked to increased risk of insect and pathogen outbreaks (Perry 1988; Hessburg et. al. 1994) and high-intensity wildfires (Arno and Ottmar 1994a). Although increased mortality resulting from these conditions has been postulated as a significant threat to forest productivity, the extent of increased mortality on the Eastside has not been determined adequately. However, U.S. Forest Service summary statistics indicate that tree mortality, as a percent of stocking on national forests, has not increased in the Interior West and has decreased in the Pacific Northwest over the past four decades (U.S. Forest Service 1992b). Although some concern has been expressed over their reliability (W. Brad Smith, U.S. Forest Service, Washington, D.C., personal communication 1995), these data suggest that the need for thinning is relatively limited and non-urgent.

Silvicultural thinning is being advocated by some as a tool to facilitate the development of forest conditions that more closely resemble those that would occur under a natural disturbance regime (Hessburg and Everett 1994), reduce risks of catastrophic loss (Mason and Wickman 1994; Harvey 1994), and facilitate the reintroduction of fire as an integral ecosystem process (Mutch et. al. 1993; Arno and Ottmar 1994b). Although thinning within the context of intensive forestry is not new, its efficacy as a tool for ecological restoration is controversial and largely unsubstantiated. Very little empirical research has investigated the impacts of thinning treatments on a wide array of ecosystem components and processes and on differing forest types. However, anecdotal evidence and at least one empirical study (Weatherspoon and Skinner in press) suggest that stand density reduction through harvest treatments may not result in lower fire damage or risk and, in fact, may exacerbate fire damage. Conventional thinning operations may have little damping effect on fire behavior, given that the reduction of fine fuel (≤ 3" diameter) levels are typically not the objective of treatment.

Although our current understanding of the ecological effects of thinning is incomplete, available evidence indicates that thinning operations, even when properly conducted, can result in significant adverse ecological impacts, including:

- reduced habitat quality for sensitive species associated with cool, moist microsites or closed-canopy forests

(FEMAT 1993);
- damage to soil integrity through increased erosion and compaction (Harvey et. al. 1994; Meurisse and Geist 1994);
- increased mortality of residual trees due to pathogens and mechanical damage (Hagle and Schmitz 1993; Filip 1994);
- creation of sediment that may eventually be delivered to streams (Beschta 1978; Grant and Wolff 1991);
- increased near-term fire hazard (Fahnestock 1968); and
- dependence on an excessive number and density of roads (Henjum et. al. 1994; Megahan et. al. 1994).

Given the potential for serious adverse ecological impacts, many scientists have indicated that previously managed areas are the highest priority for thinning and other treatments, at least until the presumed benefits of these actions can be better documented (Henjum et. al. 1994; Perry 1994a). The approach to thinning described here is designed to accomplish the presumed benefits associated with this practice while minimizing ecological risks by focusing first on identifying areas where thinning treatments are appropriate (or not) from a landscape perspective, and then establishing management guidelines that would ensure retention of important structure at the stand level.

STANDARDS AND GUIDELINES

Thinning should be prohibited in the following types of areas:

- roadless areas ≥ 1,000 acres (inventoried RARE II and uninventoried) and in smaller ecologically significant roadless units (Henjum et. al. 1994);

- old-growth stands, except where it can be conclusively demonstrated that treatment is necessary to protect the stand's ecological integrity;

- riparian protection zones, as defined in Chapter II above or by the FEMAT (1993) and the National Marine Fisheries Service (1995a), and immediately adjacent to these zones in areas that have a moderate to high risk of slope instability or are prone to windthrow;

- slopes steeper than 30% on pumice soils and 60% on other soil types (Henjum et. al. 1994);

- sensitive areas associated with poor/unstable soils, unproductive sites, or low regeneration potential (Henjum et. al. 1994);

- watersheds that exceed cumulative effects thresholds and are therefore in a presumptively unstable condition (Isaacson 1986);

- sites where other potentially incompatible management objectives (e.g. providing for specific wildlife habitat needs) take precedence; and

- forest types that have not been affected significantly by fire suppression, including 1) higher-elevation forests dominated by Engelmann spruce, subalpine fir, whitebark pine, and subalpine larch and 2) wet-site forests dominated by western hemlock, western red cedar, and western white pine.

Thinning should be allowed in the following types of areas:

- forests that are in the stem exclusion stage of stand development (Johnson et. al. 1994), with priority given to dense stands of shade-tolerant species that are accessible by existing road systems;

- tree plantations;
- stands most altered as a result of fire suppression (e.g. south-facing slopes, lower-elevations);
- stands previously managed through partial overstory removal; and
- sites within 1/4 mile of human settlement areas (i.e. wildland/settlement interface).

Thinning should be allowed only after the prescribed fire option has been scientifically considered and determined to be unfeasible.

In areas proposed for thinning:

- Retain all living or dead trees older than 100 years or with a diameter at breast height (DBH) of 15 inches or greater (Wickman 1992; Bull 1994; Henjum et. al. 1994).
- Determine an upper diameter limit criterion for stands where the 15 inch standard will not ensure the retention of the largest cohort of overstory trees. In uneven-aged stands, retain all trees larger than the mean diameter in the stand (quadratic mean diameter). In even-aged stands with less variability in size, retain all trees larger than 5% over the quadratic mean diameter.
- Retain at least 40% of the stand's basal area. The maximum basal area retention should vary according to the productivity of the site (as measured by site class) and by forest type (Henjum et. al. 1994; Beschta et. al. 1995).
- Retain at least 20% or more (depending on site-specific wildlife habitat needs) of the area considered for treatment in an unthinned condition. Retention of some dense areas provides important structural diversity, wildlife cover, and undisturbed soil/understory conditions within managed stands. The exact percentage and location of untreated areas should be determined on a site-specific basis to maximize their effectiveness in meeting ecological objectives. Treated areas should include both small/dispersed (≤ 1/8 acre) and large/aggregated (≥ 5 acres) unthinned patches (FEMAT 1993).
- Retain all dominant and co-dominant trees of early seral species, and favor the selective removal of the small-diameter (≥ 9" DBH), suppressed, shade-tolerant, understory trees that have become established as a result of fire suppression and past logging practices (e.g. true fir).
- Retain all existing components of the forest's diversity, including trees with atypical crown architecture, snags, hardwoods, number of canopy layers, and down logs. Thinning should not reduce existing conditions for these attributes and, where found to be inadequate, should facilitate their development.
- Retain sufficient levels of large coarse woody debris ("CWD") to maintain site productivity and provide for wildlife habitat needs. Specific levels of material to be retained should vary according to site class and forest type, but thinning should not reduce levels below those recommended by Graham et. al. (1994). These levels should be considered minimums, and, as the authors note, many areas may benefit from higher levels. On sites where CWD is inadequate or absent, appropriate numbers of down trees should be left on the forest floor.
- Plan thinning treatments at the landscape-scale, as opposed to stand by stand (Perry 1994a). A relatively small portion of the landscape should be treated in a single operation; where treatment of larger areas is warranted, managers should stagger successive thinnings over time to achieve ecological objectives.

- Physically remove from the site slash and other unmerchantable material generated as a result of thinning or, if this is not feasible, burn under strictly defined conditions that minimize potential damage to soils and other resources. Where appropriate, thinning should be followed by the reintroduction of prescribed fire (as described in the previous chapter).

- Survey for rare, sensitive, threatened, and endangered species before any ground-disturbing activities take place. Particular attention should be directed at plants (vascular and non-vascular), lichens, fungi, mollusks, amphibians, and non-volant mammals (as per FEMAT 1993). Lists of species requiring surveys should be developed for each national forest, building from those developed by state Natural Heritage Programs, and the analysis of the Interior Columbia Basin Ecosystem Management Project's Scientific Integration Team. Any sites where rare species that are known to be sensitive to human-caused disturbances are located should be protected.

- Ensure that guidelines for protection of soil integrity (described in Chapter VIII) are met. Thinning prescriptions should minimize compaction and disturbance of the soil surface organic layer. Ground-based skidding should be generally prohibited, unless it can be conclusively demonstrated that soil integrity will be protected (Beschta et. al. 1995).

- Utilize existing road systems and landings. No new permanent or temporary roads should be constructed to facilitate silvicultural thinning operations. Analysis associated with potential thinning projects should determine the need for undertaking maintenance, improvement, or obliteration of road segments that pose a threat to watershed integrity (Henjum et. al. 1994; Beschta et. al. 1995).

- Develop and implement a comprehensive monitoring program to evaluate the effects of various practices under different conditions, and determine to what extent thinning activities are meeting ecological objectives. Conservative (i.e. low risk) experimentation of various silvicultural techniques and treatments should occur only in previously logged areas. Thinning guidelines should be revised to reflect new information, using an adaptive management approach (FEMAT 1993).

CHAPTER VI: POST-DISTURBANCE LOGGING

OBJECTIVES

The objectives of management recommendations for post-disturbance logging are to:

- address the major ecological consequences of removing "dead and dying" trees;
- identify areas where post-disturbance logging should be prohibited; and
- establish standards and guidelines for avoiding long-lasting and significant ecological damage to post-burn stands from logging.

