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Riparian Management Guide

Willamette National Forest

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EXECUTIVE SUMMARY

GENERAL RIPARIAN MANAGEMENT

Riparian areas along perennial streams, lakes, and wetlands comprise a little over 100,000 acres, or approximately 6% of the 1.7 million acres of the Willamette National Forest (WNF). These riparian areas provide numerous economic, social, and ecological benefits to the Forest.

The primary goal of riparian management is to provide self-sustaining streamside forests that will ensure the desired conditions of riparian resources for the future. According to national policies of the U.S. Forest Service, riparian-dependent resources receive first priority in forest management along streams, lakes, and wetlands. Removal of riparian vegetation for timber harvest must be justified, both ecologically and administratively. All land management entails a certain degree of uncertainty and is likely to change over time; thus, some margin for risk must be included in riparian management policies.

Given the high value of riparian resources on the WNF and the associated administrative and economic benefits, a no-programmed harvest riparian management policy provides accurate planning, increases effective land management, and maintains a diverse array of options for future Forest management. A no-programmed harvest riparian management policy over much of the forest also is an essential component of policies to manage forest landscapes and to maintain components of mature forests in young stands.

LANDSCAPE AND BASIN MANAGEMENT

Effective land management maintains the ecological linkages of riparian resources throughout the forest landscape. Continuous corridors of riparian forests provide essential connections between different management areas distributed throughout the Willamette National Forest. Riparian management zones also contribute essential elements of continuity for policies to minimize fragmentation of the forest. No other landscape feature within the National Forest offers the natural continuity of riparian areas.

Management of forest landscapes must identify and retain the natural patterns of riparian resources at scales ranging from specific harvest sites to multiple river drainages. Land use planning in the Willamette National Forest operates at two scales: broad project areas that may encompass several thousand acres and individual harvest units within a project area. Basin planning is designed to minimize the potential for cumulative effects, maintain potential inputs of woody debris, maintain continuous riparian corridors with structurally complex plant communities throughout the basin, and rehabilitate degraded riparian resources within the basin.

HARVEST UNIT MANAGEMENT

Site-specific riparian management prescriptions are developed after basin management objectives for riparian areas have been identified by the planning team. Delineating the boundaries of the riparian management zone will largely determine the effectiveness of subsequent management in meeting riparian objectives.

The entire floodplain should be included within the riparian management zone. Failure to do so will seriously jeopardize riparian management objectives during major floods. Forest Service policy requires land managers to "avoid adverse impacts which may be associated with the occupancy and modification of floodplains and with the destruction, loss, or, degradation of wetlands".

Delineation of the riparian management zone starts at the edge of the active channel or mean high water level, and extends horizontally on both sides. Active channels consist of all portions of the stream channel carrying water at normal high flows, not just the current wetted channel. They include side channels and backwaters, which may not carry water during summer low flow. For optimal management of riparian resources, riparian management zones should have variable widths that are delineated at ecologically significant boundaries, rather than arbitrary distances around a stream, lake or wetland.

No timber harvest is programmed from riparian management zones along Class I, II and III streams, intermittent Class IV streams in unstable watersheds, lakes, or wetlands. Partial harvest of vegetation (<50% of the stand in the riparian management zone) is permitted on intermittent Class IV channels in moderately stable watersheds and ephemeral Class IV streams in unstable watersheds. Complete harvest of overstory vegetation is permitted in intermittent Class IV streams in watersheds with stable soils and ephemeral Class IV streams in watersheds with stable or moderately stable soils.

The choice of logging system for a particular site should consider the riparian area and its degree of protection. No trees in the harvest unit should be felled in a direction that would result in their entry into the riparian management zone, except along stable and moderately stable Class IV streams. Logs should be yarded uphill if possible when passing over or through riparian management zones. In some harvest units, cable corridors may need to be cut through the riparian management zone. When a suspension corridor is cut, these logs should be placed in the channel and riparian management zone if the area is deficient in large woody debris. The amount of woody debris left in the channel and forest floor within the suspension corridor should approximate natural volumes for the site.

Riparian vegetation plays a critical role in the dynamics of forest plant communities as well as providing numerous ecological functions for other aquatic and terrestrial communities. A major objective of riparian vegetation management is to maintain the species diversity, age composition, and structural complexity of riparian forests.

Most future riparian functions will be guaranteed if natural abundances and distributions of all sizes of woody debris are maintained in streams, lakes, floodplains, and lower hillslopes. Of all the ecological functions of riparian areas, the process of woody debris loading into channels and floodplains requires the longest time for recovery after harvest.

Appropriate riparian management avoids excessive loading of woody debris. No clean-up should be prescribed for any stream, lake or wetland under normal conditions. Slash should be removed only in sluggish stream reaches or in cases of extremely large deposits that are judged to create significant risks for aquatic or wildlife resources.

In general, no timber should be salvaged from any riparian area of the WNF. Given the numerous functions and benefits of riparian vegetation and woody debris, there is no reason to remove salvaged timber from riparian areas, except to meet the needs of riparian-dependent resources. Riparian trees may be felled and used on site or removed to another riparian area if local stand conditions are adequate. Additionally, blowdown is not a management failure and downed trees should not be removed from riparian management zones. The riparian management zone was designed for the trees to die and fall into the stream channel, and windthrow is the most common source of natural debris loading.

The primary objective for fish management on the WNF is to maintain the quality of habitat and food supply for all anadromous and resident fish populations at all stages of their life cycles. Riparian management zones established for water quality and fisheries needs may not meet wildlife habitat requirements. Riparian management zones should be designed to ensure diverse types and amounts of wildlife habitats found in riparian forests and meadows.

REHABILITATION

Both natural and man-caused events can have adverse impacts on riparian functions, despite the best attempts to protect them. Silvicultural and geomorphic techniques may be effective in rehabilitating degraded riparian resources. Highest priorities in all silvicultural operations in riparian areas should be given to creating taxonomically diverse and structurally complex riparian plant communities.

If a riparian area has been damaged by a natural or land use-related disturbance, the probability of continued disturbance must be considered. Any improvements associated with rehabilitation projects can be negated by treating the symptom rather than the source of disturbance.

Channels in many streams have been simplified and destabilized by stream clean-up, salvage operations, debris torrents, and floods. In areas with adequate equipment access and sources of large wood, channel structure and volumes of large woody debris can be restored through channel rehabilitation projects. Understanding the current status of channel structure and/or fish communities is essential for developing appropriate project objectives.

Natural channel materials should be used for rehabilitation whenever available. Persistence of installations is increased where log structures are placed in geomorphically stable locations and configured to resemble natural accumulations of wood. Movement of introduced logs should not be considered a failure, particularly if the logs are retained within a short distance downstream.

Objectives for the entire rehabilitation project and each individual component should be explicitly stated. Rehabilitation projects without future evaluation are unfinished. Subsequent monitoring is essential to determine to what degree project objectives were achieved and to improve future riparian rehabilitation efforts.

RIPARIAN MONITORING

Riparian monitoring evaluates the effectiveness of past management practices. Identification of the desired future condition of riparian areas is a fundamental basis for any monitoring and evaluation of resource information. Riparian monitoring is essential for developing effective management policies in future forest planning.

CHAPTER 1

INTRODUCTION

The Willamette National Forest (WNF) and the U.S. Forest Service (USFS) recognize that riparian areas in national forests support a wide array of resources with high economic and ecological values. Riparian areas provide clean water, fish and wildlife habitat, timber, and recreational opportunities. These multiple functions of riparian areas need to be recognized for effective land management.

The primary objective in all stages of riparian management is protection of riparian resources, as established in the National Forest Management Act. U.S. Forest Service policy mandates management of "riparian areas in the context of the environment in which they are located, recognizing their unique value" (FSM 2526.02), and requires its managers to "give preferential consideration to riparian dependent resources when conflicts among land use activities occur" (FSM 2526.03).

This guide is designed to provide an understanding of the significance and functions of riparian areas as a foundation for sound forest management. The document begins with a discussion of fundamental concepts and definitions of riparian areas and their resource values. Riparian processes and management objectives and practices are then described at three levels: landscape, drainage basin, and individual harvest unit. Finally, rehabilitation and monitoring techniques appropriate to riparian areas are discussed. We have also included a list of important references and an extensive glossary. In general, information within the body of the text is referenced only if it pertains specifically to the WNF and is of interest to a wide range of personnel.

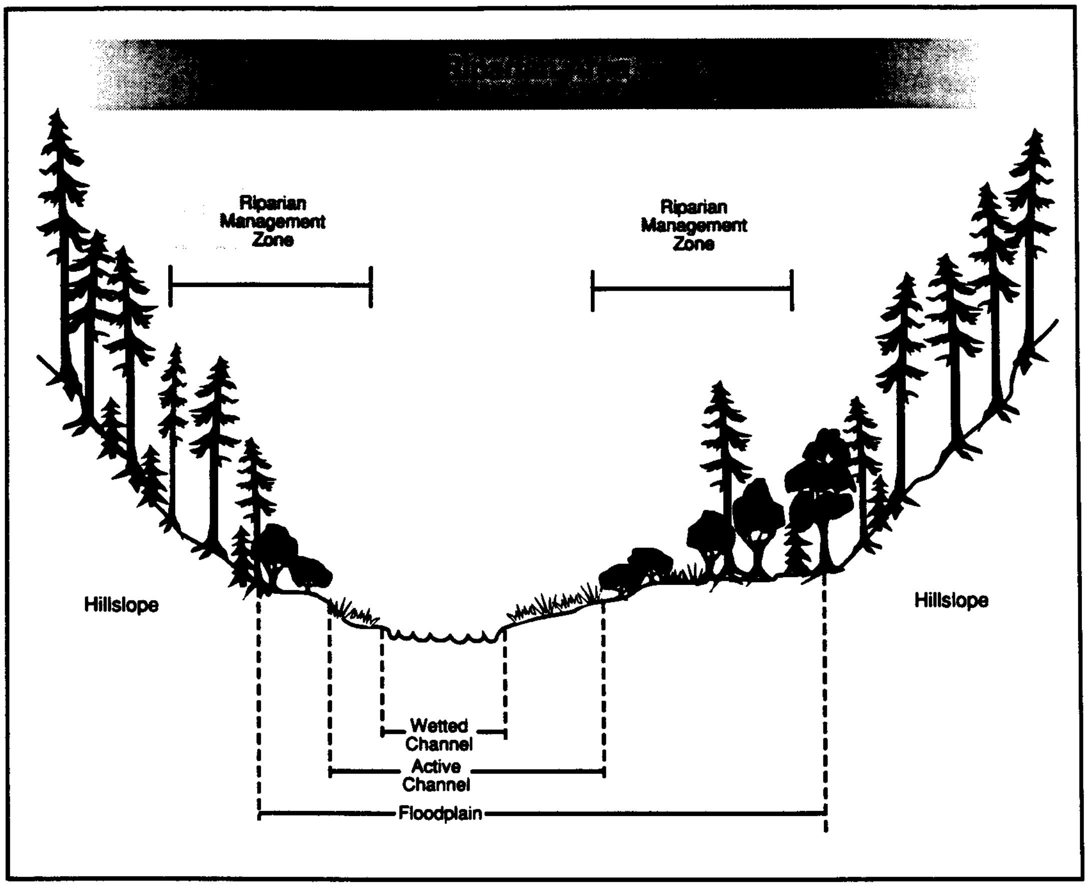
The guide is intended to serve the management and technical staff of Willamette National Forest (WNF) personnel. The general concepts and management techniques could apply to any forested riparian area. However, management details and standards are specific to the 1990 WNF Land and Resource Management Plan (see Appendix IV).

CONCEPTS & DEFINITIONS

What is a riparian area? Definitions vary depending on the perspectives of managers or scientists. The word "riparian" is derived from the Latin word for bank or shore, and simply refers to land adjacent to a body of water. Plant ecologists define riparian areas based on soil moisture conditions and unique plant communities associated with wetted soils. Consequently, riparian areas do not stop at an arbitrary, uniform distance away from the stream but vary in width and shape.

Ecosystem perspectives of riparian areas incorporate concepts from geomorphology, terrestrial plant succession, and aquatic ecology. Riparian areas are defined as three-dimensional zones of influence between terrestrial and aquatic ecosystems. The boundaries of the riparian area extend outward from the streambed or lakeshore and upward into the canopy of streamside vegetation.

Figure 1. **Cross-section of a riparian area and adjacent hillslope. Note that the actual riparian area may extend well up the hillslope, encompassing zones of influence for shading, litter inputs, and wood loading. The riparian management zone may be significantly narrower than the riparian area.**



Using this ecological approach, the WNF considers **riparian areas** to include the aquatic ecosystem and adjacent terrestrial areas directly affecting the aquatic system (Fig. 1). Influences of forests progressively decrease away from the stream, lake, or wetland. Thus, riparian areas cannot be defined by discrete lines on the ground. Specific boundaries established by the Forest Service for management practices within riparian areas are termed **riparian management zones**. Riparian management zones are contained within but may not necessarily include all of the riparian area.

Riparian area management often focuses on the immediate vicinity and local characteristics of a particular site. Land managers must also recognize the role of riparian areas as continuous corridors over the landscape, linking hillsides to streams, and upper headwaters to lower valleys. Riparian area management thus becomes important not only locally but on drainage basin and landscape levels as well.

SELECTED DEFINITIONS

Active Channel
The part of the valley floor inundated annually, including low flow wetted channel and streambanks (Fig. 2). The approximate equivalent to bankfull channel.

Basin
The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

Class I Streams
Perennial or intermittent streams with one or more of the following: 1) direct source of water for domestic use; 2) habitat for spawning, rearing or migration for large numbers of fish; or 3) sufficient discharge to have a major effect on water quality of another Class I stream (Fig. 3).

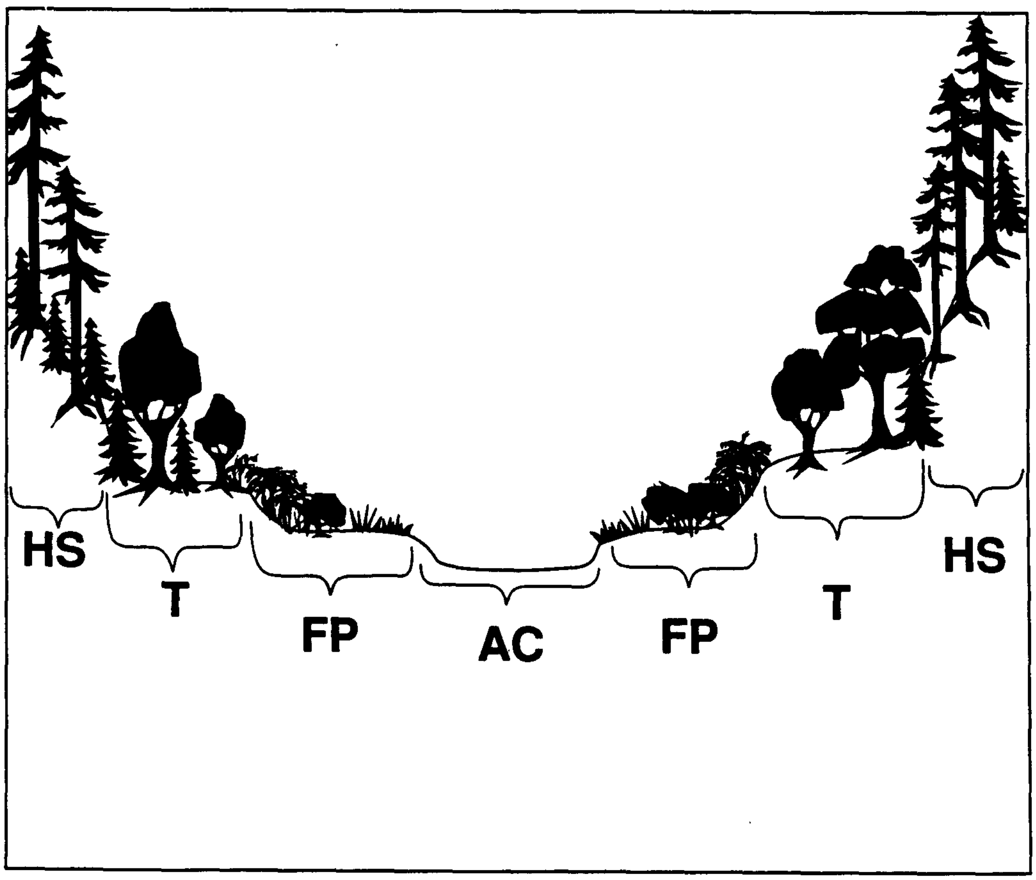
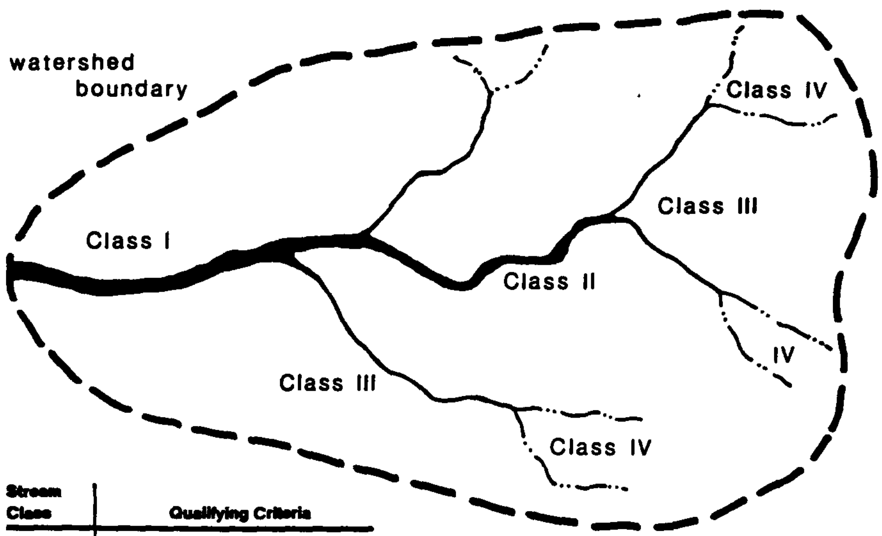


Figure 2. Major landforms of a river valley. AC - active channel; FP - floodplain; T - terrace; HS - hillslope.

Figure 3. The U.S. Forest Service stream classification system.



Stream Class	Qualifying Criteria
I	municipal/ domestic supply, large volume, anadromous fishery
II	resident trout fishery, signifant volume to affect Class I
III	perennial stream, no fish present
IV	intermittent flow

Class II Streams
Perennial or intermittent streams with 1) habitat for spawning, rearing or migration of moderate though significant numbers of fish; and/or 2) sufficient discharge to have moderate influence on other Class I or II streams (Fig. 3). Game fish are present for at least part of the year or the stream has the potential for establishment or re-establishment of a game fish population.

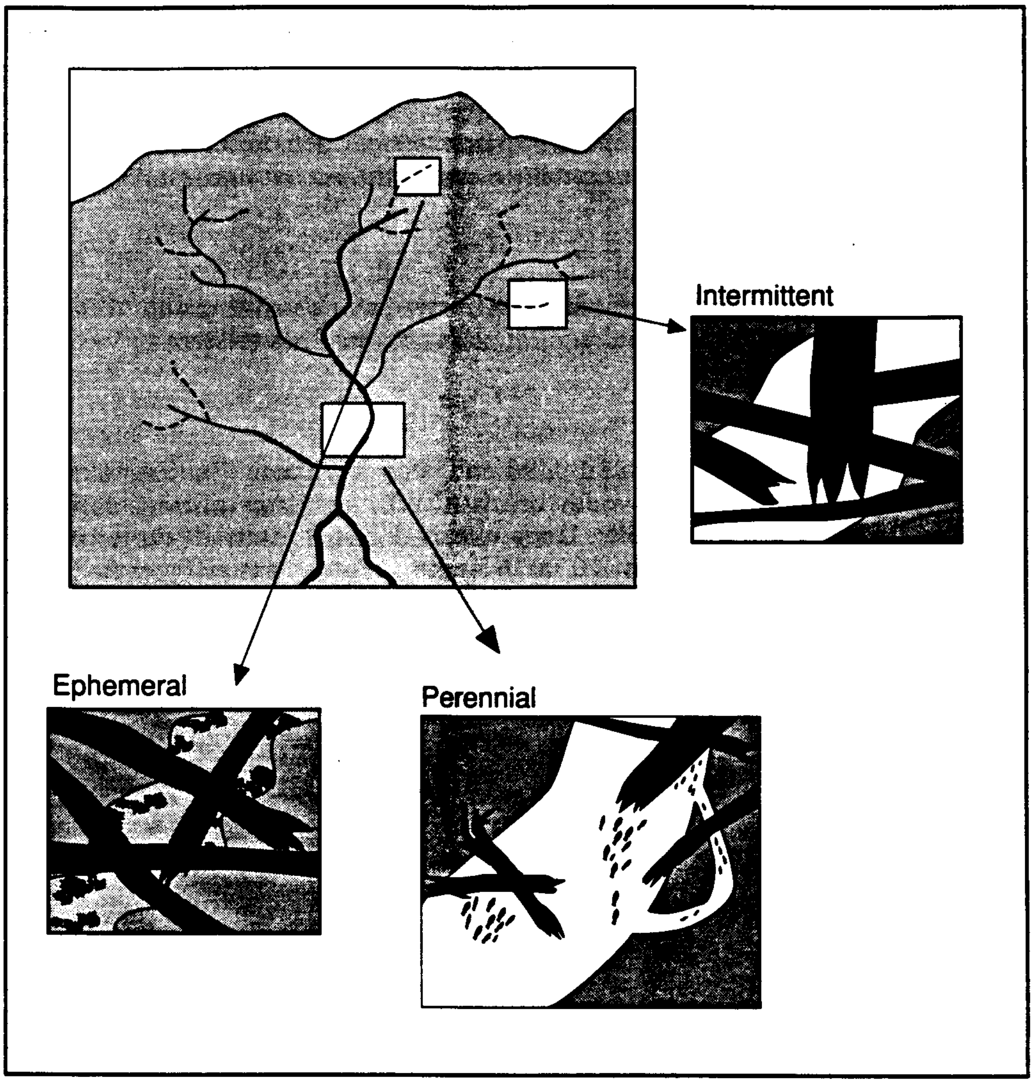
Class III Streams
Any perennial streams not meeting the criteria for Class I or II streams (Fig. 3).

Class IV Streams
Any intermittent or ephemeral streams not meeting the criteria for Class I, II, or III streams (Fig. 3).

Cumulative Effects
Effects on the environment resulting from individually minor but collectively significant events taking place over a period of time or space.

Ephemeral Streams
Streams carrying surface runoff only during or immediately after a rainstorm or snowmelt. Channels are not well defined, and usually are covered with a litter layer characteristic of the surrounding forest (Fig. 4).

Figure 4. Location and characteristics of perennial, intermittent, and ephemeral streams within a drainage.



Floodplain
Relatively flat surfaces adjacent to active channels, formed by deposition of sediment during major flood events (Fig. 2). Some floodplain areas are inundated only during extremely large, infrequent floods. Floodplain boundaries are defined by the break in slope between the hillsides and the relatively flat floor of the river valley.

Intermittent Streams
Streams that carry water most of the year, but do not flow during part of summer. In contrast to ephemeral streams, during summer low flow these channels are obviously dry stream beds (Fig. 4).

Perennial Streams
Streams that normally flow year long and have well defined channels (Fig. 4).

Riparian Area
The aquatic ecosystem and the portions of the adjacent terrestrial ecosystem that directly affect or are affected by the aquatic environment. This includes streams, rivers, and lakes and their adjacent side channels, floodplains, and wetlands. The riparian area includes portions of hillslopes that serve as streamside habitats for wildlife.

Riparian Management Zone
Site-specific boundaries established to meet riparian management objectives in riparian areas. Riparian management zones are contained within but do not necessarily include the entire riparian area (Fig. 1).

Wetland
Areas covered by shallow water or periodically saturated by the water table. Wetlands generally have wetted (hydric) soils and support plant communities tolerant of water-saturated soils (hydrophytes).

Woody Debris
Dead woody material usually composed of boles and large branches. Various terms, such as large woody debris (LWD), coarse woody debris (CWD), and large organic debris (LOD), have been used to describe this material. **Large woody debris** is material greater than 20 inches (50 cm) in diameter and 33 feet (10 m) in length. Woody material greater than 4 inches (10 cm) diameter and 3 feet (1 m) in length but less than 20 inches (50 cm) in diameter and 33 feet (10 m) in length is considered to be **small woody debris** and consists of small trees, tops of large trees, and large branches. Small branches, twigs, and slash from logging operations less than 4 inches (10 cm) diameter and 3 feet (1 m) in length are considered **fine woody debris**.

Additional definitions are included in the Glossary (Chapter VIII).

CHAPTER 2

RIPARIAN RESOURCE VALUES

The Willamette National Forest (WNF) encompasses approximately 1.7 million acres of land. Of this total, riparian areas along perennial streams, lakes, and wetlands comprise approximately 100,000 acres, or 6% of the WNF (Table 1). Despite this small acreage, riparian areas provide numerous economic, social, and ecological benefits to the Forest (Fig. 5).

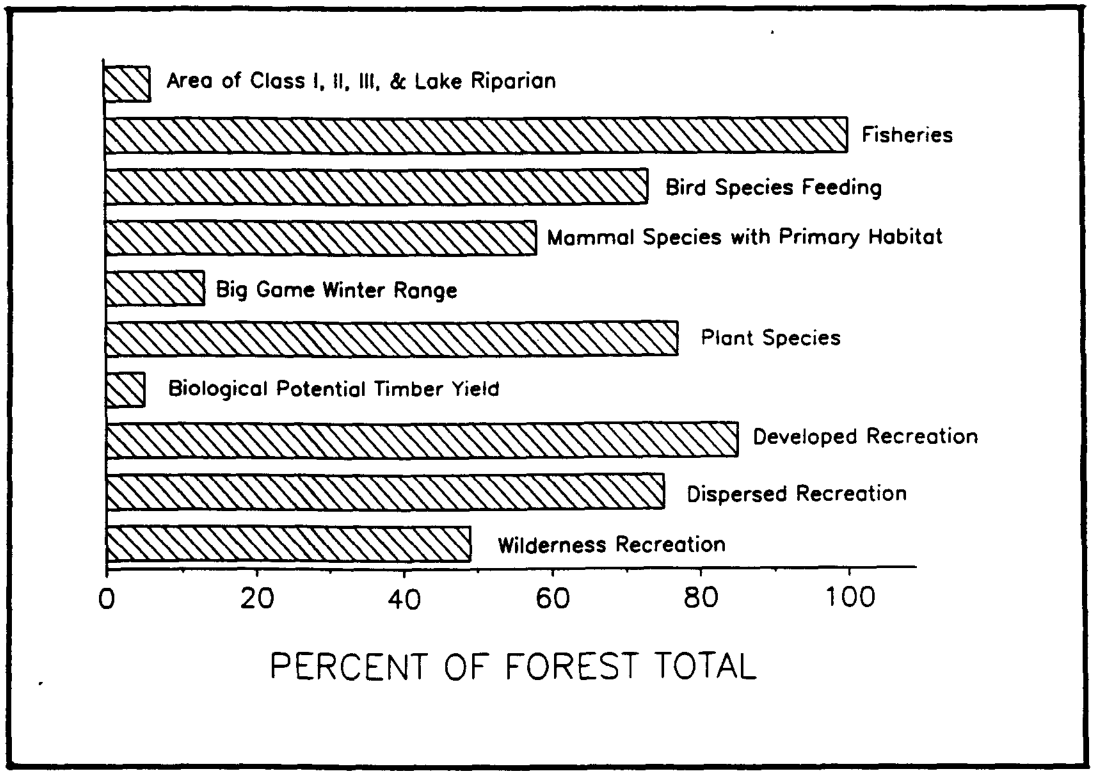
Riparian areas include six major categories of resources:

- water quality
- fish
- wildlife
- vegetation
- timber
- recreation

Table 1. Riparian management zone acreages in different habitat types on the Willamette National Forest. Riparian widths include both sides of the stream; these values are used in FORPLAN. Acreage for Class IV streams was not determined.

Habitat Type	Length (miles)	Riparian Width (feet)	Riparian Habitat (acres)
Streams			
Class I	426	400	19,496
Class II	940	200	21,252
Class III	1,295	200	29,627
Class IV	6,621		
Lakes	270 (shoreline)	150	4,457
Wetlands			23,950
TOTAL			98,782

Figure 5. **Proportion of selected forest resource uses located in riparian areas of the Willamette National Forest.**



WATER QUALITY

Intact riparian areas along streams and lakes provide buffers from natural and man-caused disturbances, thereby ensuring good water quality. Activities in small headwater streams and lakes potentially affect water quality in downstream areas.

Water Temperature

One of the most obvious effects of riparian areas on water quality is regulation of water temperature. Small undisturbed headwater streams are often completely shaded by riparian vegetation. Such small streams contribute cool water to more open downstream regions. Sources of cold water throughout a basin are vital to other important resources such as native fish populations. Therefore, shading by riparian area vegetation throughout a drainage basin is essential, particularly during summer low flows.

Stream temperature in an individual logged unit is rarely more than 2°F warmer than adjacent forested reaches in the WNF. However, the combined impacts of temperature increases in all recently harvested units within a basin may lead to significant warming of downstream reaches, adversely affecting native fish populations. At warmer water temperatures, salmonids become more susceptible to disease. In addition, they may suffer indirect mortality from competition with other fish species that tolerate warmer water, such as suckers and minnows. Most native fish species will not survive if water temperatures exceed 70°F for extended periods. Consequently, small increases in water temperatures may lead to an overall decline in salmonid populations.

