Myers

United States
Department
of Agriculture

Forest Service

Pacific
Northwest
Region

1995

Watershed Analysis

Upper Clackamas Watershed

Mt. Hood National Forest

March 1995

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Chapter 1 - Introduction

Watershed Analysis

The purpose of watershed analysis is to develop and document a scientifically-based understanding of the ecological structures, functions, processes and interactions occurring within a watershed, and to identify desired trends, conditions, and restoration opportunities. Watershed analysis is the mechanism to support broad ecosystem management objectives at the watershed scale, as described in the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl (ROD). It examines the terrestrial, aquatic, and social aspects of the watershed.

Watershed analysis is one of the four key elements of the Aquatic Conservation Strategy, as described in the ROD. These four elements are designed to operate together to maintain and restore the productivity and resiliency of riparian and aquatic ecosystems. Watershed analysis is required in Key Watersheds. Ultimately, watershed analysis should be conducted in all watersheds on federal lands as a basis for ecosystem planning and management. Watershed analysis is an ongoing, iterative process. This report serves as the basis for future analysis.

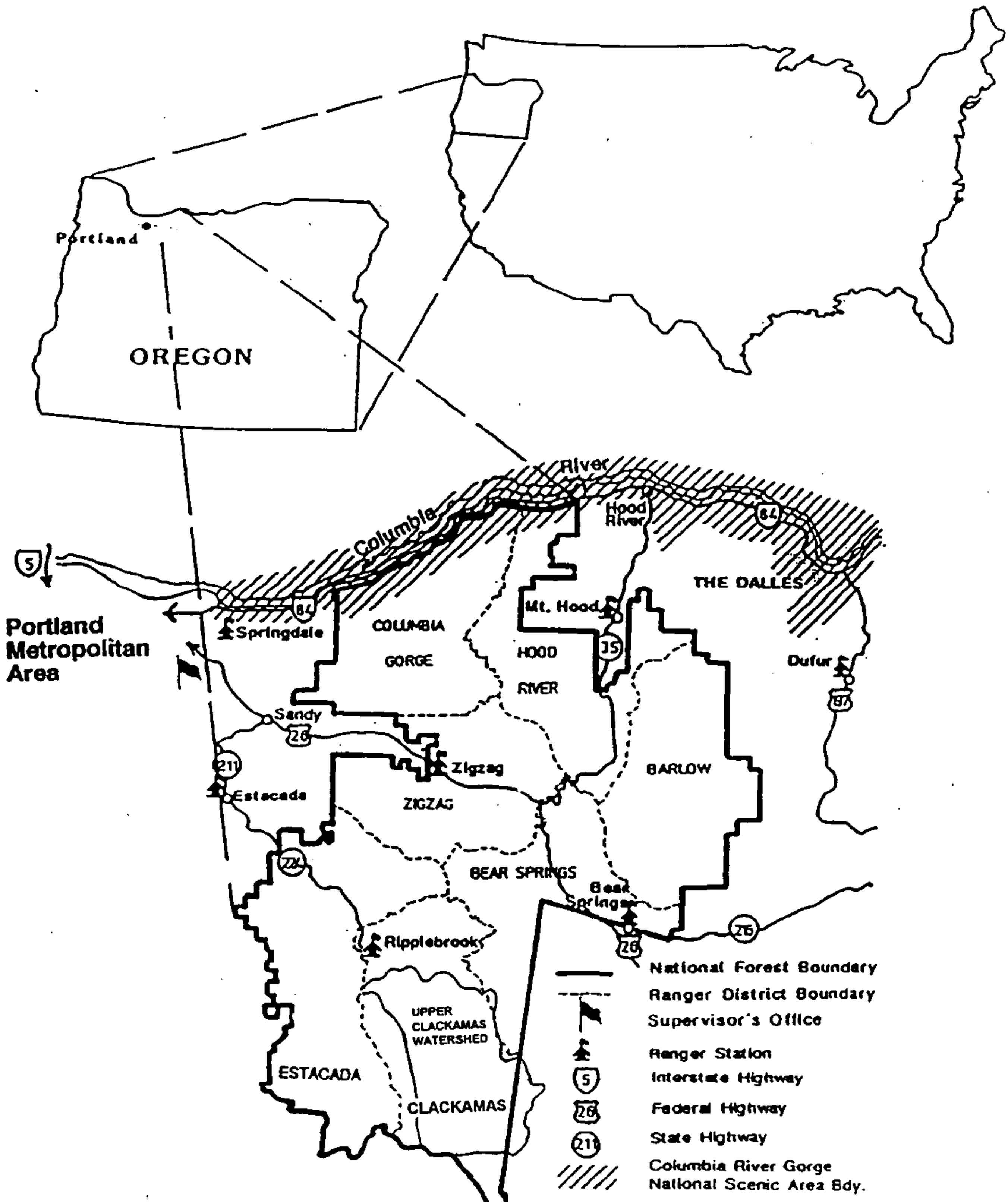
Watershed Setting

The Upper Clackamas watershed comprises 100,380 acres in north central Oregon on the west slope of the Cascade Range. It encompasses the headwaters of the Clackamas River and extends downstream to the confluence of the Collawash River (Map 1-1). It overlaps both Clackamas and Marion Counties. Approximately 95% of the watershed is within the Mt. Hood National Forest. About 5,600 acres lie within the Confederated Tribes of the Warm Springs Reservation of Oregon, and approximately 150 acres at Austin Hot Springs are privately owned. Map 1-2 displays landmarks in the watershed that are commonly referred to within this document.