PRINCIPLES

Removal of "dead and dying" trees from forest ecosystems is a controversial and multi-faceted topic. Removal of isolated or scattered dead trees should be subject to the same considerations as other logging and is not separately addressed here. This chapter focuses on non-incidental removal of "dead or dying" trees. Although such logging is sometimes subjected to less stringent standards than green-tree logging, the reverse should be true.

Post-disturbance silvicultural treatments are frequently referred to as "salvage" logging. However, "salvage" is neither an ecological nor a silvicultural term. It is primarily a word of economic, social, and political import. It has been applied to a wide variety of logging activities and used interchangeably with terms such as "sanitation," "recovery," and "forest health." In spite of the various terms associated with its use, the objective of salvage logging is timber extraction for economic purposes. Some current definitions of salvage (e.g. H.R. 1158, the Supplemental Appropriations and Rescissions Act of 1995) are expansive enough to allow salvage logging on most, if not all, Eastside federal lands.

Recently, justifications other than economics have been advanced to support post-disturbance logging; these justifications include reduced fire and insect/disease hazards, decreased erosion, and improved revegetation rates (Barker 1989; Poff 1989). However, current understanding of Eastside ecosystems and data from past salvage projects do not provide a scientific basis for aggressive post-disturbance management. In fact, no credible scientific studies have presented strong evidence justifying or supporting logging as a means of restoring ecosystem integrity. However, significant scientific evidence demonstrates that persistent, adverse impacts can and do result from this practice. These impacts include:

- loss of snag and down log habitat required by many wildlife species (Thomas 1979; Bull 1994) and soil organisms (Amaranthus et. al. 1989);
- increased soil erosion and compaction (Klock 1975; Marton and Hare 1990);
- creation of warmer, drier microclimatic conditions, and thereby increased future fire hazard (Countryman 1955; Rothermal 1983);
- simplification of forest structure (FEMAT 1993);
- loss of important sources of nutrients and organic material, with the concomitant reduction of long-term productivity (Jurgensen et. al. 1990; Graham et. al. 1994);
- reduced reforestation success (Garrison and Rummell 1951); and
- increased spread of non-native plants into burned areas (Harrod 1994).

Other post-disturbance practices, particularly active planting and seeding of non-native species, also have been shown to be detrimental (Taskey et. al. 1989; Amaranthus et. al. 1993). In short, by removing important structures and exacerbating stresses caused by natural disturbance, post-disturbance logging and other management activities impair the ability of ecosystems to recover (Beschta et. al. 1995).

A conservative (i.e. non-manipulative) approach to post-disturbance management is clearly warranted for Eastside landscapes. This approach should emphasize natural recovery. Although there may be some circumstances under which removal of dead trees provides ecological benefits, few, if any, such circumstances have been substantiated or experimentally demonstrated. Any claims of ecological benefits of such removal would require strong scientific evidence, given the 1) heightened susceptibility of post-disturbance stands to degradation from logging, 2) the frequent occurrence of unanticipated adverse ecological consequences of logging these stands, and 3) the large number of poorly documented rationales for such logging.

Given the significant adverse impacts involved, post-disturbance logging should be subject to stronger restrictions and environmental review procedures than those governing other logging and management activities. Additional guidelines are necessary because 1) post-burn soils are generally more sensitive to degradation than other soils, all else being equal (Perry 1995) and 2) protection of post-burn habitats may be critical for maintaining viable populations of species that rely on snags and coarse woody debris (Hutto in review) or are sensitive to watershed degradation (Beschta et. al. 1995). Post-disturbance logging of Eastside public lands should be permitted only under strictly defined conditions, applying the standards and guidelines outlined below.

STANDARDS AND GUIDELINES

Post-disturbance management should be prohibited in the following types of areas:

- roadless areas ≥ 1,000 acres (inventoried RARE II and uninventoried) (Henjum et. al. 1994; Beschta et. al. 1995);
- old-growth stands;
- riparian protection zones, as defined in Chapter II above or by FEMAT (1993) and National Marine Fisheries Service (1995a);
- slopes steeper than 40% (Henjum et. al. 1994; Beschta et. al. 1995);
- areas with poor/unstable soils, low productivity, low regeneration potential, and accelerated erosion potential (Henjum et. al. 1994; Beschta et. al. 1995);
- disturbed areas smaller than 100 acres (FEMAT 1993);
- high-intensity burned areas (i.e. with litter destruction) (Beschta et. al. 1995);
- areas where it cannot be convincingly demonstrated that recovery will be impaired or prevented without intervention (Beschta et. al. 1995); and
- areas where other potentially incompatible management objectives (e.g. specific wildlife habitat needs) take precedence.

In areas where post-disturbance management is allowed:

- All live trees should be retained (Beschta et. al. 1995).
- All trees greater than 20" DBH or older than 150 years (Henjum et. al. 1994; Beschta et. al. 1995) should be retained. Where trees of this size/age are not present, trees in the largest size class should be retained.
- Selective removal of small-diameter (≤ 7" DBH) trees which act as fuels and increase fire hazard should be

emphasized.

- At least 50% of standing dead trees in each diameter class should be retained (Beschta et. al. 1995).

- At least 20% of the area considered for treatment in an unlogged condition should be retained. Retention of unlogged areas provides important structural diversity, wildlife habitat, and undisturbed soil/understory conditions within logged areas. The exact percentage and location of unlogged areas should be determined on a site-specific basis to maximize effectiveness in meeting ecological objectives, but should include both small/dispersed (≤ 1/8 acre) and large/aggregated (≥ 5 acres) unsalvaged patches (FEMAT 1993).

- Levels of coarse woody debris ("CWD") needed to maintain site productivity and provide for wildlife habitat needs should be retained. Specific levels of material to be retained should vary according to site class and forest type, but should not be reduced below those recommended by Graham et. al. (1994). These levels should be considered minimums, and, as the authors note, many areas may benefit from higher levels. On sites where CWD is inadequate or absent, appropriate numbers of down trees should be left on the forest floor.

- Helicopter or full-suspension cable logging systems should be employed in a manner that minimizes soil disturbance and runoff. Use of existing landings should be maximized. Conventional ground-based logging systems should be prohibited, unless it can be conclusively demonstrated that soils would be protected (Henjum et. al. 1994; Beschta et. al. 1995).

- Existing road systems should be utilized. No new roads (permanent or temporary) should be constructed to facilitate salvage logging operations in roadless areas, riparian protection zones, and other sensitive areas. Outside of these areas, road-building should be prohibited except where new road construction may be necessary to complete a larger program of partial or complete road obliteration (Henjum et. al. 1994; Beschta et. al. 1995).

- Seeding and planting non-native species in disturbed areas should be avoided. Seeding should be employed only under strictly defined conditions where presumed benefits associated with this practice have been demonstrated (e.g. on roadbeds) or where there are several years of evidence that natural revegetation is not occurring. Only native species and local seed sources should be used for restoration. Seeding should be done in such a way to allow natural recolonization (Beschta et. al. 1995).

- Livestock grazing should be prohibited in disturbed areas unless it can be conclusively demonstrated that livestock will not impede natural recovery, introduce non-native plants into previously uncolonized areas, or further degrade the site.

CHAPTER VII: FIRE FIGHTING

OBJECTIVES

The objectives of the following fire fighting standards and guidelines are to:

- minimize ecological damage associated with fire fighting efforts;
- determine areas where wildfires should not be actively fought; and
- allow protection of human life and property.

PRINCIPLES

Fire suppression should not be a goal of forest management except when human life or private property is at stake (Beschta et. al. 1995). Although fire, especially when burning at high-intensity, can have significant ecological impacts (see Chapter IV), fire is an inevitable and ecologically essential process in Eastside forests. Instead of aiming to eliminate fire from the landscape, managers on the Eastside should focus on restoring ecologically beneficial fire regimes over time.

The natural fire cycle has maintained ecosystem integrity by reducing tree densities, maintaining low fuel loadings, controlling outbreaks of some forest pests, maintaining wildlife habitat, and triggering nutrient release. Fire suppression policies and past timber management practices on federal forest lands have resulted in increased risk of fire and insect/disease hazard on some types of stands. Fire fighting not only continues to reinforce abnormal fire regimes, but also directly causes significant ecological damage, including de-watering of small streams and lakes and increasing soil erosion through the construction of fire lines. Fire fighting activities are also extremely expensive, both in terms of dollars (Philp 1994) and human lives (see Milstein 1994). Despite substantial investments of financial and human resources, many fires are not successfully controlled or extinguished by fire fighting efforts; instead, they are extinguished when the weather changes. Because fire fighting can have significant adverse ecological impacts (Mohr 1992), there is a need for more careful decision-making concerning the circumstances under which fire fighting should legitimately take place. Important factors for consideration include threats to life and property, probability of success, and potential adverse ecological consequences of both the fire and fire fighting efforts.

Many of the dollars spent on fire fighting should be transferred to a prescribed fire fund for large-scale fire prevention. This fund should be used for landscape-scale programs to conduct low-intensity prescribed fires (see Chapter IV). To the extent that the restoration of fire and resultant fuels reduction takes place, fire suppression activities aimed at protecting human resources will become more successful and cost-effective.