Sedimentation and Turbidity

Riparian areas act as buffers and filters of suspended sediments. The abundant and diverse plant communities of intact riparian areas help ensure a source of water low in suspended sediments and turbidity.

Throughout a drainage basin, plant roots and large woody debris accumulations in intact riparian areas stabilize lakeshores, streambanks and hillslopes. This in turn reduces sediment input into lakes and streams. During floods, riparian areas dissipate the water's energy, causing suspended sediments to settle out instead of being transported farther downstream. Riparian areas with broad floodplains act as additional storage sites for sediment and water.

Although these processes operate throughout a drainage basin, they can be of critical importance in small intermittent or ephemeral headwater streams . The relative stability of these channels can significantly affect the amounts of sediment transported by the stream. Woody debris maintains the stair-step structure of steep stream channels, which is essential for trapping sediments and reducing the water velocity.

Mature riparian forests and large woody debris in streams can also serve to limit the downstream impacts of mass failures/debris torrents, particularly in headwater streams. Streamside forests reduce the potential for local failures, and downstream riparian stands intercept and impede the flow of sediment and debris. Boles of trees swept into the flow provide "reinforcement" and may reduce the length of the debris flow deposits.

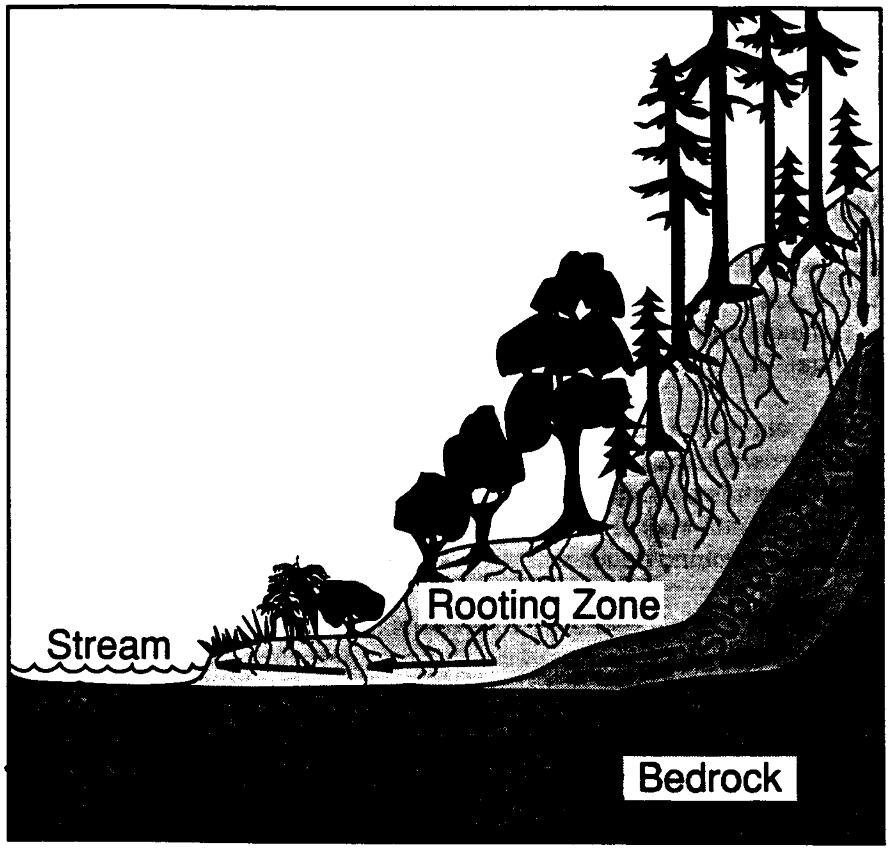
Increased suspended sediment and turbidity are major issues in water quality degradation associated with management activities in the Pacific Northwest. Sources of increased sediment load include both immediate harvest practices on site and associated forest-wide activities, such as road building. The largest source of sediment inputs is failure of poorly constructed roads. These increases in sedimentation reduce potability to downstream users and may cause serious damage to fish and wildlife resources. Although many of these activities occur in small headwater streams, the turbid waters flow downstream, eventually affecting larger streams.

Sediment deposition over stream beds or lake bottoms reduces the habitat available for aquatic insect communities. Even at relatively low levels, fine sediments deposited in fish spawning areas can kill eggs or emerging fry. At higher concentrations, suspended sediments can damage fragile gill tissues of fish. Management practices that increase sediment loads to streams and lakes have obvious deleterious effects on fish.

Nutrients

Riparian areas are both sources and storage sites of nutrients needed by aquatic and terrestrial ecosystems. These areas transform important nutrients, such as nitrogen, into forms used by both terrestrial and aquatic organisms. Riparian vegetation regulates the timing of nutrient input into lakes and streams. For example, when nutrients are lost from a hillslope after clearcutting, an intact riparian zone can intercept, store, and eventually release them, thereby preventing or delaying loss of these essential compounds.

Figure 6. **Movement of dissolved nutrients through soil into the subrooting zone and subsequent routing downslope through the rooting zone of the riparian area.**



In addition to regulating this lateral uptake of nutrients, riparian areas are important filters along a river drainage (Fig. 6). Complex channel structure, particularly in the vicinity of debris dams, reduces water velocity and increases the time available for nutrients to be used by aquatic and nearby terrestrial plants. The off-channel habitats provided by broad floodplains retain nutrients more effectively than the main channel.

FISH RESOURCES

Intact riparian areas provide fish with good water quality, food, and necessary habitats for all stages of their life cycles. The WNF contains significant populations of approximately thirty species of fish, including anadromous, resident, native, and introduced species. The native anadromous fish include spring chinook and winter steelhead. Native resident fish species found on the Forest include rainbow, cutthroat, and bull trout, and non-game species such as chiselmouth, redside shiner, several sculpins, and the Oregon chub. The Oregon chub may be proposed for listing as a threatened or endangered species under the Federal Endangered Species Act. Some stocks are found only in the WNF, such as the McKenzie redside rainbow and the Hackleman Creek cutthroat trout. Also, several species have been introduced over the years to provide a sport fishery, including kokanee (a landlocked sockeye salmon), brown trout, brook trout, crappie, bass and brown bullhead. These introduced species generally are limited to reservoirs and lakes.

Habitat

Fish require adequate habitat at all stages of their life cycle. For reproduction, all salmonids need areas with continuous water flow and gravel substrates . The fertilized eggs incubate within redds (nests) excavated in these spawning gravels. At this stage of the life cycle, fish embryos are vulnerable to suffocation by deposition of fine sediments. Accumulations of silt also may block the emergence of young fish out of the redds.

Edges of stream channels are particularly important habitats because stream energy decreases in the shallow, low velocity margins (Fig. 7). Young fish are found almost exclusively in stream margins, backwaters, and side channels, particularly those with protective cover. These lateral habitats contain much higher amounts of algae and dead organic matter than main channel habitats. As a result, aquatic insects are approximately six times more numerous than in main channels. As flood waters rise, these areas also provide cover and low velocity refuge for adult and juvenile fish. The braided channels common in broad floodplains increase this edge habitat.

In streams, adult fish are most frequently found in pools. Pool habitats are both a refuge from stream flow and a source of easily captured food from drifting invertebrates. However, in order to be effective fish habitat, pools must also have cover for refuge from both predators and floods.

Large woody debris creates pools, stores sediment and organic matter to control water quality, traps spawning gravels, and provides fish with cover in both lakes and streams. Different size classes of wood play different roles in stream ecosystems. Very

Figure 7. Backwater and edge habitat created by wood and boulders along stream margins.

large logs are key stabilizers in lateral accumulations and debris jams. Intermediate sizes may serve the same function in smaller channels, but in larger streams they form the interlocking structure of debris accumulations. Smaller pieces of wood, such as branches, twigs, and broken pieces, create "sticky wickets" that trap leaves and sediments.

Riparian areas around lakes also provide critical fish habitat. Trees that fall into lakes supply cover for fish in shallow shoreline areas and serve as habitat and food for aquatic invertebrates. Lake tributaries and shoreline habitats are used for spawning and rearing of juveniles. Delivery of sediment or changes in water temperature around these areas can affect lake fish populations significantly.

Food

Riparian area vegetation exerts a strong influence on the amounts and types of food available to invertebrates and thus to fish. Most fish in streams and lakes of the WNF are predators, depending on aquatic insects and other invertebrates for their food. In small, shaded streams, this invertebrate community is dependent on riparian leaf and needle inputs for its food base. Conifer needles are low in food quality but are abundant and enter the stream year round. Deciduous leaves, on the other hand, are higher in food quality but enter the stream only during a short period in autumn. The combination of the two leaf litter types provides a stable, diverse food base for aquatic invertebrates (Fig. 8). In larger open-canopy streams and lakes, aquatic invertebrates also feed on algae growing in the stream, which is much less abundant than terrestrial litter but is a more nutritious food. Along lakes, the vegetation near the shoreline, whether from tree leaves or grasses, provides an important food base.

Figure 8. **Aquatic insects, such as this caddisfly larva, are common food items for fish in streams of the Willamette National Forest.**

Maintaining this food base in streams requires the presence of wood. Without the complex filters created by debris accumulations, leaves entering the stream quickly move out of the system before being eaten by insects. The wood itself also supplies a low-quality but long-lasting source of organic matter.

WILDLIFE RESOURCES

The abundant and diverse plant communities of riparian areas provide stable and complex habitats needed for wildlife in the WNF. Of the wildlife species found on the Forest, approximately 90% use riparian areas associated with streams, lakes and wetlands for some portion of their life history; 10% are found exclusively in riparian areas (see Appendix I).

Habitat

Riparian areas provide habitat for thermal cover, foraging, hiding, resting, breeding, and rearing. Species such as dippers, kingfishers, beavers, river otters, muskrats, Pacific giant salamanders, and water shrews depend primarily on riparian areas to fulfill all of their habitat requirements.

Figure 9. Elk feeding in grass and herb communities found along streams and rivers.

Riparian vegetation buffers temperature and humidity extremes, thereby creating favorable microclimates. In summer, riparian areas are cooler and more humid than uplands. In winter, riparian areas are less exposed to wind than ridges and upper slopes, and snow depths are less. Consequently, species from elk to salamanders find thermal refuges in riparian areas (Fig. 9).

The dense vegetation, complexity of landforms, and presence of water combine to provide hiding and resting cover. Small mammals and birds use the dense thickets along streams and lakes as refuges from predators. Waterfowl require riparian vegetation for resting places and for protection during severe weather. Small mammals such as water shrews and voles depend on the cover and increased habitat heterogeneity provided by large downed timber in riparian areas. Wetlands provide specific habitat for small amphibians.

Riparian areas are important fawning areas for big game mammals, denning habitats for small mammals, and nesting sites for many species of songbirds. Ospreys and bald eagles build their nests in tree snags along lakes and large rivers. Cavity-dwelling birds, which nest in standing dead trees, are a significant component of riparian wildlife communities. Waterfowl use lake margins and wetlands as nesting sites, and species such as harlequin ducks and mergansers nest along steep mountain streams.

Riparian areas are continuous corridors across the landscape, providing natural migration routes for many species, such as ruffed grouse, bats, and beaver. Big-game species, such as elk and deer, use riparian areas as they migrate between summer and winter habitats.

Figure 10. Riparian areas are essential habitats for fish-eating birds, such as the kingfisher.

Food

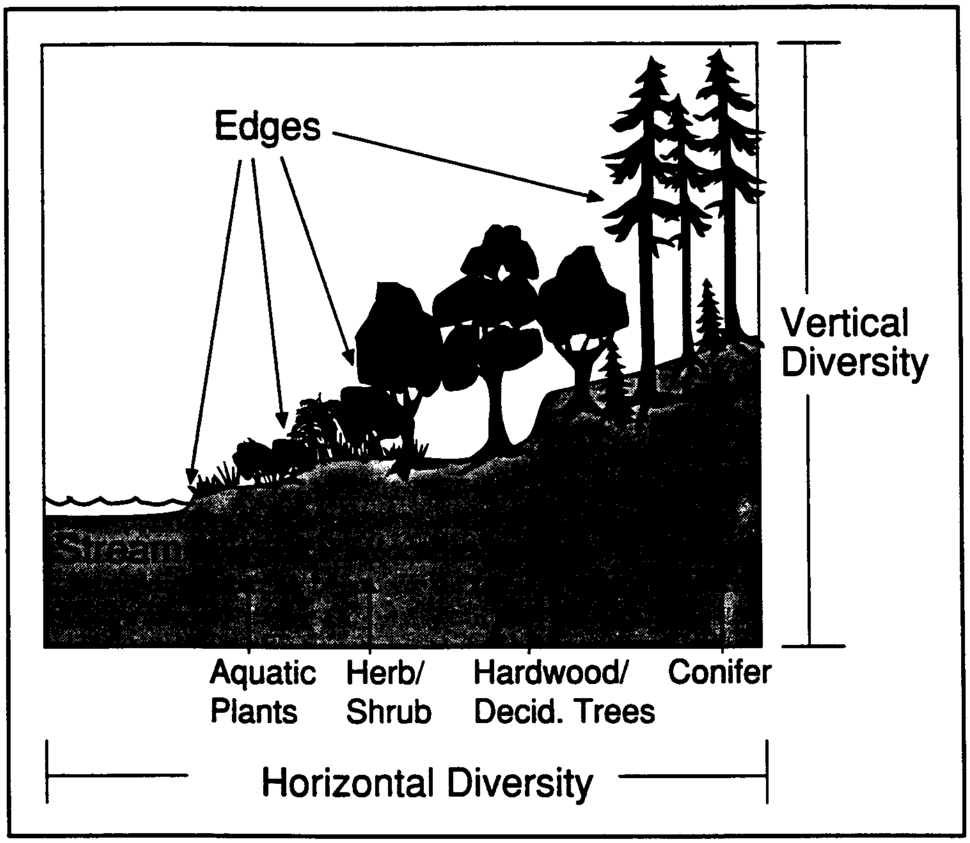
The same complexity and diversity of vegetation and landform also provides rich sources of many types of food. Herbivores encounter a wide array of herbaceous, shrubby, and woody plants in riparian areas. Species as diverse as deer, snakes, beavers, bats, woodpeckers, herons and cougar all depend on the riparian area for food. The emerging adult aquatic insects from streams, lakes, and wetlands are predictable food sources for insectivorous amphibians, birds, and mammals. Some species, such as kingfishers, dippers, otters, and salamanders, are totally dependent on aquatic organisms as a source of food (Fig. 10). Riparian areas also are critical sources of drinking water for most wildlife species.

TERRESTRIAL VEGETATION

Riparian areas are critical contributors to plant diversity in forest ecosystems of the WNF. Much of this diversity stems from the complex array of gravel bars, islands, and floodplains present in the riparian area. These topographic features vary in disturbance frequency, substrate composition, soil moisture content, nutrient regime, depth to water table, and distance from water. Different successional stages of plant communities occur in a mosaic of patches in the riparian area (Fig. 11). Because of this patchiness, the number of plant species in riparian forests is twice that of hillslope forests. Recent studies in the WNF have found a range of 19-32 plant species in upslope communities. In contrast, adjacent riparian areas had 51-107 species. Wetlands, such as bogs, seeps or marshes, often contain unique associations of plants, and may harbor rare species.

Figure 11. Stream channels and floodplains contain complex mixtures of herbaceous, deciduous, and coniferous plant communities.

Figure 12. **Horizontal and vertical diversity created by the normal sequence of plant communities extending from the active channel to the lower hillslopes.**



These diverse plant communities associated with numerous channel and floodplain surfaces along a river valley increase horizontal complexity. Downed logs and other woody debris, which originate from the riparian and hillslope stands, also contribute to horizontal structural complexity. The numerous patches of herbs, shrubs, deciduous and coniferous trees, and standing dead snags also create a multilayered canopy, leading to high vertical diversity (Fig. 12). In addition, openings over streams, lakes, and wetlands provide distinct gaps or natural breaks in the forest canopy (Fig. 13). The complexity of riparian plant communities is mirrored in the high numbers of animal species, both aquatic and terrestrial, dependent on the riparian area.

During catastrophic wildfires, riparian plant communities may have a higher survival rate than nearby hillslope areas. The higher humidities and damper soils adjacent to lakes and streams may help protect plants in these areas, particularly the larger conifers. As a consequence, stringers of old, large trees may be found even in previously burned riparian areas. Riparian forests may play critical roles in recolonizing upland forest communities.

TIMBER

Riparian areas are often considered the most productive areas for timber within a watershed. Although some of the largest individual trees are found here, much of the riparian area includes unsuitable or damage-prone growing sites for commercially valuable tree species. Riparian soils are poorly developed assortments of stream sediments, flood

Figure 13. Opening in the forest canopy created by the stream channel.

deposits, and decaying riparian litter. Rooting zones are frequently inundated by elevated water tables. During floods, streamside trees are battered, and young trees are frequently uprooted or buried. Undercut and oversteepened streambanks often increase the rate of mortality of streamside trees.

Recent research in the WNF indicates that riparian management zones contain timber volumes less than 75% of those found in mature upslope forests (Table 2). Riparian areas contain potential timber resources, but the ecological values of riparian trees for riparian-dependent resources must be considered before their commercial timber value.

Table 2. Examples of timber volumes in riparian areas and hillslopes within the Willamette National Forest.

SITE	BASIN	TOTAL BASAL AREA (ft^2/ac) RIPARIAN	UPSLOPE	STOCKING RATIO RIPARIAN/HILLSLOPE
Mack	McKenzie	260	346	75%
French Pete	McKenzie	217	305	71%

RECREATION

Recreational use is concentrated in riparian areas, where scenic values are high. Up to 80% of the WNF's dispersed recreation occurs in the riparian area. A wide range of recreational activities depends on healthy riparian areas, including picnicking, hunting and fishing, wildlife viewing, and white-water boating (Fig. 14). Almost all campgrounds in the WNF are located within riparian areas, and most remote campsites in wilderness and general forest are also located along streams and lakes.

Conflicts between recreation and ecological values of riparian areas are inevitable because of high use. For example, roads have been constructed along streams, rivers, and lakes in many drainages of the WNF. Although these roads provide public access to many miles of riparian areas, they impair other riparian resource values, such as fish and wildlife habitat within floodplains.

Boating use on large streams, rivers, lakes, and reservoirs is another common conflict between recreation and other riparian resources. Woody debris jams and floating logs are hazards for rafts, kayaks, and motorized boats, but this debris is ecologically essential. Compromises between safety and ecological value are inevitable, particularly in Wild and Scenic Rivers.

Figure 14. Recreational use of riparian resources.

SUMMARY

Intact, mature riparian areas serve a major role in the maintenance of numerous forest-wide resources. Riparian areas also draw more people for recreation than any other area in the WNF. Their protection and rehabilitation are essential for the continuation of these resource values. Moreover, continuous corridors of intact riparian areas must be maintained throughout the WNF: they cannot exist as isolated fragments and still perform their diverse functions. Managers must carefully consider riparian management throughout drainage basins and over the forest landscape. Riparian areas provide the critical links among an array of different forest-wide resource values.

CHAPTER 3

LANDSCAPE MANAGEMENT

The primary goal of riparian management is to provide self-sustaining streamside forests that will ensure the desired conditions of riparian resources for the future. Effective riparian management takes advantage of the natural ability of terrestrial and aquatic ecosystems to sustain their structure and function. Land use practices that maintain the natural patterns and dynamics of riparian communities across the Willamette National Forest can minimize long-term degradation of riparian resources.

Continuous corridors of riparian forests also provide essential connections between different management areas distributed throughout the WNF (Fig. 15). For example, the array of interior old-growth forests can be continuously linked along the mature to old-growth forests within riparian management zones. These riparian zones can also serve are corridors for the dispersal of plants and animals between harvested watersheds, roadless areas, wilderness areas, special habitat management areas, and designated recreational lands. No other landscape feature within the National Forest offers the natural continuity of riparian areas.

Figure 15. Patterns of river valleys dissecting forested landscapes in the WNF. Notice the continuity from ridgelines to lower valleys along the stream network.

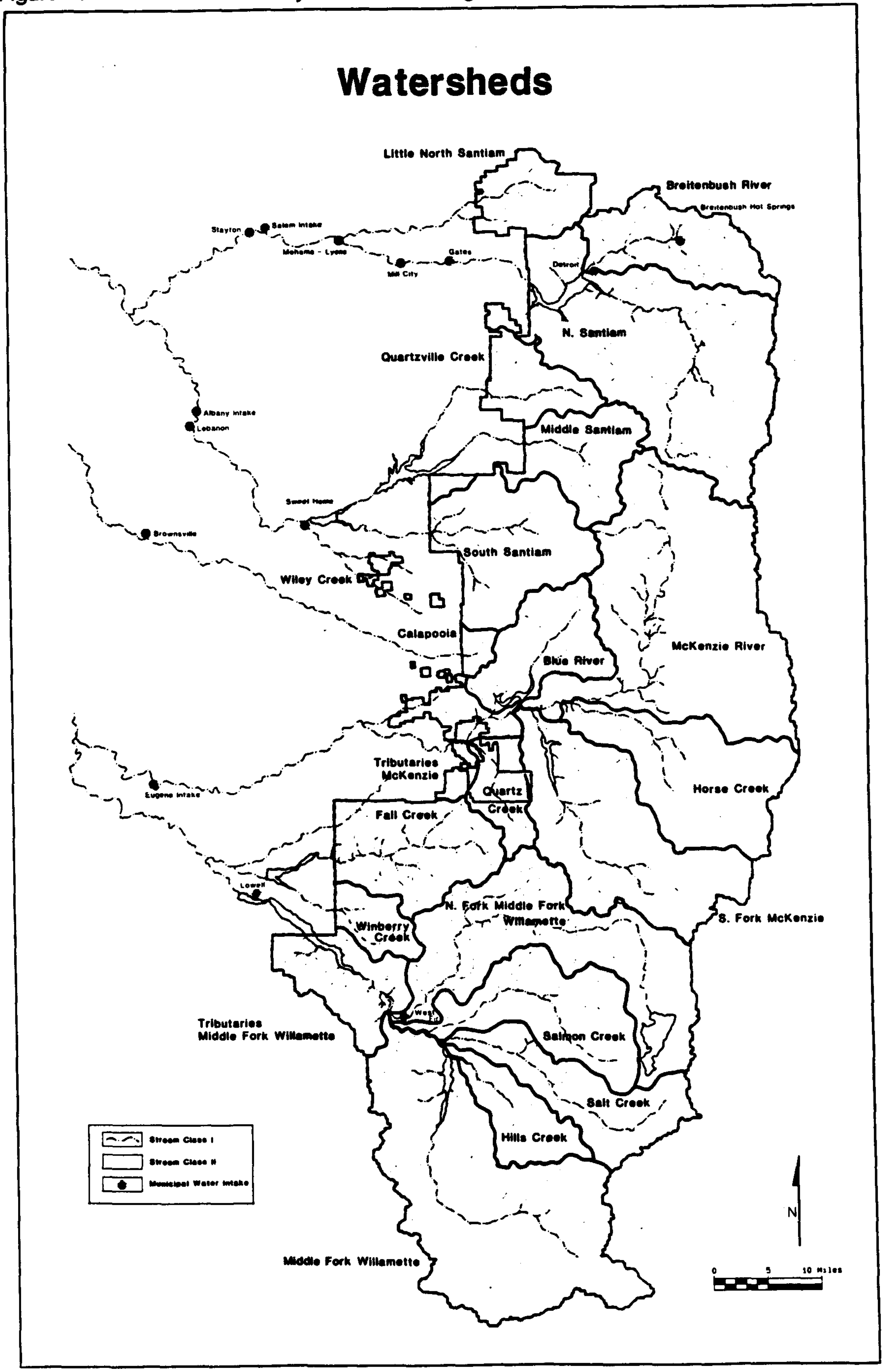
The landscape of the WNF encompasses six major river drainages that flow into the Willamette River (Table 3 and Fig. 16):

North Santiam River
Middle Santiam River
South Santiam River
McKenzie River
North Fork of the Middle Fork of the Willamette River
Middle Fork of the Willamette River

Table 3. **Miles of stream classes contained in the drainages within each of the WNF Districts.**

District	Basin Name	I	II	III	Total
Detroit	Little North Santiam	9.7	20.2	29.9	59.8
	Breitenbush	17.6	47.5	39.6	104.7
	North Santiam	41.4	103.8	127.7	272.9
Sweet Home	Quartzville Cr.	9.7	22.0	21.1	52.8
	Middle Santiam	20.2	47.5	54.6	122.3
	South Santiam/Canyon	19.8	44.9	46.6	111.3
	Calapooia/Wiley Cr.	2.6	6.2	7.0	15.8
Blue River	Blue River	22.0	59.9	44.0	125.9
	South Fork McKenzie	29.9	66.0	75.7	171.6
	Lower McKenzie Tribs	2.2	9.7	7.0	18.9
	Quartz Cr.	2.2	5.3	11.4	18.9
McKenzie	McKenzie	40.9	9.7	19.3	69.9
	Horse Cr.	18.5	8.8	13.2	40.5
Lowell	Fall Cr.	37.0	76.6	96.8	210.4
	Winberry Cr.	6.6	25.5	19.4	51.5
	Middle Fork Willamette Tribs	10.1	56.3	46.6	113.0
Oakridge	N. Fork Middle Fork Willamette	47.5	88.8	126.8	263.1
	Salmon Cr.	28.2	50.2	102.1	182.2
	Salt Cr.	26.4	37.8	67.7	132.0
Rigdon	Hills Cr.	6.2	25.5	51.0	85.4
	Middle Fork Willamette	27.3	128.4	242.0	439.1
Total		426.0	940.6	1249.5	2662.0

Figure 16. **Watersheds and major stream drainages** of the Willamette National Forest.



Each river drainage can be divided into smaller sub-drainages or basins, based on topography, geology, and channel characteristics. A basin represents collections of smaller watersheds, ranging from 20 acres to more than 5,000 acres, that collectively serve as the source for a major perennial stream. A specific harvest unit normally occupies only a portion of a particular watershed.

Effective land management maintains the ecological linkages of riparian resources throughout the forest landscape. Simply focusing on individual harvest units or small watersheds may jeopardize the continuity of riparian corridors and the long-term integrity of riparian resources. Management of forest landscapes must identify and retain the natural patterns of riparian resources at scales ranging from specific harvest sites to multiple river drainages. Influences of forest management on riparian resources also spans time scales ranging from immediate post-harvest effects to long-term changes in valley floor forests and geomorphology over centuries.

LANDSCAPE PATTERNS

Corridors of streamside forests are prominent features of the mountainous landscapes of the Pacific Northwest, forming continuous bands of alternating broad floodplain valleys and narrow canyons (Fig. 17). The patterns of riparian resources along the river valleys are created over several centuries by succession of riparian forests and the development of river channels during major floods. Numerous small streams from the steep headwaters supply cold water, sediments, nutrients, and biota to the lower rivers. Floods and landslides reshape channels and create mosaics of streamside forests.

Figure 17. **Riparian corridors** in the Willamette National Forest connect the sequences of different valley floor landforms and associated streamside forests.

As forest landscapes are changed by land use practices, catastrophic disturbances, or climate change, riparian areas serve as natural routes for the routing of water and sediment and the dispersal of plants and animals. Transport of water, suspended matter, and organisms from headwaters to lowlands is a conspicuous function of streams and rivers. Upstream transport and dispersal also occurs, either through active movement of organisms or passive transport of propagules and material. The rich pool of plant and animal species and moderate microclimate enhance the role of riparian areas in dispersal across the landscape. This ecological function is even more critical when fire, winds, or other disturbances alter upslope forests more than those associated with streamsides.

Patterns of riparian areas in forest landscapes are apparent to resource specialists and nonprofessional observers alike. Intricate networks of streams and rivers link even the highest and most remote areas of the forest to the lowlands (Fig. 18). In addition, the unique topography and environment of river valleys alter patterns of terrestrial disturbances such as wildfire and insect outbreaks. No other landscape feature rivals the importance of riparian forests in linking forest resources and the multitude of land use designations across the WNF (see Tables 4a and 4b). Riparian management zones contribute essential elements of continuity for policies to minimize fragmentation of the forest.