STANDARDS AND GUIDELINES

Fire suppression activities should be conducted only when absolutely necessary and with utmost care for the long-term integrity of the ecosystem and the protection of natural recovery processes. Specifically:

- Fire fighting activities should be conducted only where human life, property, or irreplaceable biological resources are at stake.

- Active fire suppression should not be permitted in wilderness areas.

- Fire fighting activities should not be conducted when natural fire barriers, such as bodies of water or rocky ridges, are likely to extinguish the fire.

- Fire fighting efforts should use "light hand" tactics (see Moody and Mohr 1991).

- Fire fighting activities should avoid using surface water from small streams and lakes. Pumping from lakes and streams increases the risks to aquatic ecosystems from post-fire events and generally has not proven effective in fire suppression. When pumping must be utilized, it should be conducted from sufficiently large rivers and lakes such that effects on aquatic biota are negligible (Beschta et. al. 1995).

- Fire fighting activities should be conducted in ways that avoid damaging riparian ecosystems. Bulldozing stream channels, riparian areas, wetlands, or sensitive soils on steep slopes or using such areas as access routes for vehicles and other ground-based equipment should be prohibited.

- Fire fighting activities should be conducted in ways that avoid soil disturbance. Natural firelines such as meadows, streams, and rocky areas should be used wherever possible. Fire lines created by mechanical equipment should not be permitted in stream channels, riparian areas, wetlands, sensitive soils on steep slopes, old-growth forests, roadless regions, and other ecologically sensitive areas (Beschta et. al. 1995). Construction of plowed fuel-breaks should be prohibited in roadless areas, old-growth forests, and other critical habitat types.

- Construction of helicopter landings should occur only when natural openings within walking distance are not available (Mohr 1992).

- Trees and snags should not be cut during fire fighting activities, unless they pose an unavoidable threat to human life or property. Burning trees should not be cut unless they pose a clear hazard, as these trees may survive the burn. In addition, they provide important wildlife habitat regardless of whether they survive. Hazard tree criteria should be based on 1) the species of the tree, as some species can withstand more bole consumption than others and 2) location of the tree with respect to existing roads and property at risk of damage if the tree falls (Mohr 1992).

- Fire fighters should be held accountable for their conduct when working and camping on public lands. Low- or no-impact camping practices should be followed. Vegetation clearing around campsites should not be permitted (Mohr 1992). Fire camps should not be located on areas subject to compaction.

- Fire training courses should emphasize low-impact tactics (see Moody and Mohr 1991). Individuals without low-impact training should not be allowed to fight fires on federal lands.

- Fire fighting efforts and crews should be evaluated and rated based on performance (Mohr 1992). Crews which do not follow low-impact tactics should be reprimanded and, for repeal failures, removed from future efforts.

- Wildfire management planning should be coordinated with prescribed fire plans and activities to optimize the efforts of each fire management component.

- Policies should be developed to reduce the number and density of human structures within areas with high potential for wildfires. Construction of new structures should be discouraged in fire-prone areas (Beschta et. al. 1995). Efforts should be made to educate the public about land owner risks and responsibilities in fire-dominated landscapes.

- Wildfire management strategies should be developed, proposed, and offered for public comment, with a Record of Decision following, similar to other agency actions.

CHAPTER VIII: SOIL CONSERVATION

OBJECTIVES

The objectives of the following soil conservation management recommendations are to maintain and restore the productive capacity of soils, considering the full range of ecological roles soils play:

- providing critical nutrients to support primary productivity of terrestrial systems;
- influencing quality, quantity, and flows of water in aquatic systems; and
- contributing to both biological diversity and biological integrity.

PRINCIPLES

"The importance of soil to forest productivity and health cannot be overstated." (Perry 1994b). Variations on this fundamental premise are a common refrain in the literature and agency documents, but it is a recitation all too frequently violated in practice. Management standards and practices must be developed that recognize not only the central importance of soils, but also their vulnerability to degradation and, given the intensity of disturbance, the often very long time required to recover soil function and integrity.

Management activities must comply with existing law and principles of ecosystem-based management. For instance, the Multiple Use Sustained Yield Act of 1960, Section 4(a) addresses the need for "...coordinated management of the various resources, *...without impairment of the productivity of the land*...," and the National Forest Management Act (Section 5(C)) recognizes "the fundamental need to *protect and where appropriate, improve the quality of soil*, water, and air resources." These laws are reflected in the first "basic principle" in former Forest Service Chief Robertson's guidance on Ecosystem Management: "Take [C]are of the [L]and by *protecting or restoring the integrity of* its *soils*, air, waters, biological diversity, and ecological processes." (emphasis added) (Robertson 1992). None of these laws or principles allow for reduction in soil productivity or integrity.

Current standards typically either set limits on soil compaction and disturbance (commonly 20%) or call for soil disturbance to be "minimized." Both are untenable. The 20% standard was chosen on the basis of perceived operational practicality and is not soundly based either on science or the law. Similarly, an admonition to minimize damage can only be based on a set of assumptions about levels and kinds of activities that are to occur, for instance that a certain level of resource extraction is going to be accomplished using particular equipment and techniques. Ecosystem-based management, however, should be based on assumptions about ecological capacities, such as the maintenance of soil nutrient cycling rates or productivity, that then can be used to set limits on management activities, not vice versa.

Perhaps the most obvious needs relative to soils are to avoid management-induced erosion, nutrient losses, and mass wasting. Lost soil represents lost productivity. Soil that reaches streams reduces water quality and, in excess of background levels, typically degrades aquatic habitat values. Less obvious issues may be of equal concern, however, such as the maintenance of soil quality, which can be considered in terms of structure, organic matter, and food webs. Even subtle degradation of these soil attributes can reduce resiliency, reduce the ability of the soil to hold nutrients, and leave soils more vulnerable to further damage (Childs et. al. 1989).

The most prevalent soil disturbances on Eastside public lands include road-building, logging, grazing, fire suppression, fire, mining, and motorized recreation. The effects of these disturbances are mediated through their effects on the closely interrelated attributes of soil structure, soil organic matter, and soil biological activity; effects on any one of these soil attributes will be reflected in the others.

Two recent references that provide excellent overviews of soil ecology and management issues are Perry et. al. (1989) and Harvey et. al. (1994). Some selections from the latter publication can help to articulate and reinforce the highly complex and integrated nature of soils and the landscapes they influence.

> "Contemporary studies indicate that soil quite literally resembles a complex living entity, living and breathing through a complex mix of interacting organisms – from viruses and bacteria, fungi, nematodes, and arthropods to groundhogs and badgers. In concert, these organisms are responsible for developing the most critical properties that underlie basic soil fertility, health, and productivity. Biologically driven properties resulting from such complex interactions require time lines from a few to several hundreds of years to develop, and no quick fixes are available if extensive damages occur.
>
> "Thus, maintaining structure is critical to soil productivity and sustainability, and because the processes are dynamic, they require a constant high rate of carbon input, conversion, and loss.
>
> "The relation between forest soil microbes and [nitrogen] is striking. Virtually all [nitrogen] in eastside forest ecosystems is biologically fixed by microbes.... Thus, to manage forest growth, we must manage the microbes that add most of the [nitrogen] and that make [nitrogen] available for subsequent plant uptake.
>
> "To maintain ecosystem productivity and sustainability, soil quality must be maintained." (Harvey et. al. 1994).

Soil structure is characterized by aggregates of mineral soil, soil organisms and organic matter, and the pores created by this aggregation. Aggregate surfaces are key sites of biological activity, and pores allow for the exchange of gases and the movement of water, nutrients, and organisms. Compaction of soil by ground-based logging equipment or livestock reduces pore space and kills soil organisms responsible for nutrient cycling. At higher pressures (or more vulnerable conditions such as high soil moisture levels), soil compaction causes the breakdown of soil aggregates. While porosity, living space for soil organisms, and aggregate structure are key ecological considerations, management effects are typically considered in terms of changes in volume, bulk density, soil strength, and resistance to penetration. Although compaction is one of the more explicit objectives pertaining to soils in current forest plans, standards are often violated (Public Forestry Foundation 1995). Compaction is widespread in Eastside soils, and there is ample evidence that compaction causes decreased productivity for terrestrial vegetation and soil organisms (Childs et. al. 1989) and adversely affects flows and quality of water (Henjum et. al. 1994). Observed and projected times to recover from compaction range from several decades to many hundreds of years.

Ripping, tilling, and subsoiling have been used in attempts to restore of compacted soils. Although such efforts may contribute to hastening recovery of permeability, they are costly, may adversely affect soil food webs, and thus nutrient cycling in forest soils (Ingham 1994), and have not been demonstrated to restore soil structure, function, or integrity.

Soil Carbon and Coarse Woody Debris ("CWD")

Soil carbon is especially important for soil water retention, cation exchange, nutrient cycling, and erosion control (Page-Dumroese et. al. 1991). Soil carbon can be influenced by removal through harvest or fire or through disruption and mixing during logging and site-preparation activities.

Recommendations for retention of CWD found in Graham et. al. (1994) (see also Chapter VIII) should be considered absolute minimums for areas where analysis has shown a need for removal of trees and/or logs. These levels are not a target for all lands, and as the authors note, many areas and species benefit from higher levels of CWD. Standards should be developed to ensure retention of sufficient carbon – in all size classes – to support long-term levels of this nutrient in litter and surface soil layers. Risks of possible damage to soils from wildfire must be carefully weighed against risks of soil degradation from reduction in CWD and other adverse effects from CWD removal activities.

Soil Organisms and Food Webs

Although the importance of soil organisms is widely recognized, consideration of these organisms has not substantially entered into forest management. Recent work by Ingham and others suggests that measurements such as the ratio of fungal to bacterial biomass and the Maturity Index for nematodes may be useful indicators of soil health (Ingham 1994). In a paper currently in review for *Applied Soil Ecology*, Ingham and Thies show that clearcutting can reduce fungal biomass in forest soil by 10-fold, which is, by itself, a significant loss of carbon. Results from a more recent work by Ingham, not yet submitted for publication, indicate that the loss of the fungal component in forest soils can prevent the regeneration of conifer seedlings in that soil. Development and refinement of inventorying and monitoring methods that incorporate measures such as these should be vigorously pursued.

Fertilizers often have unpredictable adverse effects on soil food webs and, therefore, their use must be considered somewhat risky (Harvey et. al. 1994). Especially in grassland areas, fertilizers have been shown to enhance the vigor and abundance of weed species instead of native plants, leading to site degradation (Ingham et. al. 1986a and 1986b).

Microbiotic Crusts

Microbiotic crusts (also known as cryptobiotic or microphytic crusts) are a group of soil organisms requiring special recognition and management consideration. These living crusts play particularly crucial roles on the Eastside, mediating key processes of soil stabilization, soil fertility, soil moisture, and establishment of vascular plants. They are also particularly susceptible to damage from physical disturbance (Kaltenecker and Wicklow-Howard 1994; Williams 1994) (see also Chapter IX).

STANDARDS AND GUIDELINES

Logging and Mining

Areas prone to shallow landslides (i.e. debris torrents) or erosion should be identified and timber harvest should not be permitted on such sites unless "...peer-reviewed scientific study conclusively demonstrates that harvest does not degrade the soils or release sediment to streams." (Henjum et. al. 1994).

On areas prone to surface soil erosion, adequate surface cover (i.e. litter) should be maintained to resist erosive forces following completion of all harvest, post-harvest, and fuel treatment activities.

Ground-based logging equipment should not be employed on slopes greater than 30%, and exposure of mineral soil should be minimized where aerial systems are employed (retain at least 80% of the duff layer intact).

"Do not log or mine on fragile sites until peer-reviewed scientific study conclusively demonstrates that soil integrity is protected and that forest regeneration after logging is assured." (Henjum et. al. 1994). Such sites should be defined and delineated. Examples of fragile sites include: lava fields, low-elevation forest sites transitional to grasslands or desert shrublands, high-elevation forests, wetlands, areas with high water tables, and frost pockets.

On ash soils, heavy ground equipment should be used only under operational conditions that ensure that compaction will not occur. Low-impact ground equipment is likely to be acceptable only if it can be conclusively demonstrated that no associated compaction or loss of topsoil will follow (after Henjum et. al. 1994).

Mining plans must ensure compliance with the Clean Water Act, and should incorporate standards to ensure maintenance or re-establishment of soil microbial and fungal components to support revegetation.

Compaction

Ripping is not an appropriate method of treating compacted soils; subsoiling may be carefully used to attempt to rehabilitate previously compacted areas but should not be prescribed as mitigation to offset compaction from planned management activities.

Compacted areas, including roads, skid trails, landings, developed recreation sites, and recreational trails should be considered as permanent dedication of land to non-productive uses. While such allocations may be necessary for multiple use objectives, they reduce ecosystem productivity, and should be kept to an absolute minimum. On both an activity and a sub-watershed basis, the maximum amount of land allowed to be dedicated to these uses should be less than 10%. Compaction of soils should not be permitted otherwise.

Fertilizers

Using fertilizers to accelerate tree growth generally should be prohibited. Fertilizers should be allowed only when necessary to restore heavily degraded soils or to establish vegetation on highly disturbed sites such as road cuts. Measures should be taken to keep fertilizers out of streams. Potential use of biosolids (sludge) should be explored and limited experimental tests conducted.

Off-Road Vehicles ("ORVs")

Use of off-road vehicles should be carefully monitored and restricted to designated roads and trails (after Kaltenecker and Wicklow-Howard 1994). ORV trails should not be located in or allowed to adversely affect riparian and wetland areas. If such measures cannot be effectively enforced, ORVs should be prohibited.

Inventory and Monitoring

Degradation of Eastside soils has occurred, in part, due to failure to enact adequate operational standards, but also due to failure to meet existing standards, failure to monitor adequately implementation and effectiveness, failure to respond adaptively to results of monitoring, failure to inventory adequately conditions prior to activities, and failure to establish adequate reference or control areas. The Eastside Environmental Impact Statement should ensure that activities that potentially may degrade soils or soil food webs will be undertaken only after inventory and monitoring plans have been established, funding for these activities has been assured, systems of accountability (including line officer performance elements) have been established to ensure that these activities take place, and policies to hold management accountable to respond to the results of monitoring have been established.

Restoration

Restoration priorities should be established based on the inherent productive potential of soils, the degree of degradation, and the degree of urgency and ecological importance of the area. Such priorities should be established in the context of watershed-level restoration plans (see Chapter II).

CHAPTER IX: LIVESTOCK MANAGEMENT ON FORESTS AND GRASSLANDS

OBJECTIVES

The objective of grazing management recommendations is to re-establish natural disturbance regimes and ecosystem processes on low- and mid-elevation forests, alpine and riparian meadows, grasslands, and shrub-steppe of the Eastside by managing and, where necessary, eliminating disturbances by domestic livestock in sensitive landscapes and communities. Restoration and maintenance of natural disturbances and ecosystem processes are critical for restoring ecological integrity to these ecosystems.

PRINCIPLES

Native herbaceous species are not adapted to intense grazing pressure.

Native herbaceous species of the Eastside did not evolve under intense grazing from large mammalian herbivores (Stebbins 1981; Mack and Thompson 1982). As a result, native species are not adapted to grazing and trampling by exotic livestock. After a century of livestock grazing, Eastside native herbaceous species have been severely depleted in number or driven locally extinct. Their loss exposes plant communities to increased erosion and invasion by introduced weedy species (see Chapter X). Once introduced, these weedy species often form monoclone communities that can exclude native species permanently.

Historic upland forest structure and disturbance regimes are required for forest ecosystem stability.

Forest structure, species composition, and disturbance regimes that approximate pre-settlement conditions are more likely to produce stable, productive, resilient ecosystems (see Belsky and Blumenthal 1995 for supporting scientific literature and discussion). In some forest types, livestock grazing and trampling, changes in fire frequency, and logging have led to the development of dense thickets. These stands have lost their resiliency to traditional and human-caused disturbances.

In most of the low- and mid-elevation interior forests, early Euro-American settlers found open, park-like stands dominated by fire-resistant ponderosa pine, western larch, and Douglas-fir and underlain by dense swards of grasses, sedges, and herbs. This open forest structure appears to have been stable over long periods of time. Two key environmental factors – dense grass swards and recurrent cool fires – were responsible for this stability:

<u>Dense grass swards</u>. Forest understories were dominated by bunch grasses such as Idaho fescue, bluebunch wheatgrass, and Sandberg's bluegrass in xeric habitats and by pinegrass and elk sedge in mesic habitats. These grasses and sedges formed dense swards that were critical to the formation of park-like forest structure because they:

> a) reduced conifer recruitment by competing with tree seedlings for water and nutrients. Conifer seedlings can rarely out-compete vigorous grasses, which have dense, shallow root systems. As a result, fewer conifers become established in understory communities dominated by dense populations of grasses and sedges than in communities where the herbaceous layer has been grazed and trampled by domestic livestock;
>
> b) formed fine fuels that carried cool ground fires through forests;
>
> c) stabilized soil surfaces with their dense roots, preventing loss of top soil and erosion on steep mountainous slopes; and
>
> d) prevented invasion by alien weeds.

Recurrent cool fires. Low-intensity fires swept through open ponderosa pine and mixed conifer forests of eastern Washington, Oregon, and Idaho every 5-38 years (Belsky and Blumenthal 1995). The low-elevation forests of the Blue Mountains, for example, burned on average every 10 years (Hall 1976). These fires were important in that they:

> a) thinned regenerating conifer stands, preventing establishment of dense stands of saplings. In the absence of fire, heavy conifer regeneration can develop into dog-haired thickets that become stressed during hot summers and periods of drought. Stressed trees are vulnerable to pests, parasites, and disease organisms, and suffer high mortality. As trees die, fuel loads build up in forests, making them vulnerable to hot, destructive fires;
>
> b) removed dead and dying trees and litter, reducing the fuel load before it became so high as to turn low-intensity fires into stand-replacing conflagrations;
>
> c) removed diseased trees that might otherwise have acted as loci of infection for the rest of the forest; and
>
> d) thinned young trees so that hot fires were less likely to spread.

Cryptobiotic crusts are critical components of arid-land ecosystems.