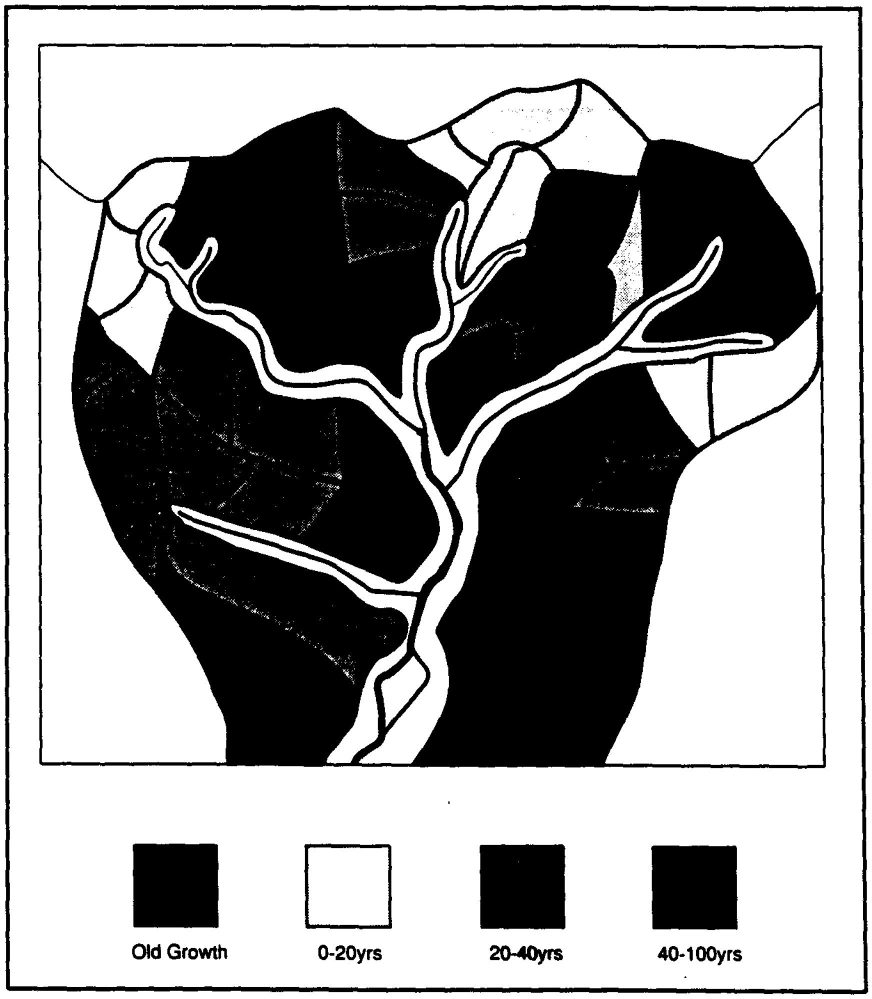


Figure 18. Patchwork of timber harvest units of different ages connected by riparian corridors within a river drainage

Table 4a. **Corridor types used to maintain connectivity within. Note that types V, VI, and VII are riparian areas.**

Corridor Type	Width	Management Areas
I	Variable: 1 mile+	Most no-harvest areas
II	1/2 - 1 mile	Middleground visual
III	1/4 - 1/2 mile	Foreground visual, Wild & Scenic Rivers
IV	100 - 800 feet	Trails
V	400 feet	Class I Riparian
VI	200 feet	Class II Riparian
VII	175 feet	Class III Riparian
VIII	Variable: 50 - 500+ feet	Unsuitable Lands

Table 4b. **Forest functions dependent on corridor connectivity.**

	Corridor Type							
Corridor/Access Needs	I	II	III	IV	V	VI	VII	VIII
Motorized Access:								
Non-destination & Developed		X	X					
Non-Motorized Access:								
Dispersed & Wilderness	X			X	X	X	X	X
Big Game:								
Optimal Cover	X	X	X	X	X			X
Travel & Forage	X	X	X	X	X	X	X	X
Mobile Interior Stand Species:*								
Dispersal & Forage	X	X	X	X	X	X	X	X
Breeding	X	P/M	P/M		P/M	P		
Immobile Interior Stand Species:								
Animals & Plants	X	X	X	?	X	X	X	X
Water Dependent Species								
Animals & Plants				X	X	X		

* Mobile interior species are Spotted Owls, Pileated Woodpecker (P) & Pine Marten (M).

LONG-TERM CHANGES IN FORESTS

Consideration of broader spatial scales in landscape management also requires broader temporal scales over which processes such as forest succession and channel development operate. From the perspective of human lifetimes or forest rotations, we often think of 10-100 years as "long-term". However, the ages of natural coniferous forest of the Pacific Northwest commonly exceed periods of 300-600 years. Over that interval of time, streamside forests will change successionally from young stands of shrubs and deciduous trees to stands dominated by young conifers. After more than a century, stands of mature conifers will begin to develop characteristics of old-growth forests as mortality creates gaps. Even the 60- to 100-year rotations of current forest management only cover a fraction of the natural age of typical forest stands in the WNF.

Geomorphic processes operating over the last several thousand years have shaped the landforms of river valleys in the WNF. Rare flood events that occur at intervals of several decades to centuries are largely responsible for creating the channels of streams and rivers. Floods in the Willamette National Forest since 1964 have been relatively minor. During that same 25-year period, approximately 226,000 acres of the Forest has been clear-cut, and the most recent timber harvests have occurred in the steeper headwaters. Within the next rotation, it is probable that the WNF will experience floods far larger than those of recent decades. Riparian forest conditions along streams and on floodplains during such rare flood events will determine the stability of stream channels and riparian communities.

Over the last century, forests of the WNF have been exposed to gradual changes in CO_2, atmospheric pollutants, point-source and non-point-source discharges into streams, and possible climate change. Timing of these events has ranged from acute, immediate impacts to barely perceptible change. The future integrity of the forest and stream ecosystems depends heavily on our ability to recognize and respond to environmental change. Monitoring programs are essential for detecting shifts in the status of forest and streams. Management of riparian resources across the forest must maintain intact functional ecosystems with sufficient continuity for the dispersal of organisms and resources.

MARGINS FOR UNCERTAINTY

All land management entails a certain degree of uncertainty, and is likely to change its focus or practices over time. Consequently, some margin for risk for future planning must be included in riparian management policies. Certain ecological values can be provided by intensive site management, but margins for error are narrow and management costs are high. Maintaining continuous riparian areas and floodplains dominated by mature and old-growth forests provides options for future management.

Region 6 of the U.S. Forest Service is currently reviewing current management practices in terms of minimizing fragmentation of forests. Riparian areas are the major landscape component providing continuity among intact core areas throughout the forest. A no-harvest riparian management policy over much of the forest is a fundamental component of forest-wide policies to minimize forest fragmentation.

The U.S. Forest Service has identified the unique ecological importance of riparian resources and floodplains and has established national policies to guarantee their integrity. Throughout the United States, forest policy states that riparian-dependent resources receive first priority in forest management along streams, lakes, and wetlands. Removal of riparian vegetation for timber harvest must be justified, both ecologically and administratively. Given the high value of riparian resources on the Willamette National Forest and the associated administrative and economic benefits, a no-harvest riparian management policy provides accurate planning, increases effective land management, and maintains a diverse array of options for future forest management. Management of riparian resources at a landscape level not only insures effective management of water quality, aquatic resources, and wildlife resources but also provides essential elements for integrated management of traditional forest resources.

CONCLUSIONS

Over the long time frames of geomorphic processes and forest succession, issues of forest fragmentation, catastrophic disturbances, and cumulative effects are no longer hypothetical questions. These environmental changes are inevitable consequences of patterns imposed on the landscape and occurrence of infrequent but highly probable events. The major questions facing land managers are not whether these processes will occur but rather what the rate and magnitude of change will be.

An ability to develop a broader landscape context for site-specific forest practices will shape the future riparian forests. Continuity of intact riparian forests should be maintained throughout drainages. Entire floodplains must be managed to function during the large flood events that occur several times (50-100-year intervals) throughout a forest rotation (Fig. 19). Managers must understand the processes of regeneration, growth, and mortality that determine the unique stand dynamics of riparian forests. These challenges require new and broader perspectives of our forests and streams but across the landscape of the Forest.

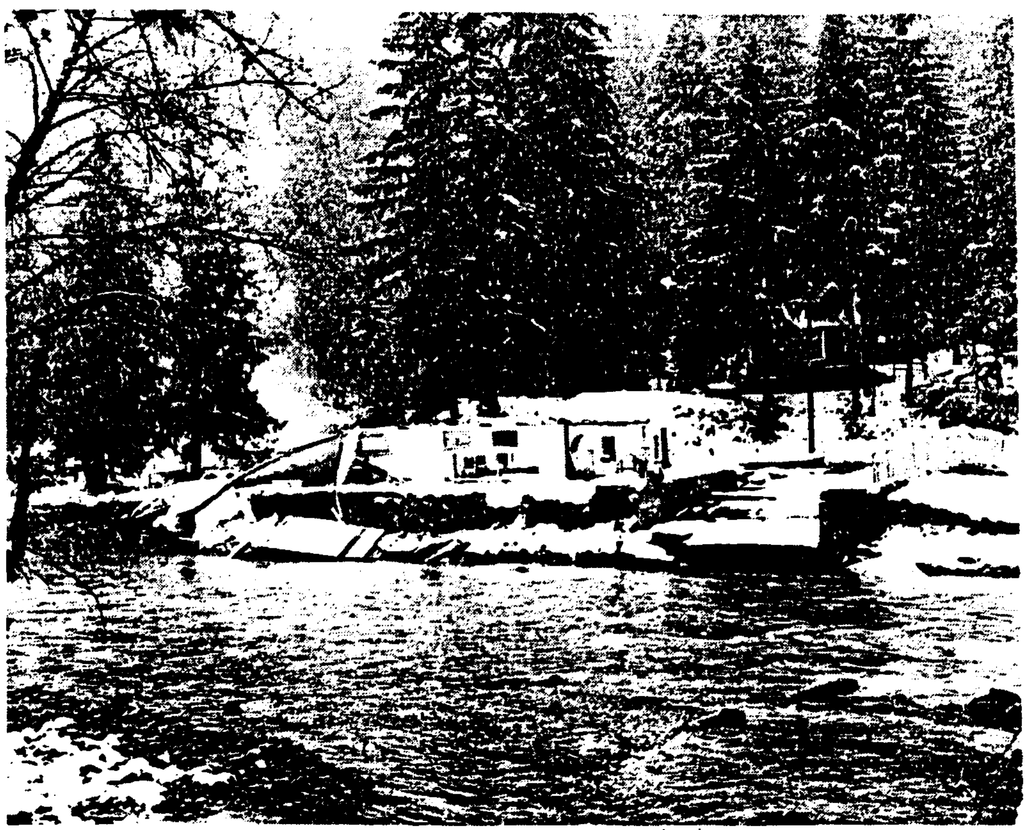


Figure 19. **Aftermath of the 1964 flood** in the Willamette National Forest.

CHAPTER 4

BASIN MANAGEMENT

BASIN STRUCTURE AND FUNCTION

Basins are made up of smaller watersheds linked by riparian corridors. Through the continuity of riparian areas and streams, processes in both upper hillslopes and headwater areas influence downstream regions. Floods sculpt existing channels and deposit sediments on floodplains. These floods alter development of riparian plant communities and provide fresh surfaces for plant colonization.

Geomorphic processes determine the shape and size of stream valleys and consequently the structure of riparian areas. Adjacent hillslopes may locally restrict river valleys, but broad valleys may allow development of extensive floodplains in other areas. Within a basin, local landforms greatly alter the hydraulics, channel morphology, and floodplains in successive downstream reaches.

Stream channels and valley floors may be **constrained** by geomorphic features such as bedrock, hillslopes, earthflows, or alluvial fans (Fig. 20). Such streams and valleys will

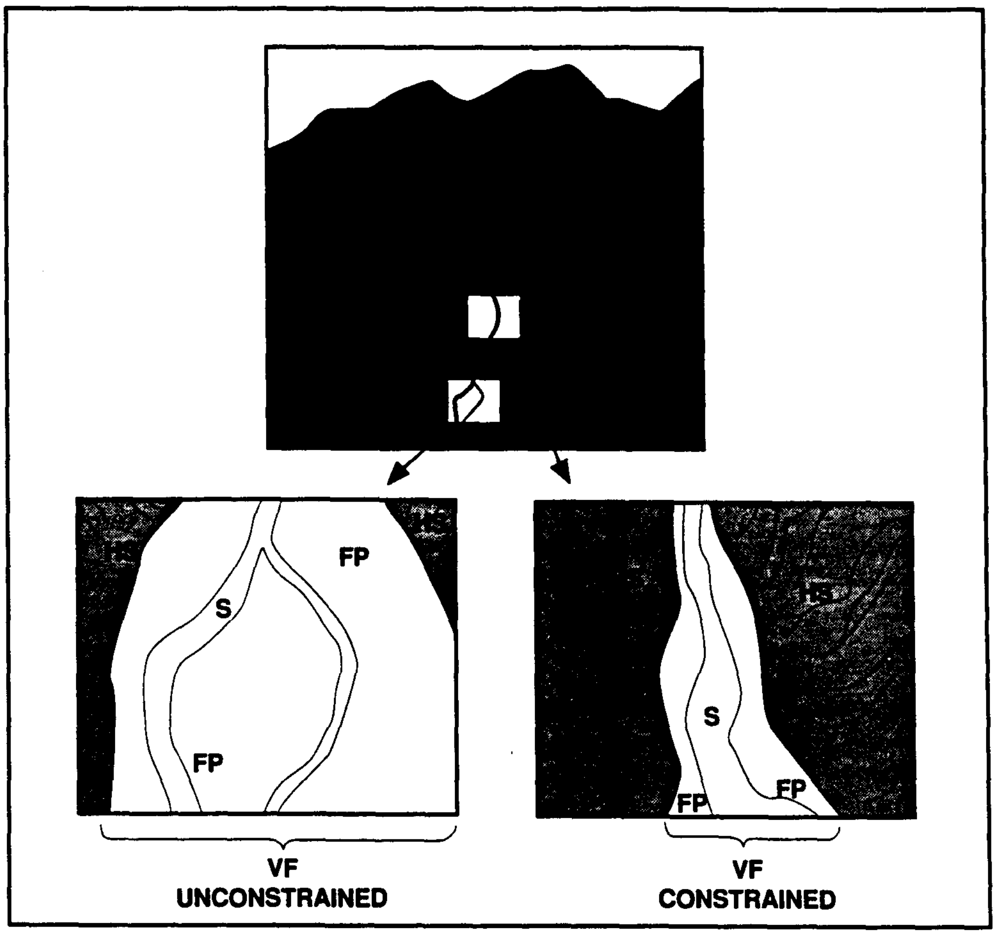


Figure 20. **Stream channels in constrained and unconstrained valleys. Note the more complex channels in the valley with the broad floodplain. S - stream; FP - floodplain; HS - hillslope; VF - valley floor.**

be "pinched" and relatively straight, with few secondary channels, backwaters, or lateral complexity. The narrow valley floor also means the riparian area will be relatively narrow and simple. Riparian plant communities may be similar in species composition to the adjacent hillslope communities. During floods, stream flows are confined in the narrow valley; consequently, the erosive energy of the stream increases rapidly with increasing discharge. Such areas provide less habitat for fish and wildlife.

Valley floor areas not confined by geomorphic features are termed unconstrained (Fig. 20). These portions of a watershed have broad floodplains upon which streams can meander, often forming a complex network of secondary, intermittent, and ephemeral channels. Riparian vegetation is characterized by mixed patches of herb, shrub, hardwood, and conifer communities, distinctly different from adjacent hillslope vegetation. At high flows, the stream may spread across the broad valley floor, dissipating much of the water's energy. These broad floodplains offer complex and stable habitats for fish and wildlife.

Although they may be locally controlled by geomorphology, streams also modify the landscape. They alter valley form by erosion and sediment deposition, creating terraces and floodplain surfaces of varying heights and ages. Within the stream channel, floods create or destroy islands and gravel bars, and redistribute boulders and woody debris.

Basin perspectives are essential for developing management objectives for both flowing and standing waters within the WNF. Lakes and wetlands frequently are viewed as isolated bodies of water. However, they receive their water supplies from the surrounding forests; thus land use practices in upslope forests within a basin may greatly affect these aquatic systems. Even seemingly isolated wetlands and lakes within a basin are connected to one another and to streams and rivers through groundwater.

The River Continuum Concept

The structure of aquatic communities and rates of ecological processes in streams and rivers change from small headwater streams to downstream rivers. These longitudinal patterns reflect changes in both the geomorphic processes that create stream channels and floodplains and the interactions of streams with the adjacent terrestrial ecosystems. Linkages between the structure and function of stream ecosystems and the physical processes and environment of streams is the basis for a major conceptual framework in stream ecology known as the River Continuum Concept (Vannote et al. 1980). The McKenzie River in the WNF was one of the four major sites where the River Continuum Concept was developed. Patterns of aquatic communities in the McKenzie River drainage will be used to illustrate the River Continuum Concept (Fig. 21).

Small Streams

In small headwater streams (typically Class II, III, or IV; first to third order), the food base is composed primarily of leaves, needles, wood, and insects from the adjacent forest. The small stream channel is almost completely enclosed by the forest canopy. As a result, little sunlight reaches the stream and aquatic plant production is low. The input of terrestrial litter provides the bulk of the food base for the stream communities.

Aquatic invertebrate communities are composed primarily of shredders, which are organisms that feed by tearing large particles apart. Most shredders in these streams are feeding on the detritus, or dead organic matters, derived from the forest. Invertebrate predators make up approximately 25% of the invertebrate communities, a proportion that remains fairly constant from small stream to large river. Fish communities in these small streams are sparse, and are usually composed of cutthroat trout and sculpins.

Intermediate Streams

In streams of intermediate size (typically Class I or II; fourth to sixth order), the wider stream channels create natural openings in the forest canopy, reducing the canopy over the stream and allowing more sunlight to reach the water surface. Production of algae and other aquatic plants increases with greater light intensities; while the relative contribution of forest litter decreases because inputs are restricted largely to stream margins.

Aquatic invertebrate communities are composed of both scrapers and shredders, reflecting the shift in the food base. Scrapers are invertebrates which obtain their food by scraping the surface of rocks and other substrates. In these streams, microscopic plants or algae create a film over every wetted surface, and the scrapers feed primarily on this food resource. Shredders are still found, but they make up a smaller proportion of the total. Fish communities become more diverse, commonly including several species of trout, sculpins, minnows, suckers, and occasionally anadromous salmon.

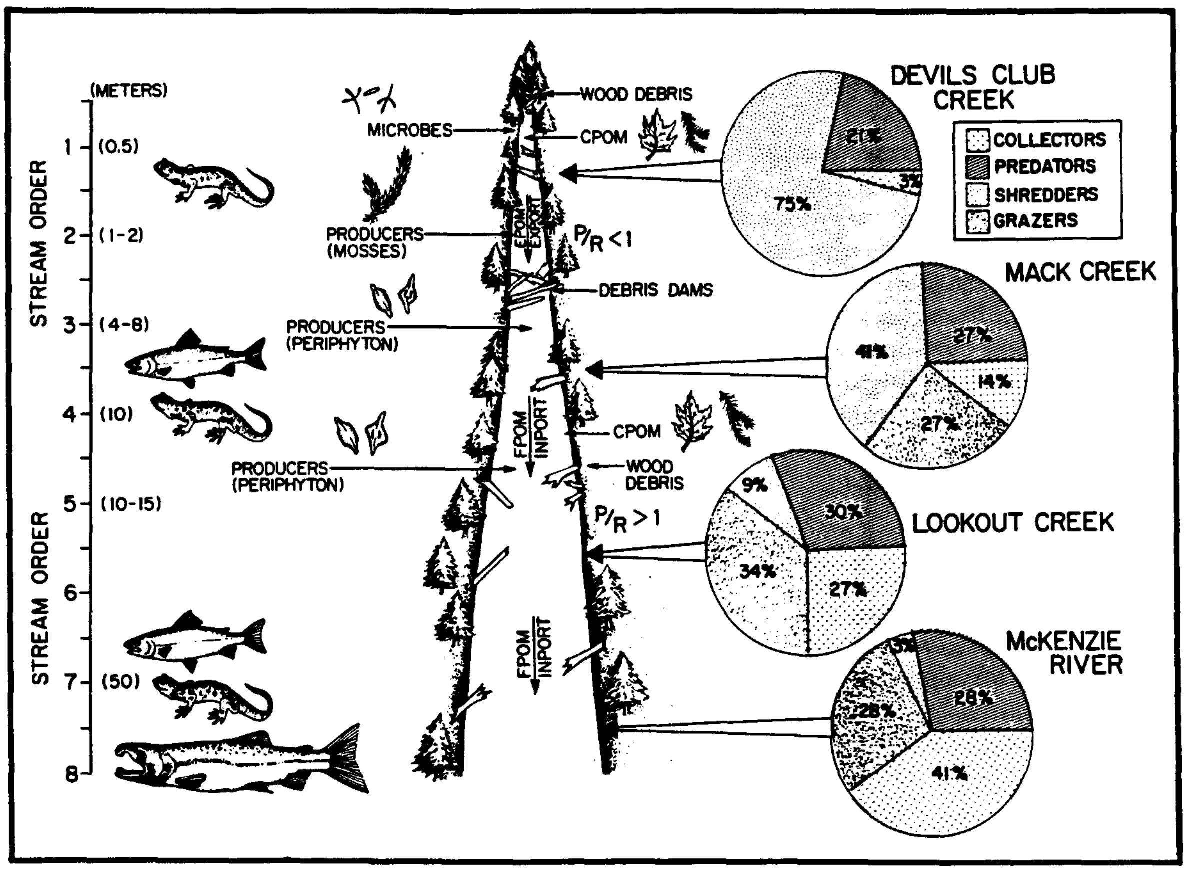


Figure 21. **Changes in aquatic communities from small streams to large rivers in the McKenzie River drainage, illustrating the River Continuum Concept. CPOM and FPOM are coarse (>0.04 inches) and fine (<0.04 inches) particulate organic matter.**

Large Rivers

In the larger rivers (Class I; seventh order and greater), the food base largely reflects instream plant production, organic matter from upstream reaches, and organic material from adjacent floodplains. These lower river channels may be extremely wide, and the forest canopy is restricted to a relatively narrow fringe along the edge. In clear, shallow rivers, such as the upper McKenzie or Santiam Rivers, aquatic plant production on the river bottom can still provide the majority of the food base. In deeper, lowland rivers, such as the Willamette River, phytoplankton or suspended algae are a major component of the aquatic plant production. In both cases, the delivery of organic matter from upstream reaches is a significant component of the food supply. Often this organic matter is made up of small particles that have been broken or eaten by organisms in upstream areas.

At first glance, one might assume that the interaction of the forest with the stream was diminished in larger rivers because of the wider channels and limited riparian fringe, but this is not the case. Development of extensive floodplains in large rivers creates a new facet in the interaction of forests and streams. During most of the year, floodplain forests produce tremendous quantities of organic matter that are stored on the surface of the floodplain. During floods, the river captures this organic matter and delivers it to the main channel. In addition, the flushing of dissolved material from the floodplain soils contributes a rich supply of dissolved nutrients for aquatic communities. In many rivers, production of fisheries and other aquatic communities increase after major floods, a phenomenon known as the flood pulse concept (Junk et al. 1989). Thus, floodplains along streams and rivers increase the interactions of the stream with the adjacent forests, creating important ecological linkages between land and water throughout a river drainage.

Invertebrate communities in large rivers are dominated by collectors, a functional feeding group of aquatic organisms that obtain their food by collecting small particles. Collectors may obtain their food in this flowing environment either by gathering or filtering. Gatherers sweep up the fine particles by brush-like appendages. Filterers attach nets to the bottom that filter particles from the water. Other filterers have comb-like appendages that filter particles from the water around them. Scrapers still make up an important component of invertebrate communities, but shredders are a small portion of the assemblage. Fish communities in lower rivers contain many more species or trout, salmon, whitefish, sculpins, minnows, suckers, and lampreys. Many species found in the smaller streams are not present or become rare, and several species that are found only in larger rivers are added to the community.

This natural progression of communities and ecological processes in streams is based on interactions with adjacent forests and physical processes that shape stream channels. Land use practices potentially change both of these factors and subsequently may alter the natural pattern of stream ecosystems along a stream course. Recognition of the intricate linkages between forest and stream and between headwaters to downstream rivers is essential for effective management of aquatic resources within river drainages in forested landscapes.

Cumulative Effects

Processes in headwater areas influence downstream regions through the riparian network. Consequently, poor management practices in small, headwater harvest units are transmitted and amplified throughout a basin in the form of altered streamflow, water quality, and sediment transport. Small, individual activities can have significant, additive impacts or *cumulative effects* when combined on a basin level.

An example of terrestrial processes resulting in cumulative impacts is the change in runoff patterns and streamflows after harvest. Practices such as felling, yarding, roading, and slash burning occur on relatively small units. These activities lead to changes in site processes, such as increases in snow accumulation, snow melt rate, surface erosion, and landsliding. During a single large flood event, these individual alterations collectively may lead to substantial increases in streamflows and erosion rates downstream.

Within streams, cumulative impacts may result from forest practices such as the successive salvage or other removal of woody debris from stream channels and banks during harvest. Removing this woody structure will eventually destabilize stream channels, often resulting in localized downcutting of the streambed. During storms and floods, increased sediment loads from small channels will be routed into larger streams and deposited lower in the basin.

These processes emphasize the strong linkages between terrestrial and aquatic systems, between hillslopes and valley floors, and between upper and lower portions of a drainage network. This connectivity has important implications for management practices. Changes in one part of the basin may strongly affect other areas. Hillslope conditions are especially important to riparian areas. Poor harvest practices may cause catastrophic inputs of large amounts of sediment and debris from the hillside to the stream channel. Roads and clearcuts may increase surface runoff and peak discharges, which, in turn, significantly affect channel and valley floor morphology, riparian area vegetation, and fish and wildlife survival. Other types of basin cumulative effects include changes in water temperature, stream chemistry, and visual quality of scenic corridors.

BASIN PLANNING

Land use planning in the Willamette National Forest operates at two scales: broad project areas that may encompass several thousand acres and individual harvest units within a project area. Ideally, the project area should be a drainage basin, and all aspects of planning, including riparian areas, should begin at the basin scale.

Planning for riparian management is part of a broader planning process that includes an analysis of all forest resources within a basin or collection of smaller watersheds. This scoping phase, which must meet the requirements of the National Environmental Policy Act, includes the following sequence of tasks:

Form an interdisciplinary planning team of experts in the necessary technical fields. The team considers both riparian and hillslope areas.

Document basin management objectives as a basis for developing specific harvest unit prescriptions.

Identify basin management objectives of all federal, state, and local resource management agencies.

Assemble preliminary resource information based on inventories.

Identify issues and opportunities within specific drainage basins.

Identify riparian management objectives for the basin.

If additional information is necessary, inventory riparian resources within the project area.

Develop alternative strategies for meeting project objectives.

Identify a preferred alternative through discussions and negotiations.

The scoping phase outlined above examines all forest resources. Riparian objectives related to the basin scale are described below. More specific riparian objectives are provided in Chapter 6 on Harvest Unit Management.

Basin planning in the WNF focuses on four major areas of issues and opportunities: (1) minimizing the potential for cumulative effects; (2) maintaining potential inputs of woody debris; (3) maintaining continuous riparian corridors, with structurally complex plant communities and downed timber throughout the basin; and (4) rehabilitating degraded riparian resources within the basin.

Cumulative Effects

Protection of riparian areas minimizes the potential for deleterious cumulative effects. To minimize or to prevent cumulative impacts in a given basin, the planner must first assess their probability of occurrence before timber harvest. Systematic analyses of cumulative effects are applied at a basin scale. Cumulative effects analysis for each drainage basin includes preliminary information based on basin resource inventories:

- hydrologic condition
- mass movement potential
- history of mass movement
- location and condition of roads
- present riparian condition
- degree of riparian continuity

Potential impacts of future activity within the WNF and downstream from the forest boundary should then be estimated. Secondly, objectives for minimizing cumulative effects are developed. Finally, basin management practices are prescribed.

Large Woody Debris

Basin management in the WNF is designed to maintain future sources of woody debris in riparian areas of wetlands, lakes, and perennial streams. This objective may be achieved if riparian areas are excluded from programmed harvest. Where debris has been removed or lost, rehabilitation projects can attempt to replace woody debris over the short-term. Mature riparian forests must become reestablished to provide sizes and amounts of woody debris characteristic of undisturbed forests. Riparian areas in the WNF require more than a century to recover the ability to supply woody debris naturally to floodplains, stream channels, and lakes.

Riparian Corridors

Riparian areas must be assessed over entire basins to evaluate their continuity and to identify unique riparian resources. Systematic basin inventories of valley landforms and plant community structure and diversity provide a framework for basin assessment. Geographic information systems (GIS) are appropriate tools for such analysis.

Rehabilitation

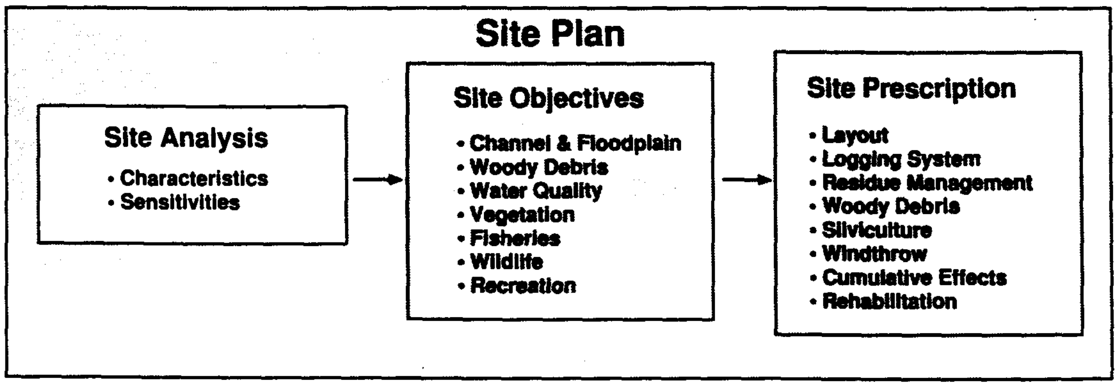
Basin planning includes evaluation of riparian areas in previously harvested or damaged areas as well as intact or uncut locations. In heavily damaged watersheds, protection of riparian resources beyond routine management practices may be required to promote riparian recovery. In addition, intensive rehabilitation projects may accelerate the return to desired ecological conditions. *Management of riparian areas for sustained ecological function over the long term is ultimately more cost-effective than short-term gains in convenience or commodity.* To this end, management strategies, both basin-wide and site-specific, must be responsive to current and future riparian conditions.