Cryptobiotic (also known as cryptogamic or microphytic) crusts are composed of mosses, lichens, green algae, and cyanobacteria that originally covered soil surfaces in arid grasslands, shrub-steppe, and dry ponderosa pine woodlands. They are important components of sustainable arid-land ecosystems in that they fix nitrogen, increase soil carbon levels, improve soil fertility, improve water infiltration, lower albedo, and stabilize soils (see Williams 1994 for references). When these fragile crusts are destroyed by trampling by cattle and sheep, which occurs under even light grazing regimes, soil fertility declines, overland flow of rainwater increases, and soils erode. Similar disturbances to cryptobiotic crusts by native ungulates is rare because native species tend not to congregate for long periods in one place. The loss of the cyanobacteria and lichens is especially damaging to arid Eastside ecosystems because, without a source of fixed nitrogen, soil nitrogen levels decline, encouraging the dominance of trees and shrubs such as western juniper and rabbitbrush, which can tolerate lower soil nitrogen levels than grasses and forbs.

Herbaceous litter is a critical component of arid-land ecosystems.

Livestock grazing reduces the biomass of plant litter that is necessary to 1) insulate grass meristems from freezing in winter and desiccation in summer, 2) insulate the soil surface from freezing in winter and losing water in the summer (i.e. mulch), and 3) add organic matter to the soil. As a consequence, removal or reduction of litter due to livestock grazing reduces plant survival, growth, and productivity (Facelli and Pickett 1991; Willm et. al. 1993; Belsky and Blumenthal 1995).

On the Eastside, reduction or removal of herbaceous litter causes grass and other low-statured plants to be more vulnerable to cold, wet winters and hot, dry summers. The bunchgrass growth-form may have evolved in response to these conditions since it is prevalent in northern temperate, arctic, and alpine ecosystems (Mack and Thompson 1982). In fact, loss of bunchgrass communities and reductions in bunchgrass abundance in Eastside ecosystems may result, in part, from livestock reductions of litter and standing dead biomass.

The incorporation of litter into soils and the importance of soil organic matter is discussed in numerous textbooks on soils (e.g. Buckman and Brady 1969). The importance of litter on the soil surface in preventing freezing of soils and impedance of water infiltration is discussed in the Interior Columbia Basin Ecosystem Management Project ("ICBEMP") assessment of western juniper by Eddleman et. al. (1995).

Livestock trampling disturbs soils and causes erosion.

The effects of livestock on soils in grasslands, shrub steppe, and desert communities have been thoroughly described (see Fleishner 1994, numerous range ecology textbooks, and most issues of *Journal of Range Management*). In short, livestock 1) destabilize topsoils by reducing the areal cover of cryptobiotic crusts, litter, and herbaceous plants, 2) disturb the soil and dislodge soil particles and rocks with their sharp hooves, and 3) compact the soil, reducing water infiltration and increasing overland flow. As a result, plant productivity declines, topsoil is lost, and erosion increases. Erosion not only degrades the area from which the soil is lost, but degrades downslope areas, especially wetlands, riparian areas, and streams. The eroded material reduces water quality for human consumption and damages wildlife and fish habitat. Increased runoff resulting from reduced water infiltration increases flooding, increases the kinetic energy of water and therefore its erosive ability, and reduces the amount of water available for late-season flow. Although the effects of livestock on forested soils have not been as extensively studied as soils in some other ecosystem types, all evidence suggests that domestic animals are just as disruptive of topsoils, watershed hydrology, and water quality and quantity in forests as in drier grasslands and shrublands (Belsky and Blumenthal 1995).

Degraded forests and rangelands can recover.

Numerous studies have shown that Eastside ecosystems can often (but not always) recover once the livestock are removed (Anderson et. al. 1982a; Zimmerman and Neuenschwander 1984; Belnap 1993; Belsky and Blumenthal 1995). Zimmerman and Neuenschwander found that after a disturbed ponderosa pine forest was protected from livestock grazing, its grass understory recovered, its natural fire frequency was restored, its fuel load was lowered, and tree recruitment was reduced. This forest is currently returning to its pre-settlement condition. Similarly, Anderson et. al. (1982a) and Belnap (1993) have shown that cryptobiotic crusts will regenerate, either naturally or when inoculated with crust species.

Recovery of species and ecosystem function is more probable in western interior forests than in drier deserts and grasslands. Numerous studies have shown that riparian areas will recover from degradation if livestock are removed. In habitats with sufficient rainfall, native grasses will replace cheatgrass and other weeds if disturbances are eliminated and native species are allowed to regain their vigor.

STANDARDS AND GUIDELINES

- Livestock grazing should be allowed only where it can be clearly demonstrated that it will not degrade soils or vegetation or reduce ecological integrity. Special attention should be given to avoiding damage from livestock grazing and trampling in old-growth forests, low- and mid-elevation forests that still have open, park-like structure, riparian zones, moist meadows and wetlands, areas with unstable soil or steep slopes, areas with functioning cryptobiotic crusts, and areas with healthy populations of native perennial bunchgrasses.

- Livestock should not be introduced into previously ungrazed areas. Livestock numbers also should be drastically reduced in most areas, starting with areas in good or excellent condition. These areas contain the genetic material and template for healthy ecosystem functioning that are crucial for future restoration of larger areas. Functioning communities are currently so limited in number and area that they should be protected immediately, before the only blueprints available for future restoration are lost.

- Priorities for rehabilitation should be 1) communities still possessing the original A horizon and most of their original flora and fauna (because it is easier and less costly to preserve communities than to restore them); 2) communities still possessing some of their A horizon and all of their B horizon and some complement of their original flora and fauna; and 3) communities that have lost most of their topsoil and native species. However, no further degradation of riparian zones or uplands should be permitted. Restoration of native flora and ecosystem processes should be a priority for management. The burden of proof that no further degradation of grazing allotments will occur should be on the grazing permittee, not on resource management agencies or public-interest groups.

CHAPTER X: PREVENTION OF ALIEN PLANT INVASIONS

OBJECTIVES

The objectives of the following alien plant management recommendations are to:

- prevent deliberate and unintentional invasion and spread of alien plants into previously uncolonized areas on the Eastside;
- revise federal land management policies to emphasize prevention of invasion rather than control of invaders;
- develop control strategies to reduce or eliminate alien plants without causing disruption of ecosystem components and processes;
- increase education and awareness about biological invasions of alien plants; and
- broaden the legal definition of noxious weeds to include intentionally introduced species which have become aggressive colonizers and displacers of native ecosystem processes.

PRINCIPLES

Biological invasions of alien plants present one of the most serious threats to long-term maintenance of ecosystem health and biodiversity (Mack 1981 and 1986; Tyser and Key 1988; Westman 1990). Degradation and destruction of biological resources have resulted from policies of non-action and inappropriate action (Cottam and Stewart 1940). Invasion and colonization by alien plants reduce the health and integrity of ecosystems in many ways. These invasions degrade resource values (Bucher 1984; Pimental 1986), alter ecosystem processes (Melgoza et. al. 1990; Verstraete and Schwartz 1991; Walker and Vitousek 1991), affect trophic levels (Harty 1986; Kerpez and Smith 1987; Vitousek et. al. 1987), and lead to endangerment and extinction of native species (Parenti and Guerrant 1991; Flather et. al. 1994). Interspecific interactions between native and introduced species adversely affect more than 50% of all threatened and endangered species in the United States (Flather et. al. 1994). This is the second most important cause of species endangerment (after habitat loss). Given these impacts, prevention and control of alien plant invasions should be integral to Eastside ecosystem management policies.

In most cases, biological invasions occur gradually and inconspicuously. By the time public awareness develops, the effects are often irreversible and resources may be irretrievably committed, productivity lowered, and biodiversity reduced (U.S. Bureau of Land Management 1994). Many ecologists, including some agency personnel, have expressed concern about invading plant taxa because of their adverse environmental impacts (Bazzaz 1986; Vitousek 1986; Losensky 1987; Salwasser 1989; Soulé 1990; Temple 1990; U.S. Bureau of Land Management 1994). Land management agencies have made some efforts to control a certain class of biological invaders (noxious weeds), but have not addressed seriously the causes of biological invasions nor understood the depth and extent of this problem. Control of invading plants has been difficult, expensive, and often ineffectual (Warnock and Lewis 1980). Land management agencies should emphasize prevention of invasion rather than control of established invaders (U.S. Bureau of Land Management 1994) and should base their policies on the biology of invading species (Campbell 1993).

Terminology

Terminology in this chapter is based on Bazzaz (1986) and Lincoln et. al. (1990). "Colonizing species" refer to species that have recently entered previously unoccupied habitats, while "invaders" refer to those colonizers that have gone on to displace native components or have become dominant in parts of their new environment. A class of plant entities has been legally-defined as "noxious weeds." "Alien" or "exotic taxa" refer to species generally viewed as non-native or non-indigenous to new parts of their present range, while "introduced taxa" refers to those aliens disseminated by humans.