CHAPTER 5

HARVEST UNIT MANAGEMENT

Site-specific riparian management prescriptions can be developed after basin management objectives for riparian areas have been identified by the planning team. The WNF Standards and Guidelines are designed to ensure many of the ecological functions and characteristics of riparian areas. A single prescription or cookbook approach is not appropriate for riparian management. To achieve the most effective riparian management, current site conditions and desired future conditions should be considered in developing prescriptions for individual harvest units (Fig. 22).

Figure 22. Components involved in Site Analysis for site plan.



MANAGEMENT OBJECTIVES

Site planning must meet the requirements of the National Environmental Policy Act and all Executive Orders directed at riparian resources (EO 11988 and 11990). Riparian management zone guidelines for streams, lakes and wetlands of the WNF are summarized in Table 5a b and c. Stream size and flow regime strongly influence both unit and basin management objectives. Consequently, riparian management of streams is based in part on stream class. Site-specific objectives for management of riparian zones are described in the following sections (Fig. 23).

Figure 23. Components involved in determining Site Objectives for site plan.

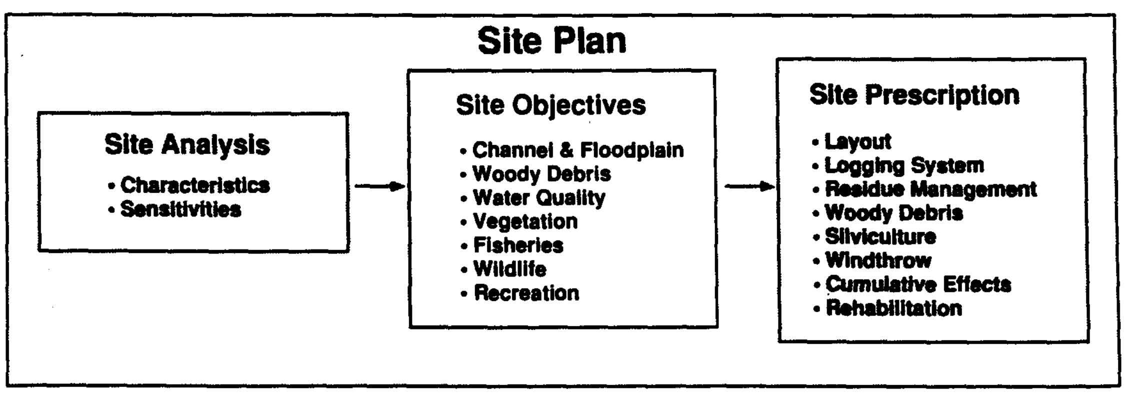


Table 5a. **Perennial Streams and Rivers:** Summary of standards and guidelines for riparian management zones.

Riparian Management Guidelines	Class I	Class II	Class III Stable[1]	Class III Moderate[1] & Unstable
Location				
Range of width from active channel[2]	150-400 ft	100-200 ft	50-100 ft	75-125 ft
Average width[3]	200 ft	100 ft	75 ft	100 ft
Objectives				
Extent of 100-yr floodplain within RMZ[4]	100%	100%	100%	100%
Temperature[5]	M & E	M & E	M & E	M & E
Input of woody debris	100%	90%	75%	90%
Input of terrestrial food resources	100%	100%	100%	100%
Bank stability	100%	100%	100%	100%
Operations				
Overstory vegetation remaining within RMZ	100%	100%	100%	100%
Understory vegetation remaining within RMZ	100%	100%	100%	100%
Directional falling along RMZ	Yes	Yes	Yes	Yes
Yarding suspension over banks	Full	Full	Full	Full
Yarding and line corridors	Yes	Yes	Yes	Yes
Stream cleanout[6]	No	No	No	No
Salvage within RMZ[7]	No	No	No	No

1 Stability ratings. See Appendix II for soil types and slope stability analysis.
2 These riparian widths represent the horizontal distances commonly required to meet management objectives.
3 These widths represent the expected averages and were used in the FORPLAN model for the Forest and Resource Management Plan.
4 100-yr floodplains are assumed to be less than 400 ft wide on a single bank. Where floodplains extend beyond 400 ft, specific site conditions will be evaluated relative to the Executive Order on Floodplain Development.
5 Objectives for shade are to maintain or enhance water temperatures. At a minimum, 80% of the existing shade will be maintained.
6 Stream cleanout is permitted immediately upstream of culverts.
7 Salvage within an RMZ after catastrophic events should be considered only to restore degraded riparian habitat and benefit riparian-dependent resources. Evaluate specific site conditions.

Table 5b. **Intermittent and Ephemeral Streams:** Summary of standards and guidelines for riparian management zones.

Riparian Management Guidelines	Class IV				
	Intermittent			Ephemeral	
	Stable[1]	Moderate[1]	Unstable[1]	Stable[1] & Moderate	Unstable[1]
Location					
Range of width from active channel[2]	0 ft	25-50 ft	25-100 ft	0 ft	25-100 ft
Average width[3]	0 ft	30 ft	50 ft	0 ft	50 ft
Objectives					
Provide floodplain functions[4]	No	No	No	No	No
Temperature[5]	M & E	M & E	M & E	No	No
Input of woody debris	0%	20-40%	30-50%	0%	0%
Input of terrestrial food resources	None	Partial	Partial	None	Partial
Bank stability	Locally Reduced	100%	100%	Locally Reduced	100%
Operations					
Overstory vegetation remaining within RMZ	None	Partial	All	None	Partial
Understory vegetation remaining within RMZ	Partial	Partial	All	Partial	Partial
Directional falling along RMZ	Yes	Yes	Yes	No	Yes
Yarding suspension over banks	Full-Partial	Full-Partial	Full	Partial	Partial
Yarding and line corridors	Yes	Yes	Yes	Yes	Yes
Stream cleanout[6]	No	No	No	No	No
Salvage within RMZ[7]	No	No	No	No	No

1 Stability ratings. See Appendix II for soil types and slope stability analysis
2 These riparian widths represent the horizontal distances commonly required to meet management objectives
3 These widths represent the expected averages and were used in the FORPLAN model for the Forest and Resource Management Plan.
4 Intermittent and ephemeral channels are assumed to have no floodplains.
5 Intermittent channels may flow during summer when stream temperatures are critical. Consider retention of vegetation for shade.
6 Stream cleanout is permitted immediately upstream of culverts.
7 Salvage within an RMZ after catastrophic events should be considered only to restore degraded riparian habitat and benefit riparian-dependent resources. Evaluate specific site conditions.

Table 5c. **Lakes and Wetlands:** Summary of standards and guidelines for riparian management zones.

Riparian Management Guidelines	Lakes	Wetlands
Location		
Range of width from mean high water[1]	500-700 ft	150-600 ft
Average width[2]	600 ft	N/A
Objectives		
Extent of 100-yr floodplain within RMZ	100%	100%
Temperature[3]	M & E	M & E
Input of woody debris	100%	100%
Input of terrestrial food resources	100%	100%
Bank stability	100%	100%
Operations		
Overstory vegetation remaining within RMZ	100%	100%
Understory vegetation remaining within RMZ	100%	100%
Directional falling along RMZ	Yes	Yes
Yarding suspension over banks	Full	Full
Yarding and line corridors	Yes	Yes
Debris cleanout	No	No
Salvage within RMZ[4]	No	No

1 These riparian widths represent the distances commonly required to meet management objectives.

2 These widths represent the expected averages and were used in the FORPLAN model for the Forest and Resource Management Plan. Wetland areas have not been delineated, and average widths were not established.

3 Objectives for shade are to maintain or enhance water temperatures. At a minimum, 80% of the existing shade will be maintained.

4 Salvage within an RMZ after catastrophic events should be considered only to restore degraded riparian habitat and benefit riparian-dependent resources. Evaluate specific site conditions

Evaluation of riparian areas within a site should consider specific objectives for:

- water quality
- active channel and floodplain
- woody debris
- fish
- wildlife
- vegetation
- recreation

Water Quality

Water quality objectives on the WNF are designed to:

- minimize increases in water temperature
- minimize increases in sediment transport
- prevent decreases in dissolved oxygen concentrations.

In all salmonid fish-producing streams, stream temperature must be maintained at or below 58°F (Oregon DEQ Standards). If the temperature is 56°F or less, a 2°F increase is permissible. At stream temperatures of 58°F or more, no measurable increases are allowed. In non-salmonid fish-producing waters, no increases above 64°F are allowed.

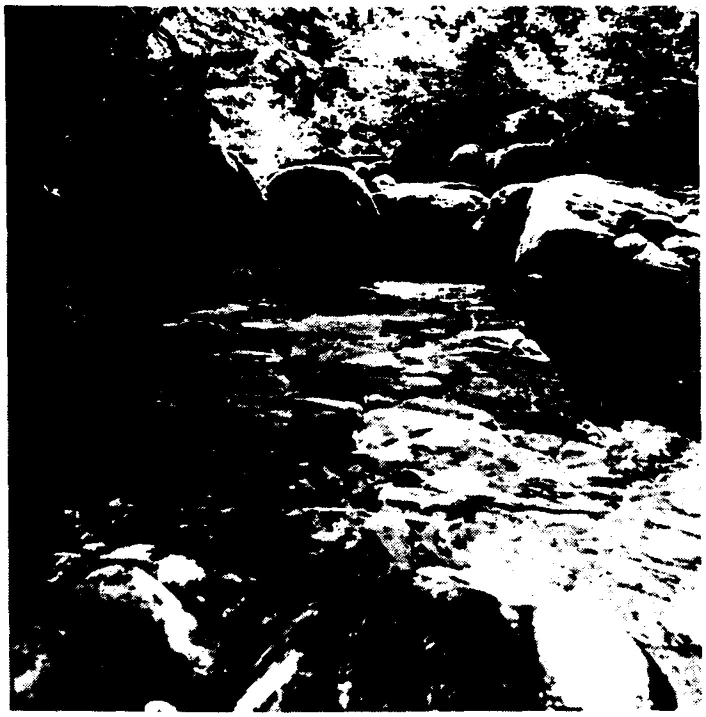
No more than a 10% cumulative increase in natural stream turbidity is allowed (Oregon DEQ Standards). Turbidity in streams fluctuates widely and is closely related to storm patterns, even in unharvested forests. Compliance with this standard is based on annual patterns of turbidity, not simply the immediate post-operation conditions.

Dissolved oxygen concentrations cannot decrease to less than 6 mg O_2/l in salmonid-bearing streams. In addition, the dissolved oxygen concentration shall not be less than 90% of saturation at seasonal low flow or less than 95% of saturation in spawning areas during the spawning, incubation, hatching, and fry stages of salmonid fishes (Oregon DEQ Standards).

To meet these standards on all Class I and II streams, water quality of upstream Class III and IV channels must also be maintained. Particularly during summer low flows, these smaller streams have significant, basin-wide effects on water quality of the larger channels. In addition, areas of subsurface flow (i.e., debris accumulations, floodplains wetlands, seeps, and springs) provide cool, well-oxygenated water to downstream reaches.

Water quality objectives can usually be met through stringent riparian area protection (Fig. 24). Use of forest chemicals (e.g., herbicides, fertilizers, insecticides, road oils) near riparian areas is discussed under specific WNF Standards and Guidelines.

Figure 24. High quality surface waters with low temperature and sediment load are commonly found in undisturbed streams of the WNF.



Channel and Floodplain

The overall objectives for channels and floodplains are to:

- maintain channel complexity and stability
- maintain full floodplain functions
- minimize risks of cumulative effects

In general, land use practices should minimize changes in geomorphic stability, sediment loading, and storage capacity for sediment and water.

In Class I, II, and III streams, the geomorphic objectives of riparian management are to maintain the physical characteristics of the stream channel and floodplain and to minimize delivery of sediment to the channel. In Class IV streams, geomorphic objectives are designed to protect downstream riparian-dependent resources. Landslides and debris flows are more common in these headwater areas and can strongly impact resources downstream. Management of Class IV streams should: 1) maintain local geomorphic stability, 2) impede downstream movement of debris flows, and 3) provide large woody debris to create stable channel structure in downstream deposits.

Riparian areas around lakes are managed to maintain shoreline integrity. Wetlands, such as seeps or marshes, may have irregular, poorly-defined margins, and riparian management should retain the complexity of these edges.

Active Channels

Management should not change existing geomorphic structure of stream channels. Maintenance of the following characteristics of stream configuration will help ensure long-term stream stability:

- width and depth
- stream course
- channel gradient
- streambed topography
- streambed and bank materials
- large woody debris

Stream channels are dynamic and are re-shaped during major flood events. If geomorphic stability is decreased by timber harvest or other management activities, channels will be more susceptible to erosion and will shift more frequently. Logs and boulders dissipate the erosive energy of the stream and are particularly important in maintaining channel characteristics.

Floodplains

Maintenance of floodplain functions is an extremely important and frequently overlooked component of riparian management. Floodplains are formed by deposits of sediment during extremely high flood events (Fig. 25). Riparian vegetation protects these areas, and removal of this vegetation through harvest or road construction makes them vulnerable to massive erosion during subsequent floods.

Figure 25. Riparian forests of the active channel and floodplain of the McKenzie River.

The riparian management zone should include the entire floodplain. Failure to do so will seriously jeopardize riparian management objectives during major floods. The Forest Service is required by Executive Orders 11988 and 11990 (FSM 2527.03) to:

> "Recognize floodplains and wetlands as specific management areas."
>
> "Avoid adverse impacts which may be associated with the occupancy and modification of floodplains and with the destruction, loss, or, degradation of wetlands."
>
> "Not permit floodplain development and new construction in wetlands wherever there is a practicable alternative."

Streams and floodplains extend beyond the upstream and downstream boundaries of individual harvest units. Site evaluation of riparian areas must consider upstream features that could affect the channel and floodplain within a harvest unit, as well as consequences of harvest activities downstream. Local channel stability and storage potential should be maximized if there are upstream areas with high rates of sediment input or water delivery, or if there are particular downstream resources at risk.

Woody Debris

Of all the ecological functions of riparian areas, the process of woody debris loading into channels, lakes, and floodplains requires the longest time for recovery after harvest (Fig. 26). Although young forests begin to deliver woody debris after several decades, large conifer logs cannot be provided by forests less than a century old. Most future riparian functions will be guaranteed if natural abundances and distributions of all sizes of woody debris are maintained in streams, lakes, floodplains, and lower hillslopes.

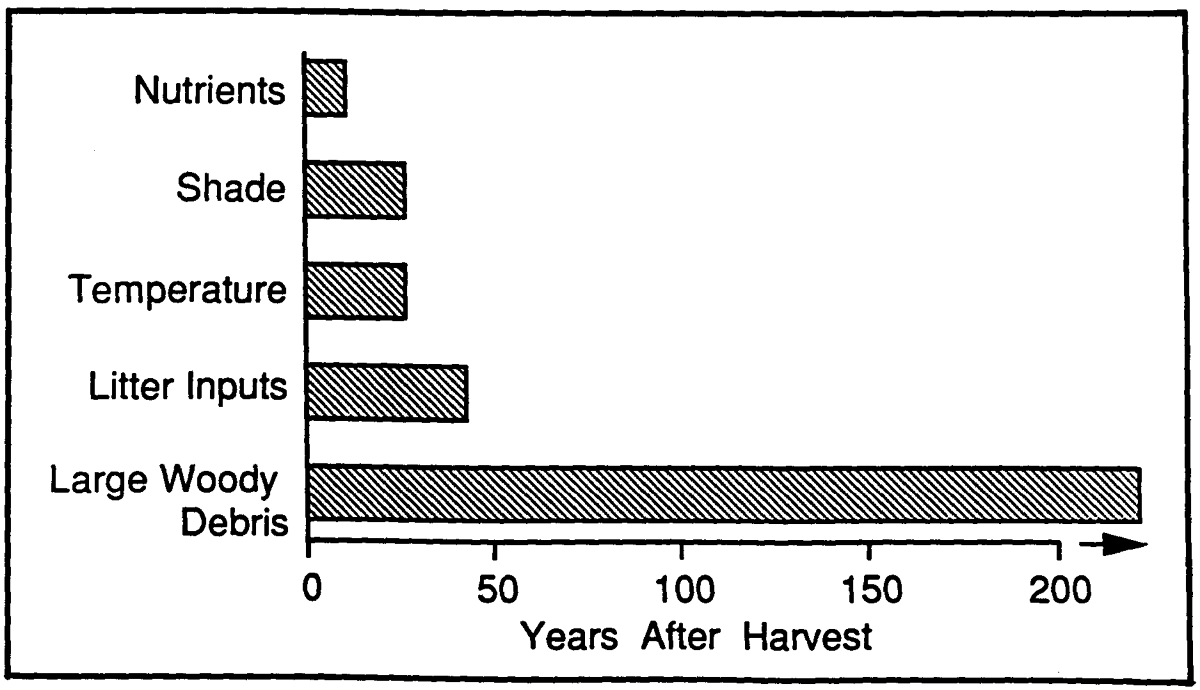


Figure 26. Years required for ecological recovery of riparian functions after timber harvest.

Figure 27. **Proportion of total loading of woody debris from the riparian forest as a function of the distance from stream edge (adapted from McDade et al. 1989).**

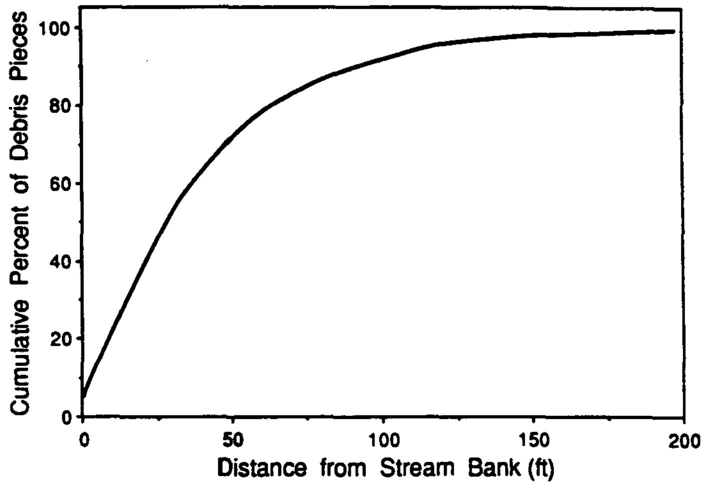


Figure 28. **Massive accumulations of logs are natural features of streams that contribute to the stability of channels and floodplains.**

Large woody debris is contributed to the active channel or lake shoreline by adjacent riparian forest (Fig. 27). A recent study of streams in old-growth forests in the Cascades and Coast Range found that 90% of the large wood in the channel originated within 92 feet of the stream margin (McDade et al. 1989). For large woody debris management alone, riparian management zone widths of approximately 100 feet are required to maintain long-term inputs to streams and lakes. Additional consideration of floodplain functions and wildlife habitats may require even wider management zones.

The WNF strives to maintain future sources of woody debris in perennial streams and lakes through a policy of no programmed harvest in riparian management zones (Fig. 28). However, woody debris is also important in small ephemeral and intermittent (Class IV) streams. In these small channels, particularly those in unstable watersheds, woody debris in the channel and on the banks stabilizes the stream and creates new habitat within debris flows when they occur.

Stream Clean-up

Where timber harvest is permitted along streams (e. g., some Class IV's), large amounts of woody debris may accumulate locally. Logging slash has the potential to retard streamflow, reduce dissolved oxygen concentrations, dam culverts and bridges, and initiate landslides and debris flows. At the same time, large pieces of wood add to the physical stability of the channel, and small debris is redistributed and stored by high flows. Appropriate riparian management avoids substantial delivery of wood, and excessive debris loading should not occur.

Normally, the first floods of autumn will redistribute slash within the active channel, where it can play a beneficial role. Removal often causes more erosion than the slash would cause in transport, and frequently damages the stream channel and riparian vegetation. Slash should be removed only in sluggish stream reaches or in cases of extremely large deposits that are judged to create significant risks for aquatic or wildlife resources.

Fish

The primary objective for fish management on the WNF is to maintain the quality of habitat and food supply for all anadromous and resident fish populations at all stages of their life cycles (Table 6). This goal is best accomplished through floodplain, channel, and shoreline protection and maintenance of long-term sources of woody debris to provide:

- spawning gravels of specific size ranges
- low rates of sedimentation
- rearing habitat for young fish (complex side channels, backwaters, shallow edges)
- cover and food sources for adult fish (pools, debris jams, stable undercut banks)
- refuge from floods and predators (large woody debris, backwaters, side channels).

Table 6. **Miles of anadromous fish habitat on the Willamette National Forest. Inaccessible habitat refers to streams historically available to anadromous fish, but now blocked by dams.**

Drainage	Existing (miles)	Inaccessible (miles)
Little North Santiam	6.2	0.0
North Santiam	0.0	35.7
South Santiam	20.5	18.2
McKenzie	56.7	70.1
Fall Creek	35.6	0.0
Middle Fork Willamette	0.0	133.3
TOTAL	119.0	257.3

Good water quality is essential for fish production. Cool temperatures and low suspended sediments are essential for salmonids. Water quality must be protected or enhanced, both in lakes and streams containing fish, (Class I and II) and in smaller tributaries (Class III and IV) to fish-bearing waters.

The numerous lakes and streams in the WNF contain many indigenous races and species of fish (Table 7 and Appendix I). The Oregon chub, a rare and sensitive species, is found in the WNF, while species and races such as bull trout and the Hackleman Creek cutthroat trout have limited numbers or distributions. Bull trout require cold water for spawning (generally less than 50°F), and are particularly sensitive to basin-level cumulative effects on stream temperature (WNF Report 1989). These rare species or races require more protective measures.

Table 7. Length and area of existing habitat for anadromous and resident fish on the WNF.

Drainage Name	Anadromous Fish Streams		Resident Fish Streams		Lakes	Reservoirs
	Miles	Acres	Miles	Acres	Acres	Acres
DETROIT R.D.						
Little North Santiam	6.2	22.8	27.6	75.1		
North Santiam	0.0	0.0	104.0	267.1		3,580
Wilderness streams	0.0	0.0	17.5	45.9		
Breitenbush	0.0	0.0	58.4	184.5		
TOTAL	6.2	22.8	207.5	572.6	964	3,580
SWEET HOME R.D.						
Quartzville Cr.	0.0	0.0	30.0	79.9		
Middle Santiam	0.0	0.0	30.4	107.9		
S. Santiam/Wiley/ Calapooia	20.5	73.6	56.1	155.2		
N. Santiam/Lava/McKenzie	0.0	0.0	19.9	41.8		
TOTAL	20.5	145.0	136.4	384.8	80	0
BLUE RIVER R.D.						
Blue River, Gate Cr.	1.5	3.0	45.1	196.8		1,420
S. Fk. McKenzie/Quartz Cr.	6.2	22.3	67.5	184.4		1,280
Wilderness streams	0.0	0.0	23.4	62.8		
TOTAL	7.7	25.3	136.0	444.0	40	2,700
MCKENZIE R.D.						
McKenzie & Horse Cr.	46.8	114.0	87.1	207.6		320
Wilderness Streams	2.2	4.4	18.7	41.6		
TOTAL	49.0	118.4	105.8	249.2	1,945	320
LOWELL R.D.						
Fall Cr.	29.0	103.4	96.8	249.1		
Winberry Cr.	6.6	24.9	26.9	63.6		
Middle Fork Willamette	0.0	0.0	54.5	133.7		1,940
TOTAL	35.6	128.3	178.2	446.1		1,940
OAKRIDGE R.D.						
Salt Cr.	0.0	0.0	53.3	115.9		
Salmon Cr.	0.0	0.0	71.7	126.1		
N. Fk. Mid. Fk. Willamette	0.0	0.0	120.3	221.7		
TOTAL	0.0	0.0	245.3	463.7	7,912	
RIGDON R.D.						
Hills Cr.	0.0	0.0	29.1	74.8		300
Middle Fork Willamette	0.0	0.0	122.7	322.3		2,410
TOTAL	0.0	0.0	151.8	397.1	292	2,710
WNF TOTAL	119.0	368.4	1,161.0	2,957	11,233	11,250

Wildlife

A fundamental objective of riparian management is to maintain wildlife species diversity, habitat, and migration and travel corridors. *Riparian management zones established for water quality and fisheries needs may not meet wildlife habitat requirements.* Because our knowledge of wildlife use of riparian areas is limited, riparian management zones should be designed to ensure diverse types and amounts of habitats, such as those found in riparian forests and meadows.

Preservation of the diverse plant community within riparian areas will help ensure survival of a diverse wildlife community. Management activities affecting riparian plant community structure, including dead or downed timber, will have inevitable impacts on wildlife through change or loss of appropriate habitat. Riparian corridor continuity should not be fragmented by harvest on individual sites.

Beaver dams and bank dens create valuable habitats for both fish and wildlife in riparian areas (Fig. 29). If there are indications of local beaver activity (e.g., gnawed stumps, dams, bank dens), riparian management zone boundaries should at least encompass the area of immediate use and provide a buffer from harvest activities.

Figure 29. **Beavers are common residents of riparian areas along streams and rivers of the Pacific Northwest.**

Specific consideration should be given to:

- preserving a complex, multi-layered canopy for structural diversity
- protecting snags and adjoining forest, particularly those used by species such as eagles or ospreys
- ensuring woody debris cover for small mammals, amphibians and reptiles (Fig. 30)
- protecting beaver dams and bank dens
- maintaining dense cover required for nesting and fawning
- protecting ponds, seeps, and springs, which are often important sources of drinking water
- protecting lakeshores or streambanks used for nesting areas by waterfowl species (e.g., harlequin ducks, mergansers, water ouzels)
- preserving riparian continuity throughout basins to ensure contiguous routes for migratory species such as elk.

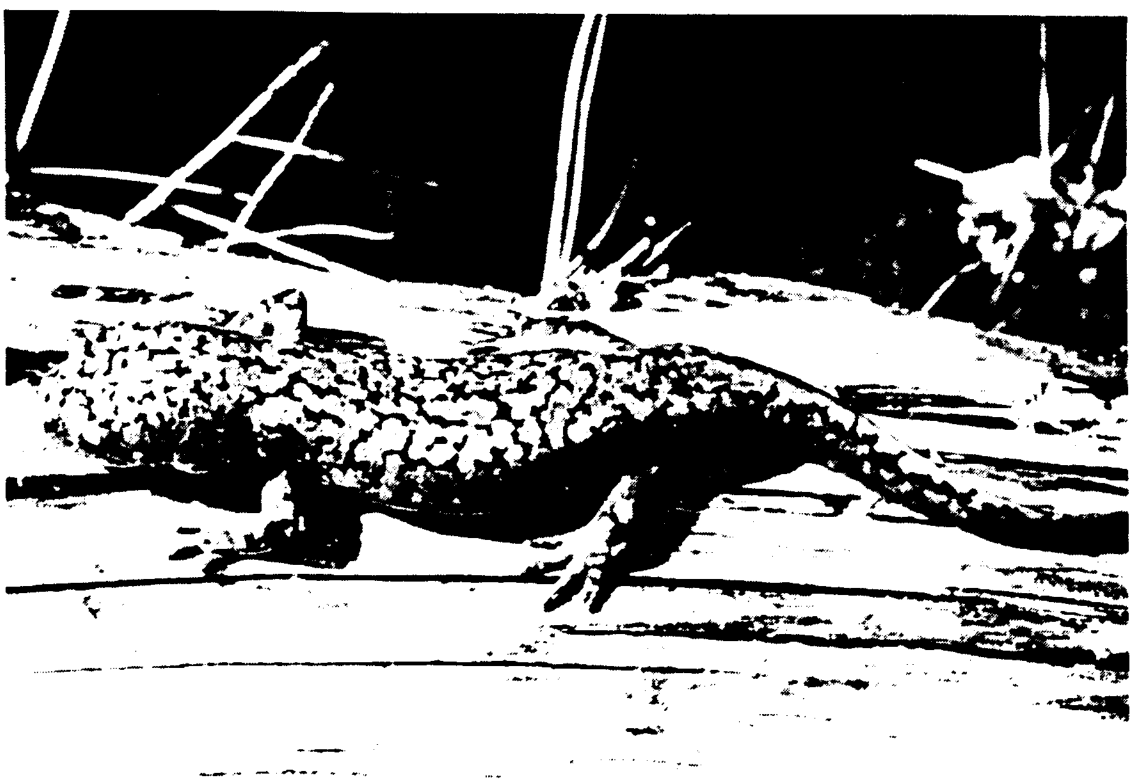


Figure 30. **Woody debris in riparian areas creates critical habitats for amphibians and other wildlife, such as this Pacific giant salamander.**

Vegetation

Streamside stands in the WNF contain approximately twice the number of species found in upslope forests. Riparian vegetation plays a critical role in the dynamics of forest plant communities as well as providing numerous ecological functions for other aquatic and terrestrial communities. A major objective of riparian management is to maintain the species diversity, age composition, and structural complexity of riparian forests.

In addition to sustaining the plant species in riparian areas, vegetation management should retain the structural characteristics of the different canopy layers along streams and lakes (Fig. 31). Riparian practices should maintain existing snags and sources of snags for the immediate future. Harvest practices should minimize changes in the riparian microclimate and soil moisture conditions so that recruitment of young plants will not be decreased. Future responses of riparian plant communities, in terms of regeneration, growth, mortality, to current management practices are uncertain. Effects of land use practices on riparian vegetation should be assessed for specific harvest sites and adjacent or downstream areas to provide a basis for designing future forest management policy.