Effect of Alien Plants on Eastside Ecosystems

Alien plants alter ecosystem function and composition in the following ways:

- invaders displace native species through competitive exclusion (Harris 1967; Thompson and Grime 1979; Weaver et. al. 1989);
- alien plants cause changes in the outputs of ecosystem processes (Hobbs and Huenneke 1992), e.g. nutrient cycling (Vitousek 1986), erosion (Lacey et. al. 1989), disturbance frequency (Young and Evans 1978), net primary productivity (Nadelhoffer et. al. 1985; Vitousek 1986), and evapotranspiration (Horton 1977; Kerpez and Smith 1987);
- alien plants reduce or eliminate habitat for native organisms (Brothers and Spingarn 1992; Nee and May 1992); and
- alien plants cause changes in and disruptions of food webs by the elimination of important native primary producers (Marks and Bormann 1972; Orians and Solbrig 1977) or replacement by maladaptive herbivores (Daubenmire 1940; Edwards and Gillman 1987).

The following examples illustrate how plant invasions have recently altered ecosystems in the Pacific Northwest:

- displacement of native plants and reduced plant diversity resulted from the entry of *Centaurea maculosa* (spotted knapweed) (Tyser and Key 1988);
- increased surface runoff and sediment yield occurred in areas infested with *Centaurea maculosa* (spotted knapweed) (Lacey et. al. 1989);
- lowered growth rate and survival of *Pinus ponderosa* in forest plantations resulted from interference by *Cirsium vulgare* (bull thistle) (Randall and Rejmánek 1993);
- permanent changes in fire regime, increased frequency and severity of stand-destroying fires, displacement of native bunchgrasses, elimination of shrub cover, increased erosion, and lowered outputs of forage were caused by *Bromus tectorum* (cheatgrass) dominance (Wright and Klemmedson 1965; Harniss and Murray 1973; Young and Evans 1976; Billings 1983; Humphrey 1984; Melgoza et. al. 1990; Peters and Bunting 1994);
- changes in uptake and cycling of soil nutrients resulted from elimination of cryptobiotic crusts, which accompany species composition changes resulting from soil disturbance (Kleiner and Harper 1972; Anderson et. al. 1982b; Bolton et. al. 1993);
- loss of species diversity occurred in timberline vegetation with invasion by *Poa pratensis* (Kentucky bluegrass) and *Phleum pratense* (timothy) (Weaver et. al. 1989);
- steady increases in the spread of *Acroptilon repens* (Russian knapweed) patches appear to have been caused by allelopathy, or plant chemical defense (Kelsey and Bedunah 1989); and
- reductions in survival and growth of *Pinus lambertiana* (sugar pine) seedlings were correlated with reductions in the formation of beneficial ectomycorrhizal fungi following seeding of the non-mycorrhizal grass *Lolium multiflorum* (annual or Italian rye) (Amaranthus and Perry 1994).

Causes of Plant Invasions on the Eastside

Plant invasions are caused largely by human activities which disturb native ecosystems (Harrod 1994; Sheley 1994; U.S. Bureau of Land Management 1994). Vegetation removal and ground-disturbing activities create opportunities for colonization by alien plants (Bazzaz 1983; Orians 1986). Transportation of alien plant propagules is often accomplished through deliberate or inadvertent human activities or the behavior of livestock (Durgan 1989; Guillerm 1991). On public lands, the primary activities which promote the spread of alien plants are road-building and road-use, logging, grazing, forage seeding, and some erosion control and fire rehabilitation measures (Wilcove 1989; Tyser and Worley 1990; Le Houérou 1991; Saunders et. al. 1991).

Consequences of Plant Invasions

Management activities associated with logging, road-building and road-use, and grazing are rapidly accelerating the rate of plant invasions on public lands (Scott et. al. 1988; Tyser and Worley 1992; Johnson et. al. 1994). Infestations of noxious weeds (only a small subset of alien taxa) are doubling every 5-6 years on U.S. Bureau of Land Management lands on the Eastside (U.S. Bureau of Land Management 1994). A total of approximately 393 taxa have currently been identified as invaders within the North Cascades and Columbia Basin (Wooten and Morrison in press). These alien plants have already lead to great resource damage resulting in considerable economic costs (O'Toole 1988; U.S. Bureau of Land Management 1994). Alien plant invasions have led to endangerment of native species and plant communities (Chicoine et. al. 1988; Tyser and Key 1988; Weaver et. al. 1989). Numerous cases exist where environmental and legal thresholds for degradation and disturbance have been exceeded (Warnock and Lewis 1980; Penders 1995). Public agencies are unprepared to face upcoming land management challenges in this rapidly changing field. Prevention of further spread into unroaded, unmanaged, and relatively pristine areas is critical to long-term conservation of ecosystem resources, as these areas still retain undisturbed native flora and natural resilience to management-induced disturbances (DeAngelis and Waterhouse 1987; Wilson 1989; Hobbs and Huenneke 1992; West 1993; Johnson et. al. 1994).

Environmental Effects of Weed Control with Herbicides

Herbicides have been widely used to control plant invasions. Adverse environmental and human health effects associated with herbicide application are becoming increasingly apparent (Katan and Eshel 1973; Warnock and Lewis 1980; Pimental and Edwards 1982; Feldman 1991), as in the following examples:

- Much of our native fauna is threatened by the synergistic effects of synthetic compounds on living estrogenic activity. These estrogenic compounds are associated with many herbicides and pesticides (Fox 1992; Colburn et. al. 1993; Guillette in press).
- Herbicide application is implicated as one of the causes in the global decline of amphibian populations (Blaustein and Wake 1995).
- Replacement of beneficial mycorrhizal flora and the iron chelators they produce with allelopathic actinomycetes result in the conversion of productive forestland to unforested openings (Perry et. al. 1984; Amaranthus and Perry 1987; Perry and Amaranthus 1994).
- Persistence of herbicides through soil and humus binding is unaccounted for in most quantitative measurements of toxicity used to determine safe exposure levels (Bordeleau and Bartha 1971), and the possibility exists that they may be released at unexpected times in the future (Pramer and Bartha 1980).
- Transport of pesticides up food chains and concentration in lipid tissues of secondary consumers can result in exposures to fish 49,000 times higher than to target organisms (Reinert 1967).
- Destruction of plant seeds results in declines of nontarget gophers (Brown 1978).
- Destruction of nontarget plants can result in lowered species richness and replacement by introduced species (e.g. following 2,4-D treatment of native *Veratrum californicum* in an alpine plant community) (Anderson and Thompson 1993).
- So-called "inert ingredient" laws allow the application of toxic compounds such as kerosene, diesel fuel, or fungicides to be used as 98% of a mixture's application rate (Grier 1994).
- Surfactants in different commercial preparations of glyphosate result in 400-fold greater toxicity to sockeye salmon fry (Monroe 1988).
- Human and other nontarget mammalian species' systems and functions (e.g. nervous systems, immune systems, cellular respiration cycles, electron-transport chains, and cell membrane functions) are prone to damage and diverse oncogenic and teratogenic effects from exposure to herbicides (O'Brien 1984).
- As a result of chemical exposure, reproductive sterility has occurred in some females, reduced sperm counts have been observed in males (Carlsen et. al. 1992; Auger et. al. 1995), and birth defects have occurred in children (Wilson 1977; Kurzel and Cetrulo 1981).

- The most comprehensive weed management plans still may cause irreversible and irretrievable resource commitments, such as crop losses associated with drift of supposedly non-toxic chlorosulfuron (Fletcher et. al. 1993) or the 1995 herbicide spill resulting from the crash of an herbicide truck into a creek (and release of herbicides into water) on the Okanogan National Forest in Washington.

In 1989, a five-year injunction against herbicide spraying by the Pacific Northwest Region of the Forest Service was lifted after the Forest Service prepared the Final Environmental Impact Statement and accompanying Record of Decision on Managing Competing and Unwanted Vegetation (Torrence 1988), and an agreement was mediated between the U.S. Department of Agriculture and plaintiffs, the Northwest Coalition for Alternatives to Pesticides (O'Brien 1989). Provisions of the Record of Decision and mediated agreement stipulated use of prevention strategies when feasible, use of herbicides only as a last resort, and performance of site-specific analysis and monitoring.

In spite of the mediation, excessive reliance on chemical control measures continues to be found commonly in federal land management policies. For instance, this type of control measure dominated the Interior Columbia Basin Ecosystem Management Project's scientific contract report on noxious rangeland weeds (Sheley 1994). This policy violates both the letter and intent of the mediated agreement in which herbicide use is to be used only as a last resort.