Figure 31. **Diversity of plant communities and complex canopy layers found in riparian areas must be retained.**

Recreation

Riparian areas are among the most heavily used recreation sites in the WNF (Fig. 32). Present and future recreational opportunities (e.g., hiking, fishing, camping, boating) should not be impaired by management activities. To this end, visual quality, user access, unique features, and future recreational potential should be evaluated for individual harvest units. Influence of management activities on recreational values of adjacent areas should be considered.

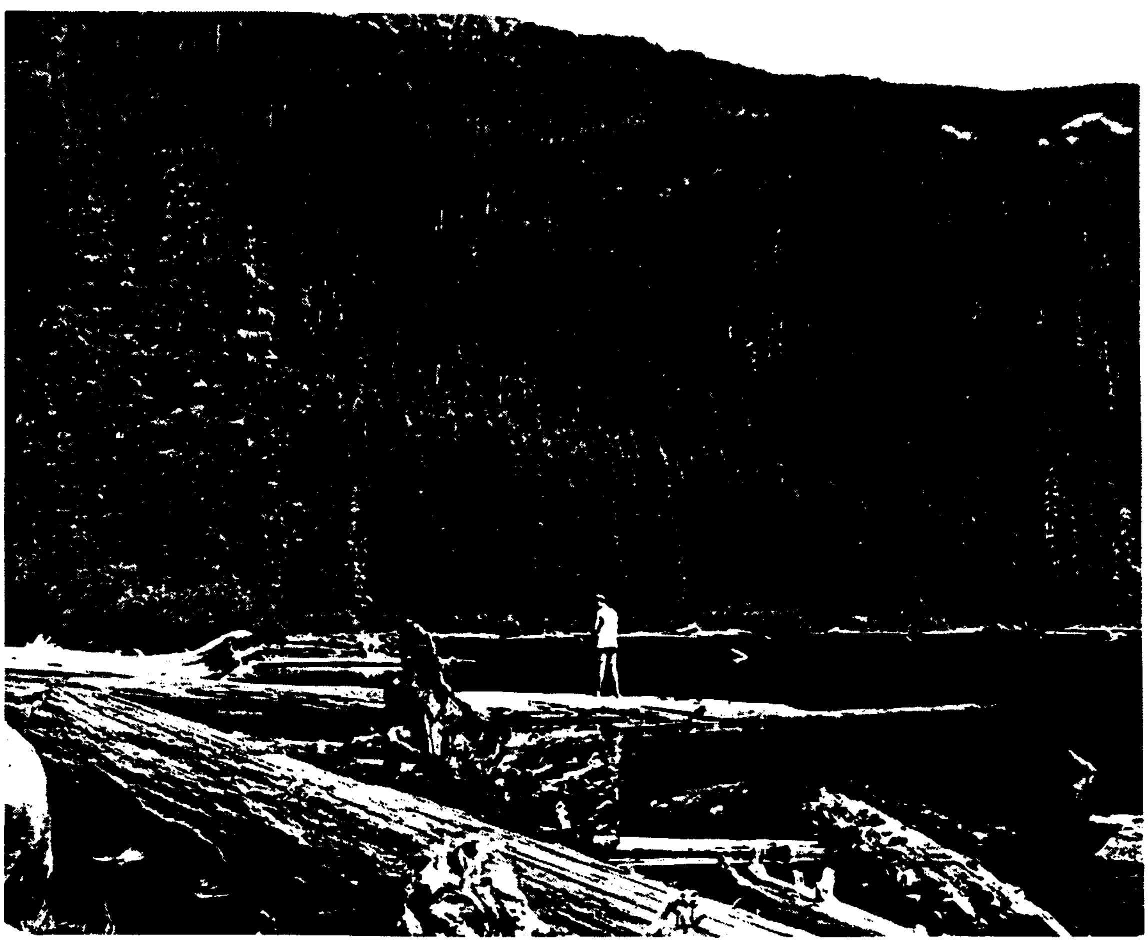


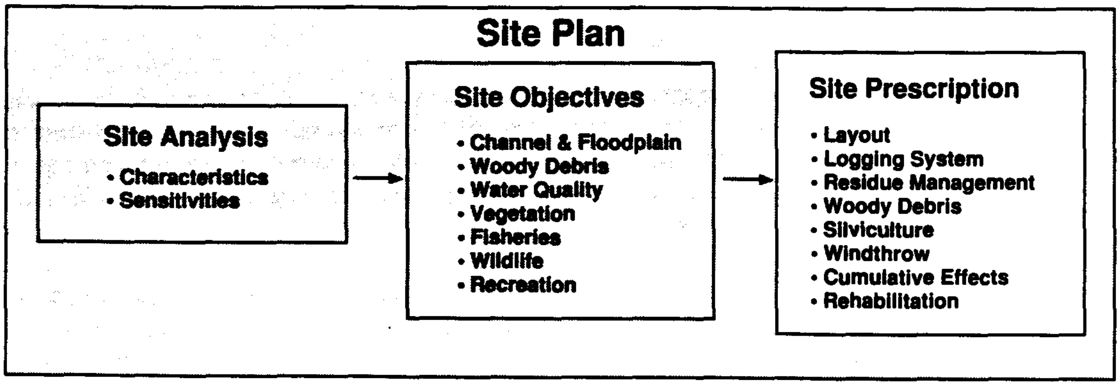
Figure 32. **Lakes and their surrounding riparian areas are important recreation sites in the Willamette National Forest.**

SITE PRACTICES

Site prescriptions should be designed to achieve basin goals and long-term conditions desired for the site (Fig. 33). The major components of riparian management for specific harvest units include:

- habitat type classification
- layout
- vegetation management
- woody debris management
- logging systems
- timing of activities

Figure 33. Components required for Site Prescription in site planning.



Habitat Type Classification

Habitat class for a harvest unit must be determined as the basis for developing the site prescription. Specific riparian management guidelines have been developed for major types of aquatic habitats (Management Area 15): streams, wetlands, and lakes.

Streams and rivers include both perennial and intermittent flowing waters. Four major classes of streams are recognized:

Class I streams

Perennial or intermittent streams that: 1) serve as the direct source of water for domestic use (cities, small communities, recreation sites with more than 25 users); 2) provide habitats for either spawning, rearing, or migration of large numbers of fish; and/or 3) contain sufficient flow to have a major influence on water quality of another Class I stream.

Class II streams

Perennial or intermittent streams with one or both of the following characteristics: 1) provide habitats for either spawning, rearing, or migration for moderate though significant numbers of fish; and/or 2) contain sufficient flow to have a moderate influence on water quality of a downstream Class I or II stream. Game fish are present for at least part of the year or the stream has the potential for establishment or re-establishment of a game fish population.

Class III streams

All other perennial streams that do not meet the criteria for Class I or II streams.

Class IV streams

All other intermittent or ephemeral streams that do not meet the criteria for Class I, II, or III streams.

Shallow wetlands, including ponds, swamps, marshes, bogs, and wet meadows, support a prevalence of vegetation or aquatic life requiring permanently or periodically saturated soil conditions for growth and reproduction (FSM 2527.05) and the adjacent riparian area.

Lakes include major bodies of standing water that are represented on topographic maps of the forest (either USGS quadrangles or National Forest maps). They include both natural lakes and man-made reservoirs.

Correct classification is important because habitat type is a determinant of riparian management zone boundaries. In most cases, the WNF has already determined stream class for major perennial streams. In smaller headwater streams, existing information on the presence of fish or the flow regime may be inadequate. The site must then be reviewed on the ground to determine stream class.

Criteria for identifying aquatic habitats are described in the Riparian Standards and Guidelines (see Appendix III). For a more complete discussion of stream classification, see FSM 2526, R6-Supp 51, and Willamette Supplement. Additional criteria for identifying riverine wetlands are described in Federal Manual for Identifying and Delineating Jurisdictional Wetlands and in Classification of Wetlands and Deepwater Habitats of the United States.

Harvest Unit Layout

Harvest unit layout must maintain riparian continuity within the basin and preserve riparian floodplain functions. In unit layout, a land manager must establish the location of riparian management zone boundaries, roads, and landings.

Riparian Management Zone Boundaries

Delineating the boundaries of the riparian management zone will largely determine the effectiveness of subsequent management in meeting riparian objectives. The following sequence of decisions is required to establish boundaries of riparian management zones:

- identify floodplain boundaries
- locate margins of active channels and shorelines
- establish riparian management zone boundaries
- modify boundaries to reduce risk of blowdown.

Floodplain Boundaries

The entire floodplain should be included within the riparian management zone (Fig. 34) (Executive Orders 11988 and 11990; FSM 2527.03). The topographic break in slope between hillsides and the relatively flat floor of the river valley defines floodplain boundaries. Several floodplains of increasing heights may occur between the active channel and the hillslope, reflecting surfaces created during past flood events. Floodplain soils and substrates are characterized by rounded edges on gravels, cobbles, or boulders as a result of being tumbled by streams and rivers. In contrast, hillslope substrates are more sharp and angular. Vegetation may change in age or composition at floodplain boundaries; however, many floodplains have forests as old or older than hillslope stands.

Floodplain boundaries (100-year flood recurrence interval) have been identified by the state of Oregon for all major rivers and lakes. Small, deeply incised streams frequently lack floodplains.

Floodplains may not exist along non-riverine wetlands and lakes. In the absence of floodplains, historical high water levels should be considered in these aquatic habitats. These areas may be indicated by evidence of erosion by wave action, reduced plant cover, and sharp transitions in plant community composition.

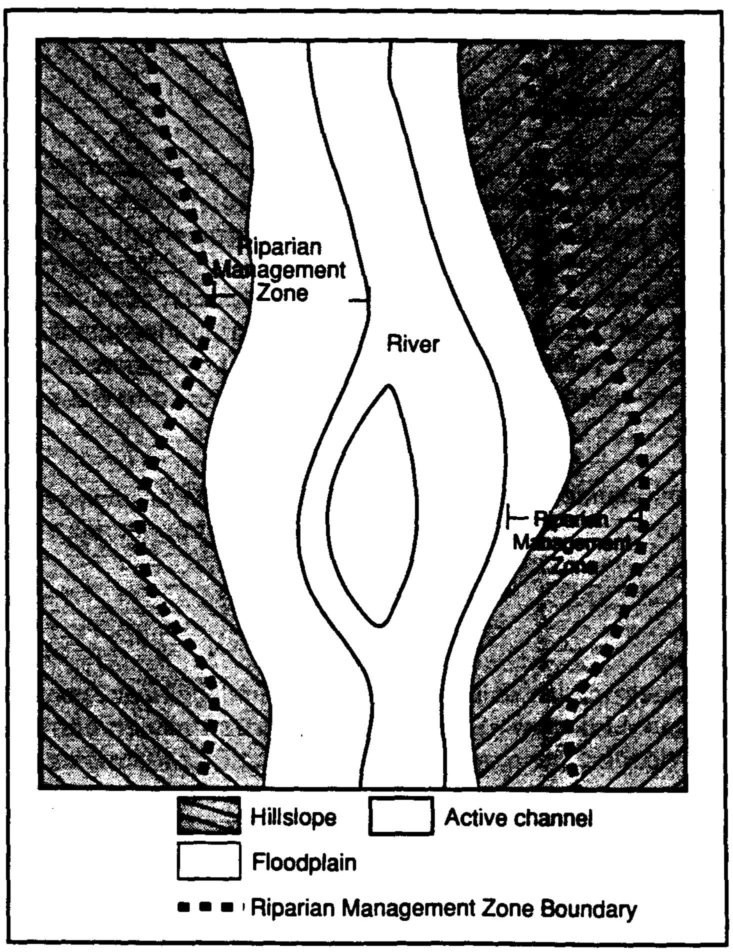


Figure 34. **Layout of a riparian management zone along a stream with complex channel and floodplain.**

Active Channel and Shoreline Boundaries

After floodplains have been identified, widths of riparian management zones are established along active stream channels. *Delineation of the riparian management zone starts at the edge of the active channel or mean high water level, and extends horizontally on both sides.*

Active channels consist of all portions of the stream channel carrying water at normal high flows, not just the current wetted channel. This includes side channels and backwaters which may not carry water during summer low flow. All islands and gravel bars are part of the active channel and not part of the riparian management zone.

Active channel boundaries are indicated by abrupt topographic breaks where frequent channel scour has steepened streambanks. Frequently, plant abundance is reduced in this area of active channel modification, and plant communities are dominated by herbs and forbs.

Riparian management zones around wetlands and lakes should be measured from the mean annual high water level. In wetlands, this zone is difficult to identify: breaks in plant community structure and topographic features provide the best means of immediate identification. With most wetlands, case-by-case on-site determinations of high water levels are required. In lakes, mean annual high water level is indicated by evidence of recent wave action and absence of extensive plant cover.

Riparian Management Zone Boundaries

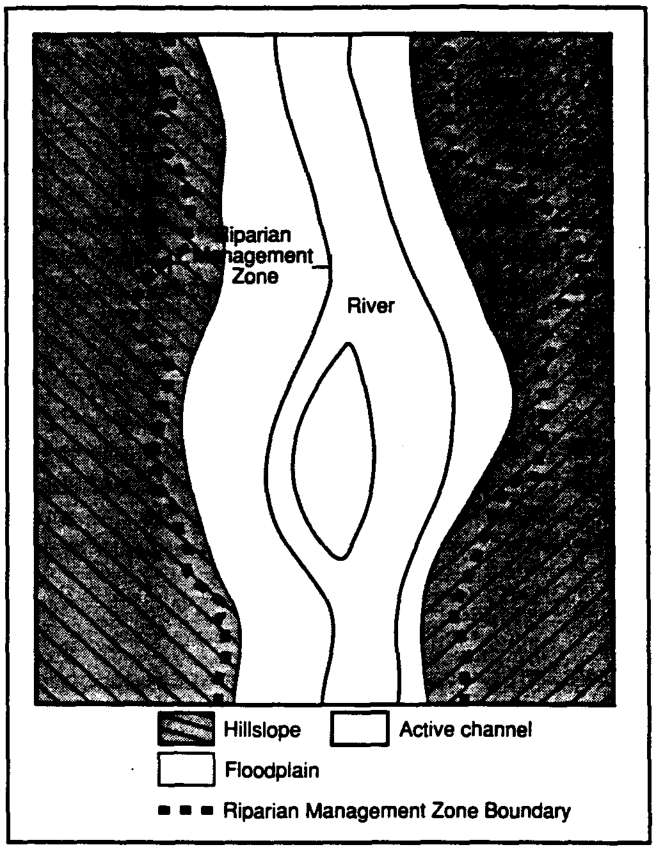
For optimal management of riparian resources, riparian management zones should have variable widths that are delineated at ecological boundaries, not at arbitrary distances from the stream, lake or wetland (Fig. 35). Riparian areas are naturally irregular or asymmetrical in shape, in response to local topography, geology, groundwater, and plant communities. Consideration of topographic irregularities can both protect riparian resources and simplify harvest unit layout. Straight, uniform riparian management zones resembling picket fences should be avoided. Locally within a unit, boundaries may be less than the recommended average width, but they should not be reduced to the point that continuity of riparian areas is lost.

Widths of boundaries described for aquatic habitats delineate the area intended for all riparian management activities. Riparian management boundaries are summarized in Tables 5a, b, and c.

Class I and II Streams

In order to meet riparian objectives, riparian management zones along Class I streams may range in width from 150 to 400 feet horizontally on both sides of the active channel. Widths of riparian management zones along Class II streams range from 100 to 200 feet. In most cases, these distances will encompass the entire 100-year floodplain. On some large Class I streams, a portion of the floodplain may extend beyond the 400 foot riparian management zone. This portion of the floodplain will still be evaluated and managed in accordance with Executive Orders pertaining to floodplains.

Figure 35. **A riparian management zone with boundaries of variable widths.** Note that the floodplain is entirely contained within the riparian management zone.



Class III Streams

Riparian management zones on Class III streams will vary depending on the soil stability rating (see Appendix II for definitions). Those streams on soils classified as stable will have a riparian management zone ranging from 50 to 100 feet horizontally on both sides of the active channel. Those Class III streams on moderately stable or unstable soils will require a wider management zone, ranging from 75 to 125 feet. These wider boundaries are designed to ensure local channel stability, retard flow of debris, and provide large woody material for habitat after debris flows.

Fish may move into small perennial and intermittent streams during certain seasons for spawning, rearing, or winter refuge. Tributary junctions with Class I or II streams should be closely examined for fish use. These areas of small perennial and intermittent streams that are important seasonally for fish habitat are classified as Class I or II streams and managed accordingly.

Class IV Streams

Delineation of riparian management zone boundaries in Class IV streams depends on the soil stability rating. Wider riparian management zones are required on streams in watersheds with unstable soil types (see Appendix II for SRI stability criteria). The streamside boundary of the riparian management zone should begin at the slope break for Class IV streams. Even where timber harvest is permitted to the stream's edge, boundaries are established for other management activities (e.g., understory vegetation, directional falling, yarding suspension).

In watersheds with *stable* and *moderately stable* soils, riparian management practices are designated for a zone ranging from 25 to 50 feet wide horizontally on both sides of the active channel in both intermittent and ephemeral Class IV streams. In watersheds classified as *unstable*, riparian management zones range from 25 to 100 feet wide horizontally.

Lakes

In order to maintain all riparian functions including recreation, lakes on the WNF have a riparian management zone ranging from 500 to 700 feet horizontally, but generally averaging 600 feet. This distance may be less if an adjacent ridgeline creates a logical topographic boundary.

Wetlands

Small wetlands (e.g., springs, seeps, ponds, bogs, marshes, wet meadows) are unique riparian resources. Because they vary so greatly, sites should be evaluated on an individual basis. Riparian management zones for these areas can range from 150 to 600 feet horizontally, and frequently will vary greatly in width within a given site.

Unique Local Habitats

Unique riparian resources, such as small springs, seeps, osprey nest trees, or sites of active beaver use, frequently exist outside standard/average riparian management boundaries. In these instances, managers should consider modifying boundaries to include such areas.

Boundary Modification to Reduce Blowdown

One of the major functions of riparian management zones is to provide a future source of large woody debris through windthrow, insects, and disease. The abrupt break in tree height between riparian management zones and upslope harvest units increases their susceptibility to windthrow. Catastrophic blowdown of the majority of trees within the riparian management zone will result in a more abrupt and pulsed loading of debris than intended. Thorough consideration of factors that contribute to blowdown can reduce the risk of catastrophic blowdown.

In a study of buffer strips in the Willamette, Mt. Hood, and Umpqua National Forests, blowdown ranged from 0% to 78% of the original stand density (Steinblums et al. 1984). The stability of riparian management zones was correlated with seven major variables:

- distance to uncut forest in wind direction
- change in elevation from RMZ to ridge
- distance to major ridge in wind direction
- stream aspect
- elevation of RMZ
- visual estimate of natural stability
- timber volume and site moisture class

Tree species also differ in their susceptibility to windthrow. In the western Cascades, western red cedar commonly is the most windfirm, followed by western hemlock, Douglas-fir and true firs. This pattern may vary according to geographic location, site history, and local stand conditions.

Steinblums et al. (1984) developed a detailed procedure for analysis of riparian management zone stability. The local topography, vegetation, and stream channel are evaluated on site. Both old windfalls and the pit and mound topography are examined to determine direction of damaging winds and history of blowdown. Indicators of potential natural instability (e.g., landslide tracks, jack-strawed trees, bank cutting, debris dams, swamps) are noted. Trees growing in more open stands present less wind resistance and thus less risk of blowdown; natural windswept tree forms provide greater stability.

Layout of riparian management zones can be modified to reduce risk of catastrophic blowdown. Boundaries of riparian management zones can be positioned closer to natural windbreaks (e.g., mature forests, ridgelines, rock outcrops). Riparian management zones can be blended into upslope patches of mature trees within the harvest unit. Areas of maximum width of riparian management zones can be shifted upstream or downstream to take advantage of shelter created by adjacent streamside forests.

Road Design and Location

Road failures and road-associated landslides contribute more sediment to riparian areas than any other management activity. Road failure has been a major cause of debris torrents in streams of the WNF. Sound construction methods and road locations can significantly reduce potential for long-term cumulative effects. Roads with high use during rainy portions of the year should be constructed and maintained to minimize sedimentation increases. Proper location of roads adjacent to riparian management areas and on hillslopes is a crucial component of effective riparian management.

- Minimize road construction on floodplains.
- Locate roads outside the riparian area.
- Limit stream crossings to areas where no practical alternative is available.
- Put temporary spur roads to bed be after harvest.
- Limit use of equipment in the stream channel and riparian areas.
- Consider additional surface, fill, and drainage stabilization measures for roads that contribute sediment to Class I or II streams.
- Consider closure or putting existing roads to bed in areas of unstable soils.
- Construct and maintain all roads and structures to minimize direct or indirect additions of sediment to streams.
- Sidecast and end haul material should not enter the riparian management zone, except where road entry is intended.

- Use water bars and other erosion control structures to prevent sediment delivery.
- Design culverts and other stream crossings to maintain fish passage on fish-bearing streams.
- Restrict in-stream construction activities to specified flow periods.
- Schedule dust oil application to minimize direct or indirect delivery into streams, lakes, and wetlands.

Landing Location

Landings should always be located outside riparian areas and beyond a point where sidecast could enter the riparian area. Landing sites should be selected on the basis of the least amount of excavation and erosion potential.

Landings should be located as far from riparian areas as possible if logs are yarded through the management zones. The proportion of a riparian management zone affected by cable corridors for a specific length of stream is reduced as the landing is placed farther from the stream.

Vegetation Management

Timber Harvest

The levels of timber harvest programmed within riparian management zones differ by aquatic habitat type. Programmed timber harvest and other practices in riparian management zones are summarized in Tables 5a, b, and c.

No timber harvest is programmed from riparian management zones along Class I, II and III streams, intermittent Class IV streams in unstable watersheds, lakes, or wetlands (Fig. 36). This policy is designed to ensure that management objectives for riparian-dependent resources will be achieved.

Partial harvest of vegetation (<50% of the stand in the riparian management zone) is permitted on the following stream classes: 1) intermittent Class IV channels in moderately stable watersheds; 2) ephemeral Class IV streams in unstable watersheds. Trees should not be harvested in the immediate vicinity of locally unstable areas, and trees in riparian areas can be partially harvested in downstream reaches (Fig. 37). Trees left within areas of partial harvest should be distributed along the reach in locations that maximize the resistance to debris flows and floods.

Complete harvest of overstory vegetation is permitted in: 1) intermittent Class IV streams in watersheds with stable soils; 2) ephemeral Class IV streams in watersheds with stable or moderately stable soils.

Figure 36. A no-harvest riparian management zone along a Class IV stream in an unstable watershed.

Figure 37. Partial harvest in a riparian management zone along a Class IV stream. Note the occurrence of both individual trees and clumps downstream of the leave area around the unstable site.

Suspension corridors and other recognized created openings (e.g., roads, bridges) are exceptions to programmed harvest policies. In addition, timber may be felled if needed for rehabilitation or enhancement purposes. Such judgements will be made on a case-by-case basis.

Salvage

In general, timber should not be salvaged from any riparian area, except where necessary to accomplish riparian objectives. Given the numerous functions and benefits of riparian vegetation and woody debris, there are few reasons to remove salvaged timber from riparian areas. It is generally detrimental to both the site and the basin. Treatment of standing trees, snags, and downed logs in riparian areas should be based on objectives and conditions of the landscape, basin, and site. Woody debris is lost from the active channel and floodplain, risk of sedimentation increases, and stream channels are exposed to direct solar radiation.

In riparian areas, trees damaged or killed by blowdown, fire, disease, or insect outbreaks should be retained to maintain biological diversity and to provide future snags and downed woody debris. Riparian trees may be felled and used on site or removed to another riparian area if local stand conditions are adequate.

Trees that present safety hazards for recreational or commercial users may be felled to eliminate the hazard, but should be left on the ground in the riparian area or in the stream channel. Where logs in rivers present a safety hazard to boaters, site-specific conditions should be evaluated. In most situations, these logs should be moved to a different location in the riparian area to reduce user conflicts and still maintain riparian functions.

<u>Blowdown in Riparian Management Zones</u>

Blowdown is not a management failure and downed trees should not be removed from riparian management zones. The zone was designed for the trees to die and fall into the stream channel, and windthrow is the most common source of natural debris loading. Despite careful planning for the location and configuration of riparian management zones, a large portion of remaining riparian vegetation may blow down on some units. The blowdown event accelerates debris loading faster than anticipated, but it is NOT a disaster from an ecological view, merely a change in timing.

If catastrophic blowdown creates a detrimental situation for riparian-dependent resources (e.g., barriers to anadromous fish migration, obstacles across hiking trails, unplantable conditions), modification of the debris accumulation can be considered for specific cases. Partial debris removal is preferable to complete salvage. Managers should modify debris accumulations as little as possible to achieve the desired conditions.

Shade Management

Along those Class IV streams where complete or partial harvest is permitted, understory vegetation should be maintained to the maximum extent possible for shade to maintain cool water temperatures. In all harvest operations, removal of vegetation for safety paths is required around a tree to be felled.

Silviculture

Since timber harvest is not programmed in most riparian management zones of the WNF, immediate silvicultural regeneration of the riparian area is not required in most cases. In riparian management zones with partial harvest, vegetation should be replanted. Species composition of the pre-harvest stand should be reestablished by planting species that naturally occur at the site.

Representative riparian management zones should be monitored periodically to determine whether natural regeneration is adequate for long-term stand maintenance. In cases where there is no evidence of regeneration, active silvicultural management may be required (e.g., replanting, stand manipulation, broadcast burning, fertilization). In addition, riparian areas degraded because of past practices or natural events can benefit from silvicultural management.

Few silvicultural techniques have been developed for riparian forests. Future riparian management will benefit greatly from thorough documentation and evaluation of new methods .

Large Woody Debris Management

Large woody debris is absolutely crucial to numerous riparian functions over both the short-term (seasons to decades) and long-term (decades to centuries) life of the forest in specific sites as well as downstream areas (Fig. 38). The policy of no harvest in the riparian management zone is designed to guarantee the long-term supply of woody debris to wetlands, streams, lakes, and floodplains of the WNF. If stream clean-up is prescribed, large woody debris present before harvest should be left in place.

Residue Management

Logging slash should not present a problem in wetlands, lake margins, perennial stream channels and unstable Class IV streams because no timber harvest is programmed within these riparian management zones. Direct inputs of logging slash should be minimal, and riparian zones will intercept slash from upslope harvest units.

Timber harvest in areas immediately adjacent to streams often adds quantities of slash and large debris to channels; this is most likely to occur along Class IV streams (Fig. 39). Timber harvest in these areas should use techniques that minimize debris loading into the channel (e.g., directional falling, log suspension, minimal site disturbance; see Table 5a b, and c).

Land managers should be cautious about removing slash from any riparian management zone, stream channel, lake or wetland. If residue accidentally accumulates in riparian zones, it should be left in place and not piled. No clean-up should be prescribed for any stream, lake or wetland under normal conditions.

Broadcast burning normally should not be prescribed to extend into the riparian management zone. The fire line should be located well away from the riparian management zone to avoid disturbance from burning and soil compaction. Prescribed use of fire within the zone may be recommended to maintain some riparian plant communities.

Figure 38. Natural accumulations of woody debris in a stream in the Willamette National Forest.

Figure 39. Woody debris from both natural and logging-related sources in a small stream in the Willamette National Forest.

High Risk Areas

In rare instances, residue will need to be removed from the site to prevent damage to downstream resources or impairment of water quality. Areas with shallow soils, unstable headwalls, or tension cracks in the soil surface are potentially unstable. Mass failures may originate at these locations. Also, decomposition of slash in low gradient, swampy areas may reduce dissolved oxygen levels to lethal limits for aquatic life.

In such cases, logging slash should be removed only to the extent that streamflow is no longer blocked. Slash in the riparian area can be hand piled (PUM) outside the active channel. Yarding of slash to landings (YUM) should be considered as a last resort. Imbedded large woody debris present before yarding should be left in place.

Large woody debris in the active channel or flood channel may be removed within three channel widths of the upstream side of permanent road crossings to prevent culvert or bridge failure.

Riparian areas are noted for their resistance to burning, but if fuel loading is a concern at a particular location, slash in the riparian area can be hand piled (PUM) outside the riparian management zone and burned.

Logging Systems

The choice of logging system for a particular site should consider the riparian area and its degree of protection. The best planned riparian management zone in the WNF will be useless if logs are carelessly felled into or yarded through it.

Falling and Bucking

No trees in the harvest unit should be felled in a direction that would result in their entry into the riparian management zone, except along stable and moderately stable Class IV streams. If a tree is accidentally felled into the riparian management zone, it should be left. Attempts to retrieve such logs frequently result in severe damage to planned riparian management zones.

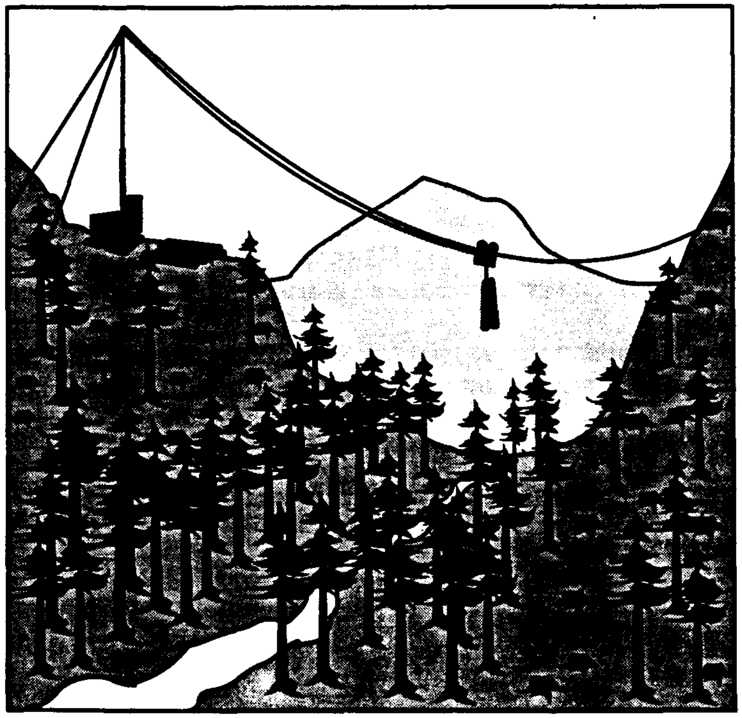
Yarding, Suspension, and Cable Corridors

All efforts should be made to protect riparian vegetation during yarding operations. Dragging logs through streams and riparian areas causes damage that takes decades to heal, and should be avoided if possible.

Logs should be yarded uphill if possible when passing over or through riparian management zones (Fig. 40). Lateral movement of logs is more restricted in uphill than in downhill yarding.

Carriage location during in-haul must be situated to yard away from the riparian management zone. Lines should be removed from the management zone prior to restringing for next line placement.

Figure 40. Yarding logs with full suspension across unharvested riparian management zone.



In some harvest units, cable corridors may need to be cut through the riparian management zone. The number of these crossings should be kept to a minimum. Corridors should not be cut through stable debris accumulations. Care should also be taken not to destroy side channels and backwaters important to fish-rearing on Class I and II streams and lakes.

When a suspension corridor is cut, these logs should be placed in the channel and riparian management zone if the area is deficient in large woody debris (Fig. 41). The amount of woody debris left in the channel and forest floor within the suspension corridor should approximate natural volumes for the site.

Created openings within the riparian management zone (such as cable roads) should each be limited to 20 feet in width and total no more than 10% of the channel edge within the activity area.

On slopes susceptible to erosion, yarding should be restricted to the dry season unless full suspension can be achieved.

Figure 41. A riparian management zone with cable corridors. Note that natural levels of woody debris are left in the stream channel and forest floor.

Class I, II & III Streams, Lakes, and Wetlands

Yarding logs across any perennial stream or any portion of a lake or wetland requires specific site evaluation, on-the-ground review, and full documentation in the environmental assessment. Predicted impacts from proposed skyline anchors and corridors must be explicitly stated. Full suspension of logs above the canopy of the riparian management area is required; particular care should be taken not to minimize vegetation damage.

Class IV Streams

Full to partial suspension is required on all intermittent Class IV streams. On ephemeral streams, partial suspension is necessary over the channel. In streams on unstable soils, care should be taken to avoid damage to the retained riparian vegetation.

Timing of Activities

Seasonal impacts of logging activities need to be evaluated. Those that may generate excessive fine sediment should be carried out in dry periods of the year so erosion control practices can be completed before the rainy season.

Class I & II Streams and Lakes

From October 15 through July 15, logging-related sedimentation is more likely to interfere with salmonid spawning, incubation of eggs in the gravels, or emergence of fry. Therefore construction activities in the stream (e.g., bridges, culverts, rehabilitation structures) normally should be limited to the period between July 15 and October 15. Activities outside the channel but likely to contribute sediment to stream channels should adhere to the same operating season and should use special installations to prevent sediment from reaching the stream.

In stream reaches used by spring chinook salmon for spawning, the period of activity should be limited to July 15 to September 15. Bull trout begin spawning in September: therefore, construction activities should be completed before September 1 in reaches they use for spawning.

CHAPTER 6

RIPARIAN REHABILITATION

Both natural and man-caused events can have adverse impacts on riparian functions, despite the best attempts to protect them. Past practices may have left areas that cannot provide full riparian functions for several centuries. Current harvest activities occasionally may damage riparian management zones, even with good planning and technology. Natural events, such as floods or fires, may also create degraded riparian conditions. Although natural variation is desirable, damaged riparian areas containing important resources may benefit from man's assistance. Silvicultural and geomorphic techniques may be effective in rehabilitating degraded riparian resources.

Successful riparian silvicultural, fish habitat, or channel rehabilitation projects all a basic sequence of planning, implementation, and monitoring. They include: (1) determination of existing conditions; (2) identification of rehabilitation needs; (3) project design; (4) implementation; and (5) post-installation monitoring.

SILVICULTURE

Silviculture practices have been concerned primarily with regenerating merchantable timber on hillslopes; however, degraded riparian areas can also benefit from these techniques. The goals of silvicultural management in riparian management zones are to provide the natural ecological functions of riparian vegetation where past practices or natural events have diminished the diversity of riparian plant communities. All stages of silvicultural activity should encourage natural patterns of succession. Highest priorities in all silvicultural operations in riparian areas should be given to creating taxonomically diverse and structurally complex riparian plant communities.

Shading

Reestablishment of shade over stream channels can be accelerated by protecting any remaining streamside vegetation, especially young trees. However, in areas dominated by shrub cover, underburning may encourage regeneration of desired tree species. In riparian areas where short-term canopy recovery is required, hardwood species (e.g., red alder, big-leaf maple, willow, cottonwood) may be planted. Coniferous species such as hemlock, western red cedar, and Douglas fir should be planted to reestablish long-term shade conditions.

Woody Debris

Snags, green trees, and cull trees should be left in place to provide a short-term debris source. Species such as western red cedar, which decay slowly, should be planted where appropriate.

Precommercial thinning removes small trees from the unit. Placing this material directly into channels should be considered for short-term channel and floodplain complexity, particularly in small streams lacking debris. This small woody debris can provide structure and organic matter for 5-15 years.

At the commercial thinning stage (40-80 years), there are two options: (1) the operation can be avoided completely in the riparian management zone, leaving natural mortality at 80-120 years to thin the area; or (2) commercial thinning can proceed, but pole timber and culls can be placed in the channel. The latter practice should be considered only if the stream channel contains inadequate volumes of woody debris.

Vertical and Horizontal Diversity

In degraded riparian areas, structural complexity and vertical diversity can be partially attained by leaving whips, snags, and green culls in adjacent harvest units. Managers should leave as many standing cull trees as possible outside the riparian management zone to feather the riparian forest into the adjacent younger forest. Group selection or single tree selection are preferable to even-age management. Thinning areas in riparian management zones should be irregularly distributed in patches rather than uniformly dispersed throughout the stand.

CHANNEL REHABILITATION

Channels in many streams of the WNF have been simplified and destabilized by prescribed stream clean-up, salvage operations, debris torrents, and floods. Riparian timber harvest has removed the source of large woody debris for these streams for the next one or two hundred years. In the few areas with adequate equipment access and sources of large wood, channel structure and volumes of large woody debris can be restored through channel rehabilitation projects.

Appropriate design of rehabilitation projects requires thorough analysis and implementation. To rehabilitate degraded stream habitats effectively, land managers should:

- evaluate existing conditions
  - channel structure
  - fish communities
  - analyze limiting factors
- develop and document objectives
- implement the project
- monitor to determine if objectives are achieved.

Evaluation

Understanding the current status of channel structure and/or fish communities is essential for developing appropriate project objectives. All too often, rehabilitation projects are initiated without identifying specific objectives. For instance, pools are created for fish habitat without determining whether existing geomorphology would support additional pools over the long term, or whether existing fish populations are actually limited by lack of pools.

Conditions of existing channel structure (including amounts of large woody debris) and fish communities must be inventoried both for the basin and on the specific rehabilitation site. Projects initiated without consideration of basin-level conditions will be significantly less effective and more prone to failure than those that perform such an assessment. Pre-harvest channel structure and fish communities should be assessed at similar undisturbed streams within the basin. If natural areas cannot be found within the basin, similar basins nearby can be used to compare with patterns found at the proposed rehabilitation site.

Geomorphic structure and channel hydraulics change from headwaters to large rivers. A rehabilitation structure may be physically stable and effective in one part of a basin but may fail rapidly in another stream reach. The location, distribution, configuration, and size of channel rehabilitation features should be consistent with the geomorphic and hydraulic properties of the stream reach.

Fish habitat rehabilitation projects should be planned to meet specific objectives related to species and age class composition of fish communities, life history characteristics, abundance, habitat availability relative to requirements, and food resources. Seasonal patterns of fish distribution and abundance within the basin should be considered.

If a riparian area has been damaged by a natural or land use-related disturbance, the probability of continued disturbance must be considered. *Any improvements associated with rehabilitation projects can be negated by treating the symptom rather than the source of disturbance.*

Inventories of riparian conditions and fish communities within a basin identify specific needs for rehabilitation activities. This assessment will determine the physical and/or biological factors that may limit channel "health" or fish populations. For example, pool availability may not be limiting fish production, but sufficient fry rearing habitat, such as edges, may be lacking. From a geomorphic perspective, limiting factors analysis may point out that the stream channel is simpler than would be expected in undisturbed conditions. Such determinations will focus the direction of rehabilitation efforts and can increase the effectiveness and long-term success of a rehabilitation project.

Development of Objectives

Objectives for the entire rehabilitation project and each individual component, including structures, and anticipated future changes should be explicitly stated. This serves as a record of management activities, supplies a basis for long-term project monitoring, and provides a foundation for developing more effective future rehabilitation techniques.

Implementation

After project objectives have been clearly identified and documented, the rehabilitation project can be initiated. A variety of materials, both natural and man-made, can be used for channel modification.

Natural Channel Materials

Stream rehabilitation projects are usually designed to restore bed materials, either logs or sediments. *Natural channel materials should be used for rehabilitation whenever available.* Natural materials are usually cheaper than artificial structures, provide ecological functions more effectively, and, unlike man-made structures such as gabions, continue to provide such functions even if transported downstream.

Large Woody Debris

Log introduction projects should attempt to restore natural distributions, abundance, and size classes of debris in streams (Fig. 42). Persistence of installations is increased where log structures are placed in geomorphically stable locations and configured to resemble natural accumulations of wood.

Movement of introduced logs should not be considered a failure, particularly if they are retained within a short distance downstream. In an undisturbed stream of the McKenzie River basin over the past ten years, no more than 4% of the wood has moved in any given year; more than 90% of the logs that moved were less than 6 feet long. Log length is a critical factor in stability: logs longer the active channel width are not likely to move very far downstream.

The importance of geomorphically-appropriate design and placement of log structures cannot be emphasized too strongly. Precautionary reinforcements (e.g., cabling, glueing to bedrock, etc.) cannot change a poorly-designed structure into effective fish habitat. Logs and stream channels naturally shift during floods. Time-lapse films of log jams in the WNF have shown that logs float up several feet during floods and drop back into place, with little evidence after the flood of having moved. Streambeds also naturally shift during floods; a location that is physically stable before a flood may become unstable if the channel changes.

Several configurations of log accumulations are commonly used in habitat restoration projects (e.g., full channel jams, sill logs, lateral deflectors, upstream or downstream V's,

Figure 42. An installation of woody debris for stream rehabilitation on Quartz Creek in the McKenzie drainage.

off-channel accumulations). Each type of debris accumulation creates different channel structure and flow characteristics. Their ability to provide fish habitat also differs greatly. Project design should carefully match debris accumulation types to the desired geomorphic and ecological objectives.

Downstream road crossings, recreational areas, and residences commonly are safety concerns in debris rehabilitation projects. If risk of downstream damage is likely, several precautions can minimize potential risks.

Securing logs to bedrock, boulders, or other logs with steel cable and epoxy is used to increase log stability. Frequently, both ends of a log are cabled to adjacent boulders or bedrock. In high-energy or bedrock-dominated reaches in particular, full cabling may be required to maintain structures during high flows. Caution should be exercised in fully cabling logs to relatively immovable objects in the channel. At high flow, tremendous forces may be directed into the log, and flotation may cause great strain if the log is totally submerged.

Partial cabling (or tethering) provides some stability but permits more flexibility than full cabling. In many structures (e.g., lateral deflectors, complex accumulations), partial cabling at the bank end of the log may result in better structure response than full cabling.

If there are no immediate downstream risks, cabling should be minimized to guarantee natural behavior of log accumulations. Logs continue to provide natural ecological functions when floated and redeposited downstream.

Where supply of large woody debris is limited, small trees (with rootwads still attached) may be cabled together in bundles to mimic the effects of larger material. While these tree bundles provide larger effective diameters, their relatively short length may limit their use to smaller streams or to the edges of larger channels. These bundles of smaller debris can create complex cover for juvenile fish.

Live Trees

In riparian areas with adequate tree stocking, some woody debris can be obtained directly from riparian management zone. Trees can be felled directly into the channel, but the lack of a root wad decreases their stability. Hydraulic excavators can push over large trees (2-3 ft dbh) and leave the root wad intact. Riparian trees can also be blasted over, but operators have little control over the direction of fall.

Boulders

Debris torrents and floods can eliminate boulders and other large channel material from stream reaches. Boulder additions, either alone or with logs, can increase the channel's ability to retain sediments and provide fish habitat. Natural configurations of boulder berms and bar features should be followed to create geomorphically stable installations.

Channel Form

After assessing fish populations, objectives may call for altering channel bedform, particularly abundances of pools. In sediment-rich streams, the practices described above will generally achieve such objectives. In bedrock-dominated streams, altering bedform is more difficult because the potential to downcut is limited. Two major approaches are feasible for creating pools in bedrock: building up the channel and creating holes in the bedrock.

Building sediment deposits over extensive bedrock surfaces can be successful, but requires large numbers of boulders, logs, or gabions. Anchoring structures to bedrock with cable is almost always required to withstand the great erosional forces present at high flows. Structures that completely span the channel will create dammed pools, at least initially. The pools may fill with sediment and gravel over time. If this occurs, secondary structures can be added to scour depressions in these deposits.

Blasting with dynamite has been used to create holes in bedrock. Blasting has many logistic limitations (cost, safety risks, limited area of influence), and often is not effective. Simple depressions in bedrock surfaces will generally fill with gravel within a few years, and the fish habitat created is not complex enough to provide cover or refuge from floods.

Complex multi-piece structures located closely to other structures have greater potential to accumulate sediments rapidly and to dissipate high flood velocities. Linking structures on bedrock to off-channel habitats (e.g., side channels, backwaters, floodplains) provides physical relief and lateral fish refuge at high flow (Fig. 43).

Figure 43. A complex jam installed without use of any cabling or glue on Quartz Creek in the McKenzie drainage. It completely spans the stream channel, and provides an important source of geomorphic roughness as well as fish habitat.

Beavers

Beavers create extensive pools with complex off-channel areas, continually bring nutrients (trees and foliage) into the habitat for aquatic organisms, and quickly repair damage during floods. Rehabilitation projects can be located near areas of existing beaver activity to take advantage of their beneficial effects.

Recolonization by beavers can be encouraged in basins where channels have been degraded. In areas without beaver, reintroduction has been successful if release sites offer good habitat. They prefer second-growth stands, which are more likely to be the sites of damaged stream channels. Additional road inspection and maintenance may be required around road crossings to prevent damming of culverts.

Gabions

Gabions are wire baskets filled with cobble and small boulders. Where large logs and boulders are not available, they offer the potential to modify channel structure with small sediments. Gabions function like boulder berms in streams and, like natural materials, should be placed in geomorphically appropriate locations and configurations.

Gabions are less effective rehabilitation structures than natural materials. They do not provide the open matrices created by log or boulder structures. When gabions fail, they create a tangled mass of "chicken wire" downstream, providing none of the desired project objectives. Gabions are generally more expensive than natural structures to install, and usually last less than 20 years.

Project Monitoring

Functionally, a rehabilitation project starts after implementation is completed. *Rehabilitation projects without future evaluation are unfinished.* Subsequent monitoring is essential to determine to what degree project objectives were achieved and to improve future riparian rehabilitation efforts. It is important to know which practices are not effective and conditions under which they fail.

In the initial planning phase, criteria for evaluation should be established. A project officer for future project monitoring should be designated, and plans for future funding of monitoring should be identified.

CHAPTER 7

MONITORING RIPARIAN AREAS

Riparian monitoring evaluates the effectiveness of past management practices and provides information for developing future management policies. Identification of the desired future condition of riparian areas is a fundamental basis for any monitoring and evaluation of resource information. Such desired future conditions for riparian areas have been identified for Region 6 of the U.S. Forest Service.

Riparian monitoring programs currently being developed by the WNF incorporate three types of monitoring: implementation, effectiveness, and validation.

Implementation monitoring determines whether Standards and Guidelines are implemented to achieve riparian objectives. Pre-harvest environmental assessments are reviewed, and operational compliance with riparian prescriptions is checked on the ground. These site reviews also determine whether all standards and guidelines were met.

Effectiveness monitoring ascertains whether riparian prescriptions and plans are achieving the overall objectives of riparian management policy. It is conducted at several scales, ranging from individual sites to large drainage basins, and includes follow-up of rehabilitation projects.

Validation monitoring establishes whether the underlying assumptions used in resource models and planning are correct. In most cases, both managed and undisturbed areas require monitoring. Validation monitoring over several decades is essential for detecting major trends in resource status.

The land base of the WNF encompasses a wide range of natural landscape features and management patterns. As a result, monitoring of riparian areas cannot be concentrated at one or two sites and then extrapolated to cover the entire Forest. At the same time, logistical and financial constraints require a stratified monitoring program that includes:

- post-project site review
- reference sub-drainages
- basin monitoring
- water quality network
- landscape synthesis of monitoring data

This stratified monitoring program examines different aspects of riparian areas at several scales of space and time. It provides information on channel and floodplain functions, water quality, fish and wildlife habitat and numbers, and riparian plant diversity and dynamics.

POST-PROJECT REVIEW

The post-project review determines if WNF Standards and Guidelines for riparian management are being implemented, in terms of environmental assessments, site analyses, site prescriptions, and operator compliance with prescriptions. All managed units in a given District undergo an office review of environmental assessments and contracts. A proportion of managed units (including rehabilitation efforts) are also reviewed on the ground immediately after operations, to determine whether the prescriptions were appropriate for the specific site, and whether they were implemented properly. Ideas for post-project review are listed in Appendix III.

REFERENCE SUB-DRAINAGES

Reference sub-drainages are selected for long-term systematic effectiveness and validation monitoring across the entire WNF. These locations include both managed and undisturbed (mature/old growth) areas. Reference sub-drainages provide information on riparian resources across a range of forest conditions and management practices. Within each selected sub-drainage, reference stream reaches or sites are chosen, and their boundaries are monumented and documented for long-term repeated measurements.

Reference sub-drainages are selected to provide a range of elevations, including the low elevation rain-dominated zone, the rain-on-snow (transient snow) zone, and the snow-pack-dominated zone. The proportion of the sub-drainage in the transient snow zone is particularly important for hydrologic analyses. These three broad elevation bands experience different winter weather conditions, and consequently have different annual runoff patterns.

Reference sub-drainages also represent major classes of watershed stability (unstable, moderately stable, stable). Soil stability, geology, and slope steepness are important criteria in stability classification. Slope stability ratings have been developed for the major soil types and subdrainages of the WNF (see Appendix II).

Each group of reference sub-drainages contains both harvested and unharvested riparian areas, as well as different proportions of the drainage available for harvest. The areas with no timber harvest serve as controls to distinguish changes caused by management practices from those related to natural variation.

Aquatic habitat types include all stream classes and lakes. Within a given reference sub-drainage, representative reaches of all stream classes (I - IV) are selected for intensive monitoring of both aquatic and terrestrial parameters. In addition to stream class, selection of reaches is based on valley floor type (e.g., unconstrained vs. constrained). If appropriate, lakes surrounded by areas of timber harvest are also monitored. Reference reaches are evaluated three times per decade, with a total of 20 miles of stream surveyed each year. The monitoring process in reference sub-drainages evaluates channel structure, streamside vegetation (including plant diversity), fish communities, and wildlife habitat. Basic components of reference sub-drainage monitoring are listed in Appendix III.

BASIN MONITORING

Basin surveys are designed to provide a broad overall assessment of fish habitat and populations. Instead of concentrating on small individual standard reaches within the reference sub-drainages, basin inventories cover many miles of fish-bearing streams. All fish-bearing streams within the WNF are surveyed twice per decade.

Basin monitoring describes channel structure, streamside vegetation, woody debris, and fish communities. Components of basin monitoring are listed in Appendix III.

WATER QUALITY NETWORK

Water quality monitoring on the WNF requires frequent sampling over a broad spatial scale. Consequently, a network of monitoring stations will be established across the Forest. The areas for basin-level water quality monitoring are selected from the reference sub-drainages used for intensive riparian monitoring. Waldo Lake and smaller lakes in areas of timber harvest are included in the water quality network. Water temperature, suspended sediments, and water chemistry are critical components of water quality for assessment. In general, all sampling will be done at regularly scheduled intervals and in response to significant episodic events, such as drought conditions or major storms.

Temperature is particularly critical in Class I and II fish-bearing streams, and can be strongly affected by Class III and IV streams. Stream temperature patterns are monitored during summer low-flow periods, to ensure that State Water Quality standards are being met. Lake temperature profiles are measured during the period of maximum thermal stratification (usually late August).

Suspended sediments and turbidity are monitored in critical municipal watersheds and fish-bearing streams and lakes. Measurements are taken during the rainy season and after large floods (>5 year recurrence interval), since most inputs occur during this time.

Dissolved nutrient concentrations are an important factor in water quality analysis. Concentrations of elements such as nitrogen, phosphorus, and organic carbon commonly increase after forest harvest. Basic chemical parameters in water quality monitoring include conductivity, pH, alkalinity, nitrate, ammonium, reduced nitrogen, orthophosphate, total phosphorus, dissolved organic carbon, calcium, magnesium, sodium, potassium, chloride, sulfate, and silica.

CHAPTER 8
GLOSSARY

Active Channel: The portion of the valley floor flooded annually, including low flow wetted channel and streambanks.

Aggradation: The geologic process of filling and raising the level of the streambed or floodplain by deposition of material eroded and transported from other areas.

Aggregate Recovery Percentage (ARP): Within a given subdrainage between 1500 and 4000 feet in elevation on the WNF, ARP is the sum of the percent recovery for each stand age/size weighted by the proportion of the area within that classification. Degree of recovery of a harvested area is based on the average diameter of the replanted trees. When the average stem diameter of replanted trees is 8 inches DBH (diameter at breast height) and there is at least 70% canopy cover, the stand is considered fully recovered. Such fully recovered stands are typically 35 years old. Stands with smaller diameter trees and lesser canopy closure are partially recovered.

Alluvial Fan: A fan-shaped accumulation of sediments deposited by streams, usually at their mouths.

Alluvium: A general term for all sediments transported and deposited by streams. Alluvium may accumulate on streambeds, fans, lakes or estuaries.

Anadromous Fish: Species, such as salmon, that hatch in freshwater, move to the ocean to mature, and return to freshwater to spawn.

Aquatic Ecosystem: Any body of water, such as a stream, lake, or estuary, and all of the organisms and nonliving components, functioning as a natural system.

Aquatic Habitat: Habitat for fish and other aquatic organisms within lakes, wetlands, or wetted channels of streams.

Backwater: An off-channel pool or eddy at lateral margins of the channel. Protected from high velocity flows, usually by abundant woody debris or boulders. Opening to main channel is less than the long axis of the backwater itself.

Bank Storage: Infiltration of water into stream bank deposits during flood flows.

Bank Full Width: Width of stream channel at normal flood flow.

Bank Stability: The ability of stream banks to withstand the erosive forces of water. Bank stability increases in the presence of deeply rooted plants.

Bar: A ridge-shaped deposit of alluvial material in the channel, along stream banks, or at the mouth of a stream.

Base Flow: Typical flow for a given stream at a particular time of year.

Basin: The area of land that drains water, sediment and dissolved materials to a common point along a stream channel.

Bedload: Particles, ranging in size from clay to boulders, which are carried by the water, but which are in at least partial contact with the bottom.

Benthos (n), Benthic (adj): Organisms living on or within the substrates of aquatic habitats.

Biological Stability: The inherent capacity for biological systems to resist change: the absence of fluctuations and the ability to withstand disturbances without significant changes in composition.

Blowdown: A tree or trees uprooted or felled by the wind.

Buffer: An area of vegetation left or managed to reduce the impact of a treatment or action of one area on another.

Canopy Cover: The more or less continuous cover of branches and foliage formed by the crowns of adjacent trees and other woody growth.

Carrying Capacity: The number of individuals of a particular species that the resources of a given habitat can support.

Channel: A waterway that contains moving water either periodically or continuously. A channels has a definite bed and banks.

Channel stability: The resistance of a stream to changes in bedform.

Climax Community: The final biotic community in a successional sequence. Usually a community that is self-perpetuating unless disturbed by outside forces.

Connectivity: Unbroken linkages in a landscape, typified by streams and riparian areas.

Constrained: A narrow valley limited in width by adjacent landforms, with a valley floor width less than two active channel widths. Valley walls are usually steep; the stream cannot meander and is a single simple channel.

Cover: Any feature that provides protective concealment for fish and wildlife. Cover may consist of live or dead vegetation or geomorphic features such as boulders and undercut banks. Cover may be used for purposes of escape from predators, feeding, or resting.

Critical Habitat: The portion of the living area of a species that is essential to the survival and perpetuation of the species.

Crown Cover: See canopy cover.

Cull: A snag, green tree, or log that is of little or no economic value.

Cumulative Effects: Effects on the environment resulting from individually minor but collectively significant actions taking place over a period of time.

Debris (organic): Logs, trees, limbs, branches, leaves, bark that accumulate, often in streams or riparian areas. Debris may be naturally occurring or the result of man's activities.

Debris Jam: An accumulation of many sizes of woody debris, generally within the stream channel, but often extending onto the banks or low terraces. Also referred to as debris dams or debris accumulations, they may be naturally occurring or the result of poor management.

Debris Loading: The amount of debris located in a specific area; it may accumulate as a result of natural processes or human activities.

Debris Avalanche/Slide: Rapid landslides occurring on hillslopes. The material moved, including sediment, wood, and vegetation, may or may not be delivered to a stream channel.

Debris Torrent/Flow: Rapid movements of material, including sediment and woody debris, within a stream channel. Debris torrents frequently begin as debris slides on adjacent hillslopes.

Degradation: Lowering of a stream bed by erosion (vs aggradation).

Deposition: The settlement of material out of the water column and onto the stream or lake bed (vs. erosion).

Detritus: Loose particulate matter formed by the breakdown of decomposing plants and animals.

Diameter Breast High (DBH): The standard diameter measurement for standing trees, taken at 4.5 feet above the ground.

Discharge: A measure of the amount of water flowing in the stream channel. Discharge depends on both the velocity of the water and the area of the wetted channel, and is generally measured in m^3/sec or ft^3/sec (cfs).

Diversity: the relative abundance and variety of species, both plant and animal, in a given area.

Drainage Area: See basin.

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

Ecosystem: A complete interacting system of organisms considered together in their environment. A biotic community and its abiotic environment.

Ecotone: A transition or junction zone between two or more naturally occurring diverse communities.

Edges/Edge Effect: Areas where two physical or biological zones meet. The increased diversity in these areas is known as the edge effect.

Flood: Abrupt increase in discharge. Frequently , flows that exceed the bankfull capacity of a given stream.

Floodplain: Relatively flat surfaces adjacent to active channels, formed by deposition of sediments during major flood events. It may be covered by water at flood flows.

Flow: Any movement of water (see discharge).

Food chain: The transfer of food energy from plants through a series of consumers by repeated eating and being eaten. Food chains interconnect to form food webs, which represent energy flow through an ecosystem.

Forage: Herbaceous plants and portion of woody species (twigs, leaves) used for food by wildlife.

Functional Groups: A classification of animals based on how they consume their food, rather than what they eat. Generally used in describing communities of stream and lake benthos.

Fry: Recently hatched fish, up to one year of age.

Gabion: Large cage filled with rocks; used in some areas as supports or abutments in streams, supposedly to increase fish habitat diversity.

Game Species: Species of fish or wildlife for which seasons and bag limits have been imposed, and which are harvested under State or Federal regulations.

Geomorphology: The geological study of land form evolution and configuration.

Gradient: The rate of vertical elevation change per unit horizontal distance; also known as slope.

Habitat: The area where a plant or animal lives and grows under natural conditions. Habitat consists of living and non-living attributes, and provides all requirements for food and shelter.

Habitat Diversity: The number of different types of habitat found within a given area.

Headwall: An area, normally wedge-shaped, at the uppermost end of a stream channel. It serves as the point of origin for surface runoff

Hillslope: Adjacent hillsides above the influences of flooding.

Horizontal Diversity: Abundance and variety of plant communities on an areal basis.

Hydrologic Recovery: See ARP.

Indirect Effects: Secondary effects which occur in locations other than the initial action or significantly later in time (WNF).

Landslide: The dislodging and fall of a mass of earth and rock.

Litter: Dead plant material, commonly leaves, needles, twigs, etc.

Mass Failure: Movement of aggregates of soil, rock and vegetation downslope in response to gravity.

Mature Forest: In the Willamette National Forest, areas containing trees whose average age is 120-200 years old. There is significantly less diversity of plant species and structure than in old-growth forest.