Non-Herbicidal Control Methods

The following are examples of a variety of types of non-herbicidal control methods and their utility:

- "Biological controls" refer to insects or pathogens that control populations of undesirable species. Such pathogens are often natural components of the original habitat of a weed that are absent in the new environment. After confirmation of specificity to target plants, managers have used biological controls to achieve desired effects on target organisms (Kelleher and Hulme 1984; Piper 1985). For example, tansy ragwort (*Senecio jacobaea*), a noxious weed affecting much of Oregon and Washington, has been reduced to about 10% of mid-1970 infestation rates by a biological control program. The program, which utilizes cinnabar moth, ragwort seedhead fly, and ragwort flea beetle, costs approximately $5 million annually. It yields a return on investment of 83% – a benefit-to-cost ratio of 13:1 (U.S. Bureau of Land Management 1994).
- Mechanical controls (e.g. mowing) are effective on obligate outbreeders such as diffuse knapweed (*Centaurea diffusa*) when the treatment is timed to precede flowering (Harrod 1991).
- Manual controls are the most selective methods for treating target organisms and may be the only available methods in certain situations, for example in wilderness areas, riparian areas, or rocky areas.
- Cultural controls that affect revegetation are important and are often specified in treatments. However, the indiscriminate use of non-native seeding mixtures has resulted in significant damage. In Hell's Canyon National Recreation Area, within the Wallowa Whitman National Forest in Oregon, yellow star thistle (*Centaurea solstitialis*) present in a seed mix applied after the 1988 TeePee fire (Bob Williams, Wallowa Whitman National Forest, Baker, OR, personal communication) resulted in over $200,000 in ongoing control costs. The regular seeding of strongly competitive and aggressive alien grasses or clover causes dramatic displacement of native vegetation (Ralphs and Busby 1979).

RECOMMENDATION AND GUIDELINES

Program Development and Cooperative Agreements

Each agency with jurisdiction over land-based resources should develop and maintain an alien plant program with funding and staff allocated to the prevention and control of invading species. Individual programs should be based on specific ecosystem processes, invading plants, and characteristic causes of invasions for each area.

Cooperative agreements between private interests, non-governmental organizations, and federal, state, and local governments should be encouraged. Land managers, field personnel, ecologists, botanists, and biologists should be consulted about the nature and spread of invading taxa, as well as invaded ecosystems. Public interest groups should be encouraged to contribute. These groups can give invaluable support and staff to weed control programs. Concerted efforts should be made to contact and educate all groups whose activities may increase the spread of alien plants.

Information Gathering

Identification of the nature and extent of plant invasions in each jurisdiction should be conducted by combining a review of known occurrences with additional surveys for new invaders. Baseline monitoring data would allow subsequent surveys to determine population trends, causative factors, rate of spread, persistence, and potential for further spread into adjacent ecosystems. Managers should review and amend lists of invading taxa and policies for their prevention and control following analysis of these data.

Prevention Strategies

Prevention strategies should be stressed over control measures, which are often futile once the population size of the invading species has reached a certain threshold. Prevention should be based on prioritization of areas based on a combination of ecosystem values and risk of invasion as follows:

> Priority 1 — Areas with intact ecosystem processes, essentially free of invaders. No management activities should be allowed which cause deliberate or inadvertent introduction of alien plants. Management objectives should prioritize the maintenance of uninvaded ecosystems.
>
> Priority 2 — Intact ecosystems with a few invading taxa that threaten ecological integrity. Invaders threaten ecosystem, plant community structure, or landscape-level processes, but control efforts may be successful. No management activities should be allowed which cause further introduction of alien plants. Management objectives should emphasize environmentally benign but aggressive biological and mechanical control measures to reduce or eliminate alien plant populations.
>
> Priority 3 — Intact ecosystems with a few invading taxa that do not threaten the ecosystem but should still be controlled. No management activities should be allowed which cause further introduction of alien plants. Management objectives should emphasize environmentally benign biological and mechanical control measures to reduce or eliminate alien plant populations.

Control Measures

Strategies for alien plant control are both more complicated and more costly to implement than prevention strategies. In general, control measures should address the nature, quantity, and number of invading species, their potential for spread to adjacent ecosystems, loss of value because of their spread, the nature of affected ecosystems, and long-term costs of control. Strategies based on these attributes are documented in U.S. Bureau of Land Management (1994), Harrod (1994), U.S. Forest Service (1990), Torrence (1988) (and the associated mediated agreement) and Hoglund et. al. (1991). Control strategies come under agency guidelines for integrated weed management ("IWM"). IWM begins with information gathering, surveying, and determining a damage threshold (Hoglund et. al. 1991). Action strategies that incorporate education, prevention, mitigation, and control alternatives are then developed as part of control measures (U.S. Bureau of Land Management 1994). Only environmentally benign mechanical, cultural, and biological control methods should be used on public lands. Given the increasing evidence for environmental and human health risks, herbicide use should not be permitted on public land.

Adaptive Management

Deleterious management practices that contribute to the spread of alien taxa should be re-examined and revised. These practices include seeding invasive species, using contaminated seed mixes, feeding with contaminated grain, transporting weeds on stock, gear, and clothing, and disturbing soils, hydrology, and nutrient flows. Some of these are long-standing practices that will require land management agencies to change infrastructures.

Further plant invasions caused by vegetation removal and ground disturbance (e.g. roading, logging, and grazing) can be prevented by eliminating these activities in intact native ecosystems (e.g. roadless areas and wilderness), where anthropogenic effects are relatively minimal. These areas are the highest priority for prevention strategies, and retain some of the last vestiges of resiliency present on the Eastside. Given the difficulty of eradication and the potential for permanent system-wide changes of unknown impact posed by alien plant species, it is irresponsible to degrade these last remnants of pristine landscape. In other areas, where alien plants are already well-established, it must be accepted that biological invasions are often irreversible.

Education

Management of invading plants requires a long-term commitment to education and awareness of the nature and extent of the problem. Plant and weed identification should be a basic skill of all land managers and opportunities to become involved should also be available to the public. Producing signs, brochures, posters, and news articles would offer a chance to communicate the problem. There should be workshops and classes that bring interested people together in informative, problem-solving formats.

Research

There is an overwhelming need for more data on the ecology and biology of plant invasions on the Eastside. Agencies and educational institutions should develop programs to research methods for solving the problems created by invading species. Through cooperative agreements, cost-sharing, and data-sharing, a better understanding of plant invasions would produce more effective prevention strategies and control techniques. Affected ecosystem components should be studied, and at-risk ecosystems, such as riparian areas, should receive high priority. Specific topics for which additional research is needed include the effects of plant invasions on nutrient cycling, mycorrhizal relationships, wildlife and biodiversity, biological controls, cultural (ecological) controls, mechanisms of spread, genetics and reproductive biology of invading species, and the effects of varying the nature, severity, and kind of causative disturbances.

Federal and State Laws Addressing Plant Invaders

Numerous federal laws, regulations, and policies have been established that address management of plant invaders on public lands. Designated "noxious weeds" receive individual consideration through several of these policies. A recent U.S. Department of Interior publication (U.S. Bureau of Land Management 1994, Appendix 2) lists legal requirements pertaining to the agency's role in management, and includes brief interpretations of their intent.

Federal Land Policy and Management Act (FLPMA) of 1976. Directs the U.S. Bureau of Land Management to "take any action necessary to prevent unnecessary and/or undue degradation of the public lands."

Public Rangelands Improvement Act (PRIA) of 1978. Requires that the U.S. Bureau of Land Management manage, maintain, and improve the condition of the public rangelands so that they become as productive as feasible.

Carlson-Foley Act of 1968. Directs agencies to destroy noxious plants growing on lands under their jurisdiction.

Federal Noxious Weed Act of 1974, as amended by Sec. 15, Management of Undesirable Plants on Federal Lands, 1990. Authorizes the U.S. Secretary of Agriculture to cooperate with other federal and state agencies and others in carrying out operations or measures to eradicate, suppress, control, prevent, or retard the spread of any noxious weed. Each federal agency should 1) designate an office or adequately trained person to develop and coordinate an undesirable plants management program for federal lands under the agency's jurisdiction, 2) establish and adequately fund an undesirable plants management program through the agency's budgetary process, 3) complete and implement cooperative agreements with state agencies regarding the management of undesirable plant species on federal lands, and 4) establish integrated management systems to control or contain undesirable plant species targeted under cooperative agreements.

U.S. Bureau of Land Management Final Supplemental Environmental Impact Statement for Noxious Weeds (1987). Declares that the U.S. Bureau of Land Management has a statutory duty to control and eradicate noxious weeds on public lands.

U.S. Bureau of Land Management Departmental Manual 517. Prescribes policy for the use of pesticides on the lands and waters under the jurisdiction of the U.S. Bureau of Land Management and for compliance with the Federal Insecticide, Fungicide, and Rodenticide Act, as amended.

U.S. Bureau of Land Management Departmental Manual 609. Prescribes policy to control undesirable or noxious weeds on the lands, waters, or facilities under the jurisdiction of the U.S. Bureau of Land Management, to the extent economically practicable and as needed for resource protection and accomplishment of resource management objectives.

U.S. Bureau of Land Management Manual 9011. Provides policy for conducting chemical pest control programs under an integrated pest management approach.

U.S. Bureau of Land Management Manual 9014. Provides guidance and procedures for planning and implementing biological control in Integrated Pest Management Programs.

U.S. Bureau of Land Management Manual 9015. Provides policy relating to the management and coordination of noxious weed activities among the U.S. Bureau of Land Management, organizations, and individuals.

U.S. Bureau of Land Management Manual 9220. Provides guidance for implementing integrated pest management on lands administered by the U.S. Bureau of Land Management. The objective is to ensure optimal pest management with respect to environmental concerns, biological, effectiveness, and economic efficiency while achieving resource management objectives.