Microclimate: Localized climate conditions; microclimatic conditions in riparian areas are generally less extreme than adjacent hillslopes.

Migration Corridor: The portion of the landscape serving as a routine passageway for fish or wildlife species as they that move from one habitat to another, often on a seasonal basis.

Mitigation: Actions to avoid, minimize, reduce, eliminate or rectify the impact of management practices.

Monitoring: Actions undertaken to assess and evaluate, including the results of management activity on a species or process.

Multiple-use: A concept of land management in which a number of resources are produced simultaneously from the same land base.

Noncommercial Thinning: The selective cutting of nonmerchantable sizes and species of trees.

Non-game: Species of wildlife and fish not managed as sport hunting resources.

Old-Growth: A forest comprised of many large trees, large snags, and numerous large down logs; having a multi-layered canopy composed of several species of trees; the last stage in forest succession. In the WNF, forests begin to show some old-growth characteristics at 175-200 years. The most extensive type of old-growth on the WNF is the Douglas fir/western hemlock forest which lives 350-750 years. Old-growth stands have a wide range of ages and sizes of trees. In some areas, the Douglas fir may be replaced by western red cedar or ponderosa pine.

Peak Flow: The highest discharges attained during a particular flood event for a given stream.

Plant Community An assemblage of plant species in a given area (NB: communities technically, ecologically, include animals as well).

Precommercial Thinning: Removal of some trees in a stand before they attain merchantable size so the remaining trees will grow more quickly.

PUM: Piled unmerchantable material; generally unusable woody material less than 8 inches x 10 feet remaining after timber harvest.

Rearing Habitat: Areas required for successful survival to adulthood by young animals. For trout, rearing areas may be the edges of streams, while for elk, they may be thickets in the riparian area.

Recovery: Return of an ecosystem to a defined condition after a disturbance.

Rehabilitation: The process of restoring a site to a former state or desired condition.

Resident Fish: Fish species that complete their entire life cycle in fresh-water.

Residue: Plant material remaining after harvest operations.

Retention: The capability of a stream to retain either water or suspended particles for any length of time.

Riparian Area The aquatic ecosystem and the adjacent upland areas that directly affect it.

Riparian Management Zone: Site-specific boundaries established by the Forest Service for management practices within riparian areas.

Salvage: The cutting of trees that are dead, dying, or deteriorating (because they are "overmature", or materially damaged by fire, wind, insects, fungi or other injurious agencies) before they lose their commercial timber value.

Second Growth: Plant growth that has come up naturally after some drastic interference, such as fire or clearcutting, has removed the previous forest.

Sediment: Material carried in suspension by water, which will eventually settle to the bottom.

Side Channel: A portion of the active channel that does not carry the bulk of the streamflow. Side channels may carry water only during winter flows, but are still considered part of the total active channel.

Slash: Residue (leaves, bark, twigs, roots, etc) left on the ground after logging.

Slope Stability: The degree to which a slope resists the downward pull of gravity. The more resistant, the more stable.

Snag: A standing dead tree usually greater than 5 feet high and 6 inches dbh. Its interior may be sound or rotted.

Spawning Gravel: Sorted, clean gravel patches of a size appropriate for the needs of resident or anadromous fish. For example, chinook require gravel 0.5 - 2 inches in diameter.

Standing Crop: Amount of living biomass, plant or animal, present in a given location. Often expressed in weight per unit area.

Stocking: A loose term for the amount of anything, be it trees or fish, in a given area, particularly in relation to a pre-determined optimum.

Stream Bank: The part of a stream channel, when seen in cross-sections, that restricts sideways water movement at normal flows. It represents a distinct break in slope from the stream bed.

Stream Blockage: Accumulation of solid, rock, and organic material deposited in a stream channel by landslides that prevent fish from moving upstream.

Stream Class: A classification of streams based on their hydrology, fisheries, and usage. Class I streams are perennial or intermittent and have significant fisheries, domestic water use, or influence on other Class I streams; Class II streams also have perennial or intermittent flow with moderate fisheries (game fish or the potential to maintain game fish populations), domestic water use, or influence on other Class I or II streams; Class III streams are perennial but do not meet criteria for Class I and II streams; and Class IV streams are ephemeral or intermittent, but do not meet criteria for Class I, II or III streams.

Stream Cleanout: Removal of debris from streams. This is no longer considered acceptable management.

Stream Order: A measure of the position of a stream in the hierarchy of tributaries. First-order streams are unbranched (no tributaries). Second-order streams are formed by the confluence of two or more first order streams, and are considered second order until they join a larger stream. Third order channels are form by the confluence of two or more second order streams, etc.

Stream Structure: The arrangement of logs, boulders, and meanders which modify the flow of water, thereby causing the formation of pools and gravel bars in streams. Generally, there is a direct, positive relationship between complexity of structure and fish habitat. Complex stream structure is also an indication of overall watershed stability.

Structure: The configuration of elements, parts, or constituents of a habitat, plant, or animal community.

Substrate: The material forming the underlying layer of streams. Substrates may be bedrock, gravel, boulders, sand, clay, etc.

Succession: The progressive development of vegetation from bare ground towards its highest ecological expression, the climax community; the replacement of one plant community by another.

Suspended Load: Particles, usually small in size, carried in suspension by the stream; these particles do no contact the streambed.

Terrace: Sediment deposits between the valley walls and the floodplain or the active channel. They may be formed by fluvial, volcanic, or glacial activities.

Tolerance Limits: The physiological band within which an organism can survive. Above or below these limits, organisms will become stressed and eventually die. Tolerance limits exist for each species for may different parameters, such as temperature, amount of light, amount of suspended sediments, etc.

Turbidity: The relative clarity of the water, which may be affected by suspended material.

Unconstrained: A wide valley floor, generally greater than two active channel widths, with extensive floodplain surfaces. The stream can meander to form a complex channel.

Upland: The portion of the landscape above the valley floor.

Valley Floor: The part of the landscape containing the stream and its floodplain.

Vertical Diversity: Within a plant community, the amount of layering along a vertical axis. Areas of high vertical diversity will have a intricate mixture of herbs, shrubs, and trees of different heights.

Watershed: A portion of at the forest in which all surface water drains to a common point. Watersheds can range from a few tens of acres that drain a small intermittent stream to many thousands of acres for a stream that drains hundreds of connected intermittent and perennial streams.

Wetland: Those areas periodically inundated by surface or ground water. They support vegetation or aquatic species requiring wholly or partially saturated soils. Wetlands include marshes, bogs, sloughs, potholes, river overflows, mud flats, wet meadows, seeps and springs.

Woody Debris : Dead woody material greater than 10 cm in diameter and longer than one meter, usually composed of boles and large branches. Various terms, such as large woody debris (LWD), coarse woody debris (CWD), and large organic debris (LOD), have been used to describe this material. **Large woody debris** is material greater than 20 inches (50 cm) in diameter and 33 ft (10 m) in length. Woody material greater than 4 inches (10 cm) in diameter and 3 ft (1 m) in length but less than 20 inches (50 cm) in diameter and 33 ft (10 m) in length is considered to be **small woody debris** and consists of small trees, tops of large trees, and large branches. Small branches, twigs, and slash from logging operations less than 4 inches (10 cm) in diameter and 3 ft (1 m) in length are considered **fine woody debris.**

YUM: Yarded unmerchantable material; generally unusable woody material less than 8 inches x 10 feet remaining after timber harvest.

CHAPTER 9

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APPENDIX I
RIPARIAN SPECIES OF THE WILLAMETTE NATIONAL FOREST

FISH AND WILDLIFE SPECIES ASSOCIATED WITH RIPARIAN AREAS

COMMON NAME	SCIENTIFIC NAME
Mammals	
Northern Water Shrew	*Sorex palustris*
Montane Shrew	*Sorex. monticolus*
Pacific Water Shrew	*Sorex bendirii*
Vagrant Shrew	*Sorex vagrans*
White-footed Vole	*Penacomys albipes*
Richardson's Vole	*Microtus richardsonii*
Oregon Vole	*Microtus oregoni*
Jumping Mouse	*Zapus trinotatus*
Yuma myotis	*Myotis yumanensis*
Beaver	*Castor canadensis*
Mink	*Mustela vison*
Muskrat	*Ondatra zibethicus*
River Otter	*Lutra canadensis*
Birds	
Common Loon	*Gavia immer*
Horned Grebe	*Podiceps auritus*
Western Grebe	*Aechmophorus occidentalis*
Pied-Billed Grebe	*Podilymbus podiceps*
Double-Crested Cormorant	*Phalacrocorax auritus*
Green Heron	*Butorides virescens*
Great Blue Heron	*Ardea herodais*
Common Egret	*Cosmerodius albus*
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Gadwall	*Anas stepera*
Pintail	*Anas acuta*
Cinnamon Teal	*Anas cyanoptera*
American Widgeon	*Anas americana*
Shoveler	*Anas clypeata*
Wood Duck	*Aix sponsa*
Ring-Necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
Barrow's Goldeneye	*Bucephala islandica*
Bufflehead	*Bucephala albeola*
Harlequin Duck	*Histrionicus histrionicus*
Ruddy Duck	*Oxyura jamaicensis*

COMMON NAME	SCIENTIFIC NAME
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Bald Eagle	*Haliaetus leucocephalus*
Osprey	*Pandion haliaetus*
American Coot	*Fulica americana*
Common Snipe	*Capella gallinago*
Spotted Sandpiper	*Actitus macularia*
Greater Yellowlegs	*Tringa melanoleuca*
Water Pipet	*Anthus spinoletta*
California Gull	*Larus californicus*
Ring-billed Gull	*Larus delawarensis*
Belted Kingfisher	*Megaceryle alcyon*
Willow Flycatcher	*Empidonax traillii*
Hammond's Flycatcher	*Empidonax hammondi*
Bank Swallow	*Riparia riparia*
Violet-green Swallow	*Tachycineta thalassina*
Cliff Swallow	*Petrochelidon pyrrhonota*
Northern Rough-winged Swallow	*Stelgidopteryx ruficollis*
Dipper	*Cinclus mexicanus*
Yellowthroat	*Geothlypis trichas*
Yellow-Breasted Chat	*Icteria virens*
Wilsons Warbler	*Wilsonia pusilla*
Red-Winged Blackbird	*Agelaius phoenicrus*

Amphibians

Roughed-Skinned Newt	*Taricha granulosa*
Pacific Giant Salamander	*Dicamptodon ensatus*
Olympic Salamander	*Rhyacotriton olympicas*
Northwestern Salamander	*Ambystoma gracile*
Dunn's Salamander	*Plethodon dunni*
Tailed Frog	*Ascaphus truei*
Western Toad	*Bufo boreas*
Pacific Treefrog	*Hyla regilla*
Red-Legged Frog	*Rana aurora*
Foothill Yellow-Legged Frog	*Rana boylii*
Cascades Frog	*Rana cascadae*
Spotted Frog	*Rana pretiosa*

Reptiles

Western Pond Turtle	*Clemmys marmorata*
Ringneck Snake	*Diadophus punctatus*
Western Aquatic Garter Snake	*Thamnophis couchi*

COMMON NAME	SCIENTIFIC NAME

Fish

* = Introduced Species

Torrent Sculpin	*Cottus rhotheus*
Reticulate Sculpin	*Cottus perplexus*
Shorthead Sculpin	*Cottus confusus*
Slimy Sculpin	*Cottus cognatus*
Mottled Sculpin	*Cottus bairdi*
Smooth Sculpin	*Cottus beldingi*
Largescale Sucker	*Catostomus macrocheilus*
Mountain Sucker	*Catostomus platyrhynchus*
Redside Shiner	*Richardsonius balteatus*
Speckled Dace	*Rhinichthys osculus*
Longnose Dace	*Rhinichthys cataractae*
Northern Squawfish	*Ptychocheilus oregonensis*
Oregon Chub	*Hybopsis crameri*
Sand Roller	*Percopsis transmontana*
Chiselmouth	*Arcocheilus alutaceus*
Mountain Whitefish	*Prospium williamsoni*
Bull Trout	*Salvelinus confluentus*
Brook Trout*	*Salvelinus fontinalis*
Brown Trout*	*Salmo trutta*
Atlantic Salmon*	*Salmo salar*
Rainbow Trout	*Oncorhynchus mykiss*
Cutthroat Trout	*Oncorhynchus clarki*
Chinook Salmon	*Oncorhynchus tshawytscha*
Sockeye Salmon*	*Oncorhynchus nerka*
Pacific Lamprey	*Lampetra tridentata*
Brook Lamprey	*Lampetra richardsoni*
White Crappie*	*Pomoxis annularis*
Brown Bullhead*	*Ictalurus nebulosus*
Large-mouth Bass*	*Micropterus salmoides*
Blue-gill*	*Lepomis macrochirus*
Stickleback*	*Gasterosteus aculeatus*
Mosquitofish*	*Gambusia affinis*
Common Carp*	*Cyprinus carpio*

PLANT SPECIES ASSOCIATED WITH RIPARIAN AREAS

Type: F = Forest
N = Non-forest (includes wetlands)

COMMON NAME	SCIENTIFIC NAME	ECO-CODE	TYPE
Grasses			
Spike Bentgrass	*Agrostis exarata*	AGEX	F
Thurber's Bentgrass	*Agrostis thurberiana*	AGTH	N
Columbia Brome	*Bromus vulgaris*	BRVU	F
Bluejoint Reedgrass	*Calamagrostis canadensis*	CACA	N
Northern Reedgrass	*Calamagrotis inexpansa*	CAIN	N
Drooping Woodreed	*Cinna latifolia*	CILA2	F
California Oatgrass	*Danthonia californica*	DACA	N
Timber Oatgrass	*Danthonia intermedia*	DAIN	N
Tufted Hairgrass	*Deschampsia caespitosa*	DECA	N
Blue Wildrye	*Elymus glaucus*	ELGL	F
Bearded Fescue	*Festuca subulata*	FESU	F
Tall Mannagrass	*Glyceria elata*	GLEL	F
Northern Meadow Barley	*Hordeum brachyantherum*	HOBR	N
Pullup Muhly	*Muhlenbergia filiformis*	MUFI	N
Reed Canarygrass	*Phalaris arundinacea*	PHAR	N
Alpine Timothy	*Phleum alpinum*	PHAL	N
Fowl Bluegrass	*Poa palustris*	POPA	N
Weak Alkaligrass	*Puccinellia pauciflora*	PUPA	N
Tall Trisetum	*Trisetum canescens*	TRCA	F
Sedges and Rushes			
Bigleaf Sedge	*Carex amplifolia*	CAAM	F
Columbia Sedge	*Carex aperta*	CAAP3	N
Water Sedge	*Carex aquatilis*	CAAQ	N
Gray Sedge	*Carex canescens*	CACA4	N
Dewey's Sedge	*Carex deweyana*	CADE	F
Sheep Sedge	*Carex illota*	CAIL	N
Jones' Sedge	*Carex jonesii*	CAJO	N
	Carex lenticularis	CALE5	N
Sierra Hare Sedge	*Carex leporinella*	CALE3	N
Mud Sedge	*Carex limosa*	CALI	N
Woodrush Sedge	*Carex luzulina*	CALU	N
Mertens' Sedge	*Carex mertensii*	CAME2	N
Muricate Sedge	*Carex muricata*	CAMU2	N
Beaked Sedge	*Carex rostrata*	CARO2	N
Holms' Rocky Mountain Sedge	*Carex scopulorum*	CASC5	N
Analogue Sedge	*Carex simulata*	CASI2	N
Sitka Sedge	*Carex sitchensis*	CASI3	N
Blister Sedge	*Carex vesicaria*	CAVE	N
Common Spike-rush	*Eleocharis palustris*	ELPA	N
Few-flowered Spike-rush	*Eleocharis pauciflora*	ELPA2	N
Baltic Rush	*Juncus balticus*	JUBA	N

Common Name	Scientific Name	Eco-Code	Type
Toad Rush	*Juncus bufonius*	JUBU	N
Drummond's Rush	*Juncus drummundii*	JUDR	N
Common Rush	*Juncus effusus*	JUEF	N
Swordleaf Rush	*Juncus ensifolius*	JUEN	N
Mertens' Rush	*Juncus mertensianus*	JUME	N
Millet Woodrush	*Luzula parviflora*	LUPA	F
Small-fruited Bulrush	*Scirpus microcarpus*	SCMI	N
Congdon's Bulrush	*Scirpus congdonii*	SCCO	N

Ferns and Fern Allies

Maidenhair Fern	*Adiantum pedatum*	ADPE	F
Ladyfern	*Athyrium filix-femina*	ATFI	F
Deerfern	*Blechnum spicant*	BLSP	F
Mountain Woodfern	*Dryopteris austriaca*	DRAU2	F
Field Horsetail	*Equisteum arvense*	EQAR	F
Scouring Rush	*Equisetum hyemale*	EQHY	F
Giant Horsetail	*Equisetum telmateia*	EQTE	F
Oak-fern	*Gymnocarpium dryopteris*	GYDR	F
Licorice Fern	*Polypodium glycyrrhiza*	POGL4	F
Western Swordfern	*Polystichum munitum*	POMU	F
Western Bracken Fern	*Pteridium aquilinum*	PTAQ	F

Herbs

Vanillaleaf	*Achlys triphylla*	ACTR	F
Columbia Monkshood	*Aconitum columbianum*	ACCO	N
Baneberry	*Actaea rubra*	ACRU	F
Trail-plant	*Adenocaulon bicolor*	ADBI	F
Pearly-everlasting	*Anaphalis margaritacea*	ANMA	F
Threeleaf Anemone	*Anemone deltoidea*	ANDE	F
Sharptooth Angelica	*Angelica arguta*	ANAR2	F
California Aralia	*Aralia californica*	ARCA3	F
Sylvan Goatsbeard	*Aruncus sylvester*	ARSY	F
Alpine Aster	*Aster alpigenus*	ASAL	N
Western Aster	*Aster occidentalis*	ASOC	N
Santalucia Boykinia	*Boykinia elata*	BOEL	F
Sierra Boykinia	*Boykinia major*	BOMA	F
Twinflower Marshmarigold	*Caltha biflora*	CABI	N
Elkslip Marshmarigold	*Caltha leptosepala*	CALE2	N
Brewer's Bittercress	*Cardamine breweri*	CABR2	N
Scarlet Paintbrush	*Castilleja minata*	CAMI2	N
Oxeye Daisy	*Chrysanthemum leucanthemum*	CHLE2	F
Western Water-hemlock	*Cicuta douglasii*	CIDO	F
Alpine Circaea	*Circaea alpina*	CIAL	F
Canada Thistle	*Cirsium arvenese*	CIAR	F
Bull Thistle	*Cirsium vulgare*	CIVU	F
Thistle	*Cirsium* species	CIRSI	F
Columbia River Larkspur	*Delphinium trolliifolium*	DETR	F/N
Pacific Bleeding Heart	*Dicentra formosa*	DIFO	F

COMMON NAME	SCIENTIFIC NAME	ECO-CODE	TYPE
Hooker's Fairybells	*Disporum hookeri*	DIHO	F
Fairy Lantern	*Disporum smithii*	DISM	F
Tall Mountain Shooting-star	*Dodecatheon jeffrey*	DOJE	N
Great Sundew	*Drosera anglica*	DRAN	N
Sundew	*Drosera rotundifloia*	DRRO	N
Alpine Willow-weed	*Epilobium alpinum*	EPAL	N
Fireweed	*Epilobium angustifolium*	EPAN	F
Smooth Willow-weed	*Epilobium glaberrimum*	EPGL	F/N
Watson's Willow-weed	*Epilobium watsonii*	EPWA	F
Wood Strawberry	*Fragaria vesca*	FRVE	F
Oregon Bedstraw	*Galium oreganum*	GAOR	F
Sweet-scented Bedstraw	*Galium triflorum*	GATR	F
White Bog-orchid	*Habenaria dilatata*	HADI2	N
Slender Bog-orchid	*Habenaria saccata*	HASA	N
Common Cow-parsnip	*Heracleum lanatum*	HELA	F/N
Small-flowered Alumroot	*Heuchera micrantha*	HEMI	F
White Hawkweed	*Hieracium albiflorum*	HIAL	F
Slender-stemmed Waterleaf	*Hydrophyllum tenuipes*	HYTE	F
Trailing St. John's-wort	*Hypericum anagalloides*	HYAN	N
Common St. John's-wort	*Hypericum perforatum*	HYPE	F
Wall Lettuce	*Lactuca muralis*	LAMU	F
Northwest Listera	*Listera caurina*	LICA3	F
American Skunk Cabbage	*Lysichitum americanum*	LYAM	F/N
Common Bogbean	*Menyanthes trifoliata*	METR	N
Northern Microseris	*Microseris boreale*	MIBO	N
Tooth-leafed Monkey-flower	*Mimulus dentatus*	MIDE	F
Common Monkey-flower	*Mimulus guttatus*	MIGU	F
Lewis' Monkey-flower	*Mimulus lewisii*	MILE	F/N
Muskplant Monkey-flower	*Mimulus moschatus*	MIMO	F/N
Primrose Monkey-flower	*Mimulus primuloides*	MIPR	N
Oval-leafed Mitrewort	*Mitella ovalis*	MIOV	F
Miner's Lettuce	*Montia parviflora*	MOPA	F
Indian Lettuce	*Montia sibirica*	MOSI	F
Indian Pond Lily	*Nuphar polysepalum*	NUPO	N
Sweetroot	*Osmorhiza species*	OSMOR	F
Oregon Oxalis	*Oxalis oregana*	OXOR	F
Western Yellow Oxalis	*Oxalis suksdorfii*	OXSU	F
Great Oxalis	*Oxalis trilliifolia*	OXTR	F
Little Elephant's Head	*Pedicularis attolens*	PEAT3	N
Bracted Lousewort	*Pedicularis bracteosa*	PEBR	N
Elephant's Head	*Pedicularis groenlandica*	PEGR	N
Yampa	*Perideridia gairdneri*	PEGA2	N
Coltsfoot	*Petasites frigidus*	PEFR2	F
American Bistort	*Polygonum bistortoides*	POBI	N
Drummond's Cinquefoil	*Potentilla drummondii*	PODR	N
Marsh Cinquefoil	*Potentilla palustris*	POPA3	N
Common Self-heal	*Prunella vulgaris*	PRVU	F
Plaintain-leaf Buttercup	*Ranunculus alismaefolius*	RAAL	N
Gorman's Buttercup	*Ranunculus gormanii*	RAGO	N
Little Buttercup	*Ranunculus uncinatus*	RAUN2	F/N
Bitterdock	*Rumex obtusifolius*	RUOB	F
Bog Saxifrage	*Saxifraga oregana*	SAOR	N

Common Name	Scientific Name	Eco-Code	Type
Cleft-leaf Groundsel	*Senecio cymbalarioides*	SECY	N
Woodland Groundsel	*Senecio sylvaticus*	SESY	F
Arrowleaf Groundsel	*Senecio triangularis*	SETR	F/N
Common Blue-eyed Grass	*Sisyrinchium angustifolium*	SIAN	N
Feather Solomon-plume	*Smilacina racemosa*	SMRA	F
Starry Solomon-plume	*Smilacina stellata*	SMST	F
Range Wooly-head Parsnip	*Sphenosciadium capitellatum*	SPCA	N
Continental Ladies' Tresses	*Spiranthes romanzoffiana*	SPRO	N
Cooley's Hedgenettle	*Stachys cooleyae*	STCO4	F
Crisped Starwort	*Stellaria crispa*	STCR	F
Longstalk Starwort	*Stellaria longipes*	STLO	F/N
Claspleaf Twistedstalk	*Streptopus amplexifolius*	STAM	F
Alaska Fringecup	*Tellima grandiflora*	TEGR	F
Western Meadowrue	*Thalictrum occidentale*	THOC	F/N
Coolwort	*Tiarella trifoliata*	TITR	F
Tofieldia	*Tofieldia glutinosa*	TOGL	N
Youth-on-age	*Tolmiea menziesii*	TOME	F
False Bugbane	*Trautvettaria caroliniensis*	TRCA3	N
Northern Starflower	*Trientalis arctica*	TRAR2	N
Western Starflower	*Trientalis latifolia*	TRLA2	F
Longstalk Clover	*Trifolium longipes*	TRLO	N
Pacific Trillium	*Trillium ovatum*	TROV	F
Common Bladderwort	*Utricularia vulgaris*	UTVU	N
Scouler's Valerian	*Valeriana scouleri*	VASC2	F
Mountain Heliotrope	*Valeriana sitchensis*	VASI	N
Inside-out Flower	*Vancouveria hexandra*	VAHE	F
California False Hellebore	*Veratrum californicum*	VECA	N
American False Hellebore	*Veratrum viride*	VEVI	N
American Speedwell	*Veronica americana*	VEAM	F/N
Marsh Speedwell	*Veronica scutellata*	VESC	N
American Alpine Speedwell	*Veronica wormskjoldii*	VEWO	N
Hook Violet	*Viola adunca*	VIAD	N
Pioneer Violet	*Viola glabella*	VIGL	F
Macloskey's Violet	*Viola macloskeyi*	VIMA	N
Marsh Violet	*Viola palustris*	VIPA2	N
Redwood Violet	*Viola sempervirens*	VISE	F

Low and Sub-Shrubs

Oregon Grape	*Berberis nervosa*	BENE	F
Salal	*Gaultheria shallon*	GASH	F
Alpine Laurel	*Kalmia microphylla*	KAMI	N
Western Swamp Laurel	*Kalmia occidentalis*	KAOC	N
American Twinflower	*Linnaea borealis*	LIBO2	F
Western Trumpet Honeysuckle	*Lonicera ciliosa*	LOCI	F
California Dewberry	*Rubus ursinus*	RUUR	F

COMMON NAME	SCIENTIFIC NAME	ECO-CODE	TYPE
Tall Shrubs			
Vine Maple	*Acer circinatum*	ACCI	F
Rocky Mountain Maple	*Acer glabrum*	ACGL	F
Mountain Alder	*Alnus incana*	ALIN	N
Sitka Alder	*Alnus sinuata*	ALSI	F/N
Saskatoon Serviceberry	*Amelanchier alnifolia*	AMAL	F
Bog Birch	*Betula glandulosa*	BEGL	N
Red-osier Dogwood	*Cornus stolonifera*	COST	F
Hazelnut	*Corylus cornuta*	COCO2	F
Indian Plum	*Oemlaria cerasiformis*	OECE	F
American Devilsclub	*Oplopanax horridum*	OPHO	F
Stink Currant	*Ribes bracteosum*	RIBR	F
Currant	*Ribes* species	RIBES	F
Sticky Currant	*Ribes viscosissimum*	RIVI	F
Baldhip Rose	*Rosa gymnocarpa*	ROGY	F
Western Thistleberry	*Rubus parviflorus*	RUPA	F/N
Salmonberry	*Rubus spectabilis*	RUSP	F
Undergreen Willow	*Salix commutata*	SACO	N
Geyer's Willow	*Salix geyeriana*	SAGE	N
Hooker's Willow	*Salix hookeriana*	SAHO	F
Pacific Willow	*Salix lasiandra*	SALA2	F
Blueberry Willow	*Salix myrtillifolia*	SAMY	N
Scouler's Willow	*Salix scouleriana*	SASC	F
Sitka Willow	*Salix sitchensis*	SASI2	F
Blueberry Elder	*Sambucus cerulea*	SACE	F
European Red Elder	*Sambucus racemosa*	SARA	F
Sitka Mountain Ash	*Sorbus sitchensis*	SOSI	F
Subalpine Spirea	*Spiraea densiflora*	SPDE	N
Douglas Spirea	*Spiraea douglasii*	SPDO	N
Alaska Blueberry	*Vaccinium alaskaense*	VAAL	F
Western Bog Blueberry	*Vaccinium occidentale*	VAOC2	N
Red Whortleberry	*Vaccinium parvifolium*	VAPA	F
Trees			
Grand Fir	*Abies grandis*	ABGR	F
Subalpine Fir	*Abies lasiocaarpa*	ABLA2	F
Bigleaf Maple	*Acer macrophyllum*	ACMA	F
Red Alder	*Alnus rubra*	ALRU	F
Pacific Dogwood	*Cornus nuttalli*	CONU	F
Mountain Ash	*Fraxinus latifolia*	FRLA2	F
Incense Cedar	*Libocedrus decurrens*	LIDE2	F
Englemann Spruce	*Picea engelmannii*	PIEN	F
Quaking Aspen	*Populus tremuloides*	POTR	F
Black Cottonwood	*Populus trichocarpa*	POTR2	F
Douglas Fir	*Pseudotsuga menziesii*	PSME	F
Cascade Buckthorn	*Rhamnus purshiana*	RHPU	F
Pacific Yew	*Taxus brevifolia*	TABR	F
Western Red Cedar	*Thuja plicata*	THPL	F
Western Hemlock	*Tsuga heterophylla*	TSHE	F

APPENDIX II

SOIL STABILITY CLASSIFICATIONS FOR SRI TYPES

SRI #	Slope	Rock Type[1]	Stability Class[2]
1	30-100	A,b (r.o.)	S
2		Br (r.o.)	S
3	Steep Headwalls	Talus (r.o.)	M
4	0-30	Lava Flows	S
5	40-80+	Cinder Cones	M
6	Gentle-Steep	Marshy, Boulders	S
7	Ridgetops	Glacial Cirques	S
8	Steep	GBr, RBr	U
9	Steep	A,B,Br	M
12	0-25	A,B	S
13	0-40	Br,T	M
14	15-35	A,B,Br,T	S
15	0-20	Al	M
16	20-70	A,B,Br,T	M
17	0-20	Al	m
19	0-45	Br	M
21	60-90	RBr,T	U
22	0-20	RBr,T	S
23	20-60	RBr,T	M
25	15-40	Br,T	M
31	60-90	T,GBr	U
33	20-60	GBr,T	M
35	5-40	GBr,T	M
44	40-80	Br	M
54	35-65	Br,A,B	M
55	40	Br,T	M
56	0-30	A	S
57	30-60	A	S
61	60-90+	A	M
62	0-35	Lava Flows	S
63	0-35	A,B	M
64	40-80	A,B	S
66	0-40	A,B	S
67	0-40	A,B	S
68	30-40	A,B	S
69	0-30	A,B	S
71	45-90	A,B	M
73	0-30	A,B	S
74	35-55	A,B	S
75	0-35	A,B	S
81	40-90+	A,B	M
82	0-30	A,B	S
85	0-15	A,B	S
91	55-90+	A,B	M
92	0-35	A,B	S

SRI #	Slope	Rock Type[1]	Stability Class[2]
93	0-40	A,B	S
94	35-60	A,B,Br	S
95	0-35	A,B,Br	S

Rock Types: A = Andesite; Al = Alluvium; B = Basalt; Br = Breccia; GBr = Green Breccia; RBr = Red Breccia; r.o. = rock outcrop; T = Tufts
Stability Classes: S = Stable; M = Moderately stable; U = Unstable

ADDITIONAL SRI TYPE STABILITY CLASSIFICATIONS

SRI #	Stability	Description
142 143 563 564 646 - 741 821 - 852 920 - 954	Stable	Gentle slopes (<60%) of any rock; or moderate slopes (40-60%) with hard rock (basalt, andesite flows); or rock outcrops
All SRI types not listed as Stable or Unstable	Moderately Stable	Steep slopes (>60%) with hard rock; or moderate slopes with soft bedrock (tuffs and breccias)
168 212 213 214 216 301 - 305 332 603	Unstable	Steep slopes on soft bedrock types

APPENDIX III

ELEMENTS OF MONITORING PROGRAMS

This appendix is intended to be a starting point for the development of a riparian monitoring system for the WNF, not an exhaustive list of components. Questions outlined below are among the more critical, but riparian monitoring may be require additional information to meet both broad and specific situations.