Additional policies are directed toward other federal or state agencies (Hoglund et. al. 1991):

The National Environmental Policy Act (NEPA) of 1969 (Sec. 102(C)(v)). Planners are required to describe any "irreversible and irretrievable commitments of resources." Most biological invasions are nearly irreversible and any actions which may promote the spread of alien plants can be viewed as an irretrievable commitment of resources.

National Forest Management Act of 1976 (Sec. 6, 90 Stat. 2949). The principal legislative mandate directing the conservation of biological diversity and recognizing the value of adapted plant and animal communities. This legislation also prohibits stand conversions, the process of management-induced irreversible change from one ecosystem to another. The inadvertent or deliberate conversion of a plant community dominated by natives to one dominated by aliens can be viewed as a stand conversion.

Code of Federal Regulations, Title 36, Part 219, Section 27, Subsection G. Management prescriptions, where appropriate and to the extent practicable, should preserve and enhance the diversity of plant and animal communities, including endemics and desirable naturalized plant and animal species, so that diversity is at least as great as that which would be expected in a natural forest and the diversity of tree species similar to that existing in the planning area. Reductions in diversity of plant and animal species from that which would be expected in a natural forest, or from that similar to the existing diversity in the planning area, may be prescribed only where needed to meet overall multiple-use objectives. Planned site conversion should be justified by an analysis showing biological, economic, social, and environmental design consequences, and the relation of such conversions to the process of natural change.

The following documents provide additional direction:

Forest Pest Management, 1990. A Guide to Conducting Vegetation Management Projects in the Pacific Northwest Region. U.S. Forest Service.

Northwest Coalition for Alternatives to Pesticides, et. al. v. Clayton Yeutter, et. al. Civil No. 83-6272-E-BU, (U.S.D.C. Oregon) Stipulated Order of May 24, 1989 (here referred to as the mediated agreement).

Managing Competing and Unwanted Vegetation, Final EIS and Accompanying Record of Decision. U.S. Forest Service, Pacific Northwest Region, Portland, OR. (Torrence 1988).

Memorandum for the Heads of Executive Departments and Agencies. 1994. Presidential direction to use regionally native plants for landscaping and construction.

WAC 16-750 State Noxious Weed List and Schedule of Monetary Penalties. Washington Administrative Code Olympia, WA. (Nov. 28, 1994).

CHAPTER XI: ROAD MANAGEMENT

OBJECTIVES

The objectives of the following road management recommendations are to:

- manage transportation systems on Eastside federal lands in a manner that does not result in significant and widespread adverse effects on terrestrial and aquatic ecosystems; and
- reduce road densities by closing/decommissioning roads that cause the greatest harm to biological resources.

PRINCIPLES

Roads have been widely constructed to facilitate resource extraction and other land management activities throughout the Eastside. Although existing road systems were planned solely to provide human access, they have resulted in numerous and significant adverse impacts to soils, water quality, wildlife, and other biological resources. These impacts include:

- direct elimination and fragmentation of wildlife habitat (Noss and Cooperrider 1994);
- reduced dispersal capability for species that do not easily cross roads or move through heavily roaded landscapes (Mader 1984 and 1988; Van Dyke et. al. 1986);
- decreased suitability of adjacent habitat through deleterious edge effects (van der Zande et. al. 1980; Schonewald-Cox and Buechner 1992);
- increased human disturbance and harassment of sensitive wildlife, resulting in reduced habitat effectiveness (Lyon 1979; Thiel 1985; McLellan and Shackleton 1988);
- increased levels of wildlife mortality due to roadkills, poaching, and increased hunting pressure (Lalo 1987; Knick and Kasworm 1989; Leptich and Zager 1991);
- increased rates of erosion and sediment delivery to streams, with resultant adverse impacts on fish and other aquatic species (FEMAT 1993; McIntosh et. al. 1994);
- alteration of natural stream flow patterns, particularly the timing and intensity of high and low flows (Megahan 1987; Chamberlin et. al. 1991);
- increased spread and establishment of alien plants and animals (Getz et. al. 1978; Harrod 1994);
- increased levels of air and water-borne pollutants (Quarles et. al. 1974; Muskett and Jones 1980); and
- compaction and displacement of soil, resulting in loss of biomass productivity (Megahan et. al. 1994).

Because of these myriad and significant environmental impacts, road construction (particularly into previously unroaded areas) is considered to be one of the most damaging elements of land management to aquatic and terrestrial ecosystems on the Eastside (FEMAT 1993; Henjum et. al. 1994; Noss and Cooperrider 1994). Average road density on national forest lands in eastern Oregon and Washington is currently estimated at over 3 miles per square mile, well in excess of levels that trigger many of the adverse effects listed above (Henjum et. al. 1994).

Remaining Eastside roadless regions have enormous ecological value. As stated by the Eastside Forests Scientific Societies Panel, "roadless regions constitute the least human-disturbed forest and stream systems, the last reservoirs of ecological diversity, and the primary benchmarks for restoring ecological health and integrity (Henjum et. al. 1994)." Any scientifically credible plan to maintain/restore ecological integrity on the Eastside must reduce road mileage from current excessive levels and protect remaining roadless regions and other ecologically sensitive areas from the adverse effects associated with roads and their construction.

STANDARDS AND GUIDELINES

Prohibit Construction or Reconstruction of Roads in Ecologically Sensitive Areas.

No roads should be constructed in the following types of areas:

- roadless areas ≥ 1,000 acres (RARE II or uninventoried) or roadless regions < 1,000 acres that are biologically significant (Henjum et. al. 1994; Beschta et. al. 1995);
- Aquatic Diversity Areas, ("ADAs"), Riparian Areas, or Biotic Reserves (as defined in Chapter II);
- old-growth forest stands or other rare or sensitive habitat types;
- areas with slopes steeper than 30%, areas with unstable soils, severely burned sites, sites where roads concentrate water on landslide-prone areas, or other areas identified as having high erosion hazard (Henjum et. al. 1994; Beschta et. al. 1995);
- watersheds that exceed cumulative effects thresholds and are, therefore, in unstable condition (Isaacson 1986); or
- areas where other potentially incompatible management objectives (e.g. specific wildlife habitat needs) take precedence.

Outside of these areas, a policy of net decrease in road mileage should be adopted on Eastside federal lands. New road-building should be prohibited except where 1) construction of new roads may be necessary in order to complete a larger program of partial or complete road obliteration or 2) it can be conclusively demonstrated that the adverse environmental impacts associated with road construction are more than offset by ecological benefits from management activities that could not feasibly occur without new road access. Where new roads are built, an equal or greater amount of road within the same 4-5th order watershed unit should be obliterated.

Develop and Implement Road Reduction Plans.

Each applicable federal agency should develop and implement road reduction plans as follows:

- Road density across roaded portions of federal forest and rangelands should be reduced to an average of less than one mile per square mile over the next decade.
- Roads for closure and decommissioning should be identified based on an ecological prioritization scheme. The magnitude of the existing and potential impacts they pose of roads to terrestrial and aquatic ecosystems should be considered (Doppelt et. al. 1993; FEMAT 1993). Highest priorities for reductions in road mileages should be given to ADAs, Riparian Areas, Biotic Reserves, Late-Successional Reserves (created by the President's Forest Plan east of the Cascade crest) newly established reserves, Research Natural Areas (U.S. Forest Service), Areas of Critical Environmental Concern (U.S. Bureau of Land Management), and other areas that are disproportionately important for protecting biodiversity and ecological integrity on the Eastside.
- Roads not essential to future management activities should be closed, obliterated, and stabilized.
- A 10 year timetable outlining road closure objectives should be developed for each national forest and U.S. Bureau of Land Management resource area.

Develop and Implement Road Management Plans.

Each applicable federal agency should:

- implement a road management program intended to reduce or minimize adverse environmental effects of roads and associated maintenance activities; and

- conduct a system-wide road analysis and increase maintenance of and attention given to culverting to improve drainage. Priority attention should be given to roads that deliver or threaten to deliver sediment to active channels. This program should accomplish at least the following goals:

  a) All existing roads should be inventoried and evaluated through an interdisciplinary team review process to determine the influence of the road upon management objectives.

  b) Roads in ecological priority areas that are not targeted for removal should be prioritized for drainage improvements, with priority attention given to roads which deliver or threaten to deliver sediment to active channels.

  c) All existing culverts and stream crossings should be improved to accommodate at least a 100 year flood, including associated bedload and debris. Prioritization should be based on the potential impact on and the ecological value of the riparian resources affected.

  d) All road construction, obliteration, and maintenance, including culvert cleaning and placement, should minimize disturbance of riparian areas and disruption of natural hydrologic flow paths and natural fish migration patterns. In addition, road activities should minimize the direct or indirect addition of sediment to streams through appropriate design, construction, and maintenance procedures, and drainage routing away from potentially unstable channels and hillslopes.

  e) Sidecasting of loose material in riparian areas during construction or maintenance activities should be prohibited.

  f) All roads crossing existing or historic fish-bearing streams should be constructed, reconstructed, and maintained to provide for fish passage.

  g) Water drafting sites should be designated during project-level analysis or fire management planning. Locations of water drafting sites should be determined to minimize effects on aquatic organisms during periods of low flow. Water drafting sites should be designed, constructed, and maintained to prevent destabilization of stream channels and sedimentation of streams.

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