POST-PROJECT

The monitoring components of this level of evaluation include administration, layout, stream channel, vegetation, fisheries and wildlife.

Administration

Prescription

Were the Environmental Assessment and prescriptions appropriate for the specific sites?
Was the site evaluated on the ground?
Were all objectives of riparian area management fully considered, from floodplain function to wildlife habitat to recreation use?
Were WNF Standards and Guidelines implemented?
Does the prescription meet or exceed the intent of the standards and guidelines?
Were Environmental Assessment and prescriptions written to comply with objectives for all levels of riparian function (i.e., site, basin and landscape)?
Were recommendations of biologists, hydrologists, ground crews incorporated?

Timing

Was adequate time allowed for completing Environmental Assessments and developing prescriptions?

Harvest Unit Layout

RMZ boundaries

Do the boundaries present after harvest meet those specified in the prescription?
Do they follow natural topographic contours?
Do they meet specified <u>horizontal</u> widths?
Are side channels included in the active channel?

Floodplain

Are floodplains included in the RMZ?

Roads and Landings

Are road crossings at least 200 feet apart or as specified in the prescription?
Were methods used for road construction sufficient to minimize erosion and delivery of sediments to the stream, lake, or wetland?
Are roads constructed to prevent failure during heavy rains?
Are landings located to prevent failure?
Do distances to landings minimize cable corridor area?

Suspension and Yarding

Were corridors located away from stable debris accumulations in the channel and floodplain?
Was there significant damage to buffer strip vegetation?
Were appropriate volumes of downed woody debris left in cable corridors?

Timing

Were construction activities in and adjacent to the riparian area timed to limit seasonal inputs of sediment?
Were impacts on fish spawning considered in determining when operations would occur?
Did construction activities meet prescribed timing restrictions?

Blowdown

Did blowdown of riparian vegetation occur?
What proportion of the buffer blew down?
Did the blowdown occur in vegetation on wet soils (poor rooting)?
Did the trees fall into the stream, lake, wetland, floodplain?
Are the trees that fell into the channel or floodplain in stable configurations?
Are blowdown logs providing potential fish or wildlife habitat?
Were natural windbreaks used effectively?

Viewsheds

Does the RMZ configuration maintain viewsheds from significant travel or recreation aspects?

Channel

Floodplain

Is the entire floodplain included in the RMZ?
If floodplain width exceeds 400 feet (horizontal), was the area beyond the RMZ managed in accordance with Executive Order 11988?

Bank Stability

Are there firmly rooted trees adjacent to stream banks and shorelines?

Woody Debris

Do the woody debris levels in the channel and on the floodplain meet or exceed amounts needed for riparian area objectives?
If the channel was deficient in LWD, was wood from suspension corridors placed at appropriate locations?

Stream Cleanout

Was stream cleanout avoided?
Is large woody debris present before harvest still in place?
Was stream cleanout of logging slash limited to high risk areas?

Stream Temperature

Do water temperatures at summer low flows meet Oregon DEQ standards?

Vegetation

Canopy
Is there still a multi-layered canopy present in the RMZ?
Does it provide shade to channel and floodplain?
Was it damaged during operations?

Understory
Is the understory vegetation still intact and diverse?
If no canopy remains, does understory vegetation provide shade and bank stability?

Buffer Damage
Was there damage to buffer strip vegetation?
Was the damage to the edges of the buffer, the interior, or the canopy?

Snags and Downed Logs
Were snags and downed logs present before operations left in place?
Did the distributions and numbers meet or exceed values required to meet objectives for riparian wildlife habitat?

Fisheries

Presence/Absence
Are there fish actually present in streams designated Class I and II?
Are fish really absent from streams designated Class III or IV?
Are sensitive fish species present?

Wildlife

Are beaver dams present before operations still intact?
Were wildlife migration corridors maintained?

REFERENCE SUB-DRAINAGES

Layout

Salvage
Has salvage of woody debris occurred in the stream channel, floodplain, or lake shore?
Has salvage reduced woody debris below levels needed to maintain full channel and floodplain function?
If riparian vegetation or debris has been salvaged, what were the objectives of salvage for riparian-dependent resources?

Blowdown
Did blowdown of riparian vegetation occur?
Did the blowdown extend up the hillslope?
How extensive is the blowdown?
Did blowdown occur on wetted soils (poor rooting)?
Is there evidence of sediment delivery to the channel after blowdown?
Are downed trees in pieces or do they still have attached rootwads?

Are the trees in stable configurations?

In the years after blowdown:
Does the woody debris remain or does it move downstream?
Does the downed wood provide appropriate bank protection, fish and wildlife habitat, and sediment and water storage?

Channel

Although the objectives and location of sampling may differ, the techniques for this portion of benchmark monitoring are essentially the same as for the basin survey.

Morphology
Is there a single, simple stream channel, or does it braid, with split channels?
Are there side channels, isolated pools, or backwaters present?
What is the sequence of channel units?
What are the estimated dimensions (length, widths, depths) of each channel unit?
What is the percent slope of each channel unit?
What are the morphometric characteristics of the lake (e.g., shoreline, shoreline development, mean depth, maximum depth, surface area, fetch, volume development)?

Floodplain
Is there a floodplain present, or is the stream confined to a narrow canyon?
How wide is the valley floor?
Is the stream channel constrained by hillslopes, terraces, or roads?
Are there terraces present on either or both sides of the stream?
What are the approximate heights of these terraces?

Substrates
What are the dominant substrates in each channel unit?
Are the substrates embedded?
How many large boulders are present in each channel unit?
Are there spawning gravels present; if so, what area do they cover?

Bank Stability
Is there strongly rooted vegetation along the stream or lake?
Is there woody debris present to provide bank stability?
Is there evidence of landslides or bank slumping?

Woody Debris
How much woody debris is present (number of pieces and volumes)?
What are the size classes (length and diameter) of wood?
Are there large stable accumulations of debris, such as full channel debris jams or lateral accumulations?
Is the wood is in jams, accumulations, or single pieces?
Do the pieces of wood still have rootwads attached?
Is the wood in the stream anchored on the bank?
What is the length of most of the wood relative to the stream width?
How do the amounts of wood compare between managed and undisturbed riparian areas? Do they differ in volume, number or size of pieces?

Vegetation

Composition
What species are present?
Are there any rare, threatened, or endangered species?
Are there unique plant associations indicative of wetlands?
How are plants species distributed spatially?
Do the species present provide structural complexity, both horizontally and vertically?
Does species composition change significantly in areas of scour versus deposition? In broad valley floors versus narrow canyons?

Density
How many of each species are present in the canopy and understory layers?
What are the approximate sizes and ages of the dominant woody species?
How do valley floor width and degree of scour versus deposition affect density of woody species?

Canopy
How many canopy layers are there?
Is the canopy completely closed or are there light gaps?
What is the approximate percent of coniferous and deciduous canopy cover over the stream or lake?

Understory
How diverse and dense is the understory vegetation?
Is its morphology predominantly shrubby or herbaceous?
How does it change with increasing distance from the stream or lake?

Snags and Downed Logs
How many snags and downed logs are present?
How are they distributed spatially?

Regeneration
Are there signs of regeneration of the major structural species (e.g., Douglas fir, hemlock, Western red cedar).
If so, what species are recruiting and how many of each?
If not, are there any particular reasons?
In riparian management zones, is there any indication of regeneration from within the buffer itself, or from leave trees nearby?

Fisheries

Presence/Absence
Are there fish actually present in streams designated Class I and II?
What species are observed?
Are fish really absent from streams designated Class III and IV?
Are there any rare, threatened, or endangered species?

Abundance
How many individuals of each species were counted?
What size were they?

Wildlife

Wildlife monitoring in riparian areas is technically and logistically difficult, generally expensive, and often provides comparatively little information for the amount of effort. Consequently, wildlife populations at the intensive benchmark sites should be assessed on a case-by-case basis. Assumptions of the amount and quality of habitat available may be based on characteristics of the riparian vegetation. Riparian areas with diverse structural components and a complex array of plant species may provide relatively good wildlife habitat. This type of analysis presumes that enough is known about the habitat requirements of each species to make such an assumption. For most riparian wildlife species this is not true. Species of particular interest or concern may be evaluated as part of this level of monitoring. Should resources become available, methods such as transect surveys in spring for riparian birds, pit trap lines for small mammals, reptiles and amphibians, or tagging of larger mammals or birds may be useful. However, because so little is known about the basic biology of most riparian species, a monitoring approach may not be appropriate.

Are there any rare, threatened, or endangered species?

Species Analysis: See above.

Beaver Dams
Are beaver dams present?
Are there indications they are being maintained?

Rehabilitation

Was focus of rehabilitation effort through silviculture or through in-channel modification?

Silviculture Rehabilitation
Has the effort provided a taxonomically diverse plant community?
Is there now a structurally complex plant assemblage?
Has stream shading been provided?
Are there appropriate densities to provide long and short-term small and large wood inputs to the channel and floodplain?

Channel Rehabilitation
Does the material added to the channel perform high or low flow functions or both?
If hydraulic change was an objective, have there been desired changes in channel morphology or position within the floodplain
Has the material provided additional bank and channel stability?
If fish habitat was an objective, does the project provide relatively stable and complex fish habitat?
If added materials are no longer in their original position, how have they changed? What caused the shift or movement?
If they moved, how far downstream? Are they still performing a channel, floodplain or fisheries function?

BASIN SURVEY

Channel

Morphology
Is there a single, simple stream channel, or does it braid, with split channels?
Are there side channels, isolated pools, or backwaters present?
Identify the sequence of channel units: what are their dimensions (length, widths, depths).

Floodplain
Is there a floodplain present, or is the stream confined to a narrow canyon?
How wide, approximately, is the valley floor?
Is the active channel deeply incised within the floodplain?
Is the stream channel constrained by hillslopes or roads?

Substrates
What are the dominant substrates in each channel unit?
Are the substrates embedded?
Are there spawning gravels present; if so, what area do they cover?

Bank Stability
Is there strongly rooted vegetation along the stream?
Is there woody debris present to provide bank stability?

Woody Debris
How much woody debris is present?
What size classes (length and diameter) is the wood?
Are there large stable accumulations of debris, such as full channel debris jams or lateral accumulations?
Is the wood is in jams, accumulations, or single pieces?
Do the pieces of wood still have rootwads attached?
Is the wood in the stream anchored on the bank?
What is the length of most of the wood relative to the stream width?
How do the amounts of wood compare between managed and undisturbed riparian areas? Do they different in volume, number or size of pieces?

Vegetation

Composition
What is the dominant vegetation type and size immediately adjacent to the stream?

Fisheries

Abundance
What species of fish were observed in each channel unit?
How many of each species?
What is the approximate length of each individual?

Wildlife

Beaver Dams
Are beaver dams present?
What are the dimensions of the dams?

Corridors
Are riparian areas used as corridors for migration?

WATER QUALITY NETWORK

Temperature
Do summer low flow temperatures in all fish-bearing streams meet Federal and State Water quality Standards?

Suspended Sediment
Do levels of suspended sediment and turbidity comply with Federal and State Water Quality Standards?

Chemistry
Do dissolved levels of important nutrients (e.g., ammonium, nitrate, phosphorus) or toxic substances (e.g., forest chemicals) meet Federal and State Water Quality Standards?

APPENDIX IV

WILLAMETTE NATIONAL FOREST STANDARDS AND GUIDELINES FOR MANAGEMENT AREA 15

Source: Willamette National Forest Land and Resource Management Plan

Emphasis: Rivers, Streams, Wetlands, Lakes and Adjacent Riparian Areas

Management Goal

The primary goal in this management area is to maintain the role and function of rivers, streams, wetlands and lakes in the landscape ecology. A significant part of this goal is to manage the vegetation in the adjacent riparian areas for:

protection and rehabilitation of the aquatic and terrestrial riparian habitat;

maintenance and improvement of water quality while minimizing risks of downstream flooding;

management of riparian areas as corridors to provide dispersal habitat for plant and animal species by maintaining connectivity among mature and old growth stands of trees;

management and inventory of riparian areas for sensitive, threatened and endangered plant and animal species;

management of riparian areas for recreation and scenic use compatible with riparian dependent species;

monitoring the impacts of upland management activities on the health and function of the riparian ecosystem.

Desired Future Condition

This management area will provide a continuous and diverse habitat for riparian dependent species and high quality water by protecting and mapping wetlands and floodplains. The water bodies and associated riparian areas will contribute to the diversity and dispersion of fish, wildlife and plants within each subdrainage and also at the larger watershed level. This management area will also provide opportunities for public use and enjoyment through both dispersed and developed recreation management. The recreation uses will be managed to avoid or mitigate adverse effects on riparian dependent resources.

Stream channels will provide diverse, stable habitat for aquatic species as well as maintaining or enhancing water quality. Vegetation on adjacent lands will be managed to provide diverse stands of conifer and hardwood vegetation which provide habitat for riparian dependent species. The amount of large woody debris, both down and standing will be maintained at or above current levels. In areas where this material has been depleted as a result of past harvesting, the amount will increase either through rehabilitation projects, as a result of natural mortality of trees, or both. Along larger rivers and streams, optimal thermal cover for big game will be provided.

Description

This management area includes the bed, banks, and water column of rivers, streams, wetlands and lakes as well as the adjacent land areas. A riparian area is the adjacent land where vegetation and microclimate are influenced by the stream or lake and the associated high water table. It includes the adjacent land which directly influences the shading and input of large and small organic material to the streams.

In addition, this area generally includes ponds, bogs, wet meadows and other areas identified in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands and in the Classification of Wetlands and Deepwater Habitats of the United States.

Additional description of the resource values, objectives and operational considerations for this management area are found in the Willamette National Forest Riparian Management Field Guide.

Standards and Guidelines

Riparian Management

MA-15-01 The width of the riparian management area shall be identified by an on-site reconnaissance of topographic and biotic features and shall be based on the watershed objectives for fish and wildlife habitats, water quality, and recreation.

MA-15-02 This management area shall include the 100-year floodplain within 400 feet from the edge of the active channel. Any portion of the 100-year floodplain extending beyond 400 feet should not be included in this management area, but shall be managed in accordance with Executive Order 11988.

MA-15-03 Widths that should be considered when determining the management area boundaries are shown below. Exceptions to this range should be documented in project records or environmental assessments. Wider areas may be designated to allow protection of riparian stands from wind, to use logical topographic, biological or road boundaries. Narrower areas are anticipated only in exceptional situations.

Perennial Streams	**Horizontal Width**
Class I	150 - 400 feet
Class II	100 - 200 feet
Class III - Stable	50 - 100 feet
Class III - Potentially highly unstable & moderately stable	75 - 125 feet
Intermittent Streams	
Class IV - Moderately Stable	25 - 50 feet
Class IV - Potentially highly unstable	25 - 100 feet
Lakes	600 feet
Reservoirs	N/A
Small Wetlands	150 - 600 feet

MA-15-04 This management area does not include areas adjacent to reservoirs. Management of areas adjacent to reservoirs should follow direction of Forest-wide S&G for water quality and other resources and management area S&G as allocated.

MA-15-05 The following process shall be used when projects or management activities have the potential to create long term, short term, or cumulative adverse effects to the values of the rivers, streams, wetlands, lakes and adjacent riparian areas:

1. Locate the management area using the following criteria;

Within the 100 year floodplain (less than 400 feet from active channel);
Occupied by water tolerant vegetation;
Having vegetation potentially capable of shading or contributing organic small matter to the water body;
Having vegetation that contributes significantly to bank stability.
Incorporate natural irregularities of topography and consider recreation and wildlife use patterns.
Required to provide large woody material to the water body.

2. Identify the beneficial uses, values and objectives for the area. (See Appendix E, Watershed) Wetland and riparian area values and objectives should be established on a subdrainage area or larger, and should address connectivity of riparian habitat and the influence on downstream effects.

3. Identify the effects of proposed actions on the following:

Public health, safety, and welfare, including water supply, quality, recharge, and discharge; pollution; flood and storm hazards; and sediment and erosion;

Maintenance of the natural systems, including conservation and long term productivity of existing flora and fauna, species and habitat diversity and stability, hydrological utility, fish, wildlife, timber;

Other uses of wetlands in the public interest, including recreational, scientific, and cultural uses. (See EO 11990)

4. Assess necessary actions to preserve the beneficial values, and to reduce or mitigate loss of wetlands by giving preferential consideration to riparian dependent resources when conflicts occur among land uses. (See FSM 2526.03)

5. Develop a riparian prescription that documents the objectives and actions to be implemented (including contract clauses and language as appropriate) in the riparian management area.

6. Monitor location and effects, and track results through appropriate databases.

Management practices shall be designed to prevent detrimental changes in water temperature or chemical composition, blockage of water courses, or sedimentation within riparian areas which seriously and adversely affect water conditions or fish habitat. (36 CFR 219.27(e)).

Water Quality

MA-15-06 Vegetation will be managed to provide water temperatures which protect beneficial uses, as described in Oregon Administrative Rules 340-41-422.

MA-15-07 All project proposals in the Salmon Creek and Marion Creek watersheds shall include an objective to improve water quality. A major part of this objective will be to maintain (Marion Creek) or reduce (Salmon Creek) maximum summer water temperatures that are 70 degrees F or less by 1995, and 67 degrees F by 2000. These watersheds are the water source for State of Oregon fish hatcheries.

MA-15-08 At least 75% of the existing shade should be maintained.

MA-15-09 Activities with potential effects on Class III and IV streams shall be scheduled and designed to maintain or improve water quality in downstream Class I and II waters.

MA-15-10 Projects shall be designed using BMPs to meet Oregon State Water Quality Standards. Refer to General Water Quality Best Management Practices, Pacific Northwest Region, 1988 and Appendix E, Watershed for further information on BMPs.

MA-15-11 Streambanks and channel stability shall be protected, rehabilitated or enhanced to meet the water quality and aquatic habitat objectives.

MA-15-12 Management in riparian areas shall provide for a continued input of large woody debris at rates similar to those in areas without past timber removal. Large wood will reduce the movement of debris torrents through channels and provide channel stability. Channel stability will also be maintained through measures listed in Forest-wide Standards and Guidelines for Water Quality.

MA-15-13 The value and functioning of floodplains shall be protected, rehabilitated or enhanced. Floodplains are valuable for reducing stream velocity and temporarily storing water during high flow events.

Wildlife and Fish Management

MA-15-14 Project activities within or adjacent to riparian areas shall protect, rehabilitate, or enhance streams to provide high quality habitat for a diversity of native aquatic species. Management indicator species for riparian areas are resident and anadromous salmonids.

Stable, diverse habitat for salmonids can be achieved with the following:

Large wood: Diameter and length of woody pieces may vary according to the stream width and gradient; pieces larger than 25 inches in diameter are generally preferred. Large wood in the stream will provide a variety of habitat and nutrient characteristics.

Pools: A primary pool every 5 to 7 channel widths in streams with less than a 2% gradient and every 3 to 5 channel widths in streams with a 2 to 8% gradient provides rearing habitat during summer low flows.

Substrate: A well sorted variety of gravels, cobbles and boulders, with less than 20% of spawning gravels in fines (<1.0mm), and less than 25% embeddedness of cobbles in riffle areas provide salmonid and invertebrate spawning and rearing habitat.

Floodplains: Stable, vegetated floodplains provide areas of slow water and refuge habitat during high flow events.

Food source: Year-round input of leaf, needle, and insect material from a variety species provide a variety of food sources for salmonids and invertebrates.

MA-15-15 Habitat rehabilitation or enhancement projects should be identified and evaluated in areas adversely affected by past events. Project proposals should consider long-term maintenance needs and should be monitored for effectiveness.

MA-15-16 Habitat for riparian dependent terrestrial species shall be protected, rehabilitated, or enhanced. Factors to consider include microclimate, vegetation, and downed woody material.

MA-15-17 Where designed to provide connectivity and dispersion, greater than 10 live, overstory trees per acre and 15 down trees per acre greater than 24 inches DBH should be maintained. This also provide down woody debris cover for small mammals, amphibians and reptiles.

MA-15-18 Habitat potential for cavity excavator species should be at least 80% of the potential population habitat in riparian areas. (See Forest-wide Wildlife Standards and Guidelines).

Recreation Management

MA-15-19 Area management practices should result in a physical setting that meets or exceeds the ROS class of Roaded Natural.

MA-15-20 Developed recreation and dispersed recreation sites should be compatible with riparian dependent resource objectives.

MA-15-21 Projects to reduce safety hazards from dead, defective or hazardous trees in riparian areas should be evaluated to ensure adverse effects to riparian dependent resources are recognized and mitigated. This includes trees currently in river or stream channels and standing dead trees adjacent to trails or other recreation facilities.

MA-15-22 Water withdrawn from streams or lakes for recreation facilities shall have no adverse effects on riparian dependent resources.

Scenic Resources

MA-15-23 All design and implementation practices should be modified as necessary to meet the VQO of Partial Retention. In the event that unregulated harvest is necessary to salvage timber within the area, practices should be employed in a manner that seeks to achieve a VQO of Modification.

Timber Management

MA-15-24 No programmed harvest shall be scheduled.

MA-15-25 Salvage harvests should occur only when existing conditions are detrimental to riparian condition and riparian dependent resources. (See Forest-wide Standard and Guideline, Changed Environmental Conditions.)

MA-15-26 A riparian prescription shall determine if trees need to be felled to maintain or enhance riparian objectives, if trees may be felled to facilitate activities in adjacent management areas, and if felled trees should be removed from the area. Riparian objectives are commonly met if yarding corridors through the area are spaced at least 200 feet apart.

MA-15-27 Streambanks shall be protected by directional felling and suspending logs above streambanks adjacent to live water during yarding, and by using appropriate road design techniques where roads might impact streambanks. On streambanks adjacent to dry stream channels, logs will be fully suspended and directionally felled where practicable. Where it is not practicable, streambanks will be stabilized following yarding activities, and prior to stream flows in the channels.

MA-15-28 Silvicultural prescriptions for existing regenerated stands within riparian areas shall be designed to achieve riparian objectives.

MA-15-29 Silvicultural prescriptions should be developed for riparian areas affected by past harvest activities or catastrophic events to reestablish stands that provide a mixture of hardwood and conifer species similar to undisturbed sites.

MA-15-30 Application of fertilizer to the riparian area, and to live water should occur only when prescribed to meet riparian terrestrial or aquatic objectives.

Fire Management

MA-15-31 Suppression strategies, practices and activities shall have minimal effects on objectives for water quality, aquatic and terrestrial wildlife and plant species, recreation, and visual resources.

MA-15-32 Fuel treatment prescriptions should protect streamside vegetation and maintain the vegetation and woody debris necessary for channel stability.

Minerals and Energy

MA-15-33 Mineral management shall be compatible with riparian resource management goals. Aquifers and downstream resources shall be protected as well as the immediate riparian resource.

Lands

MA-15-34 On lands considered for exchange a floodplain and wetland determination and assessment of impacts, with public notice shall be made. Acquisition of wetlands that may be of significant wildlife, fisheries or recreation values shall be encouraged.

MA-15-35 Special use applications should show compatibility with management area objectives before approval.

Facilities

MA-15-36 New roads should be planned to minimize effects on riparian areas. Projects should be evaluated as to which location will most likely meet riparian objectives. Locating roads outside of riparian areas is preferred when possible.

MA-15-37 Where stream crossings are necessary for access, a crossing location should be selected which will best meet riparian objectives.

MA-15-38 Construction and reconstruction of crossings or habitat improvements projects on fish bearing streams should allow for passage of both adult and juvenile fish during appropriate times of the year.

MA-15-39 Deposits of sediment (silts and clays) in detrimental amounts shall be prevented during road construction and maintenance activities, and during periods of road closures. Road surface maintenance will use materials and methods designed to minimize sediment and deleterious chemicals.

MA-15-40 Temporary roads constructed to facilitate rehabilitation and enhancement projects shall be compatible with riparian objectives, and should be closed following project completion.

Range Management

MA-15-41 Domestic livestock grazing should not be permitted.

APPENDIX V

RELATIONSHIPS BETWEEN HORIZONTAL AND SLOPE DISTANCES

Table V.1. **Side slope distances for riparian management zones** (RMZ) on different hillslope angles and selected RMZ horizontal distances.

	Slope Distances			
Slope (Percent)	50-ft RMZ	100-ft RMZ	150-ft RMZ	200-ft RMZ
10	50 ft	100 ft	150 ft	200 ft
15	51	101	152	202
20	51	102	153	204
25	52	103	155	206
30	52	104	156	208
35	53	106	159	212
40	54	108	162	216
45	55	110	165	220
50	56	112	168	224
55	57	114	171	228
60	59	117	176	234
65	60	119	179	238
70	61	122	183	244
75	63	125	188	250
80	64	128	192	256
85	66	131	199	262
90	68	135	203	270
100	71	141	212	282
110	75	149	224	298
120	78	156	234	312
130	82	164	246	328
140	86	172	258	344
150	90	180	270	360
160	95	189	284	378
180	103	206	309	412
200	112	224	336	448

To use this table, first determine the width of the prescribed riparian management zone; this dimension will be in *horizontal* feet. Next, ascertain the actual percent slope of the stream, and adjust the slope distance of the RMZ accordingly. For example, on a Class III stream where hillslopes are 50%, a prescribed RMZ of 100 horizontal feet will actually extend 112 feet from the edge of the active channel up the hillslope. Conversions from slope estimates in percent to degrees (and vice versa) and the impact on horizontal distances follow in Tables V.2 and V.3.

Table V.2. **Relationship between distance of side slope and hillslope angle expressed as percent slope.**

Slope (Percent)	Slope (Degrees)	Percent of Horizontal Distance
5	2.9	100.1%
10	5.7	100.5%
15	8.5	101.1%
20	11.3	102.0%
25	14.0	103.1%
30	16.7	104.4%
35	19.3	105.9%
40	21.8	107.7%
45	24.2	109.7%
50	26.6	111.8%
55	28.8	114.1%
60	31.0	116.6%
65	33.0	119.3%
70	35.0	122.1%
75	36.9	125.0%
80	38.7	128.1%
85	40.4	131.2%
90	42.0	134.5%
100	45.0	141.4%
110	47.7	148.7%
120	50.2	156.2%
130	52.4	164.0%
140	54.4	172.0%
150	56.3	180.3%
160	58.0	188.7%
180	60.9	205.9%
200	63.4	223.6%

Table V.3. **Relationship between distance of side slope and hillslope angle in degrees.**

Slope (Degrees)	Slope (Percent)	Percent of Horizontal Distance
2.5	4.4	100.1%
5.0	8.8	100.4%
7.5	13.7	100.9%
10.0	17.6	101.5%
12.5	22.2	102.4%
15.0	26.8	103.5%
17.5	31.5	104.8%
20.0	36.4	106.4%
22.5	41.4	108.2%
25.0	46.6	110.3%
27.5	52.1	112.8%
30.0	57.7	115.4%
32.5	63.7	118.6%
35.0	70.0	122.0%
37.5	76.7	126.0%
40.0	83.9	130.5%
42.5	91.6	135.6%
45.0	100.0	141.4%
47.5	109.1	148.0%
50.0	119.2	155.6%
52.5	130.3	164.3%
55.0	142.8	174.3%
57.5	157.0	186.1%
60.0	173.2	200.0%

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