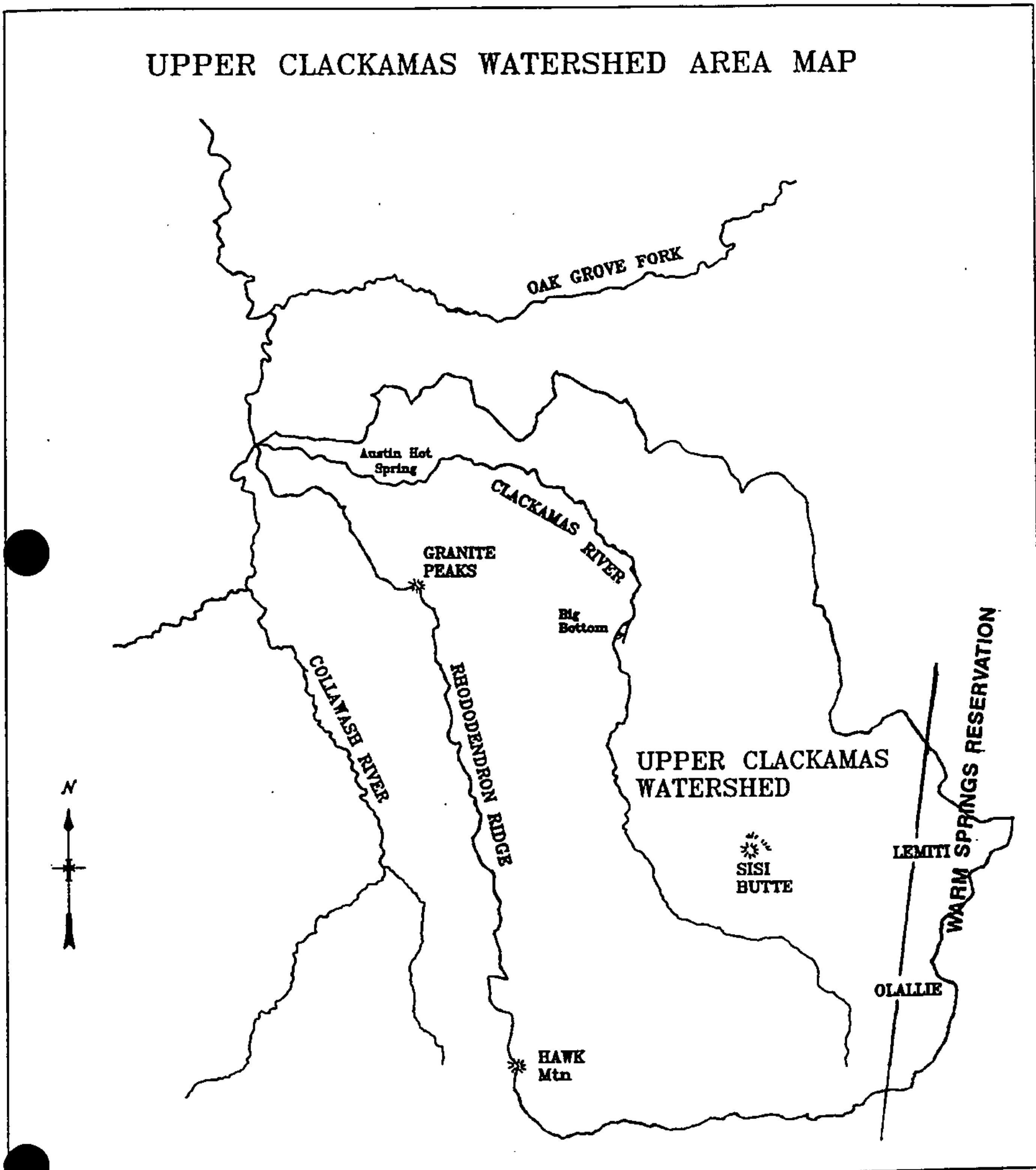
A portion of the Upper Clackamas watershed is designated as a Tier 1 watershed in the ROD. Tier 1 watersheds have been identified as a crucial refugia for at-risk fish species. The Clackamas subbasin is one of only a few within the range of the northern spotted owl that have a narrow corridor designated as Tier 1 watershed. This designation starts near North Fork Reservoir and extends to the headwaters crossing several subwatersheds. This watershed analysis will cover the entire Upper Clackamas watershed, 26% of which is designated as Tier 1. The Late-Successional Reserve (LSR) closely follows the Tier 1 boundary. Map 1-3 displays the LSR and Riparian Reserves. Refer to Chapter 4 for a discussion of both the ROD and the Mt. Hood National Forest Land and Resource Management Plan (LMP) land allocations within the watershed.

The climate is temperate, with rain and snow fall varying from 70 to 130 inches per year. The elevation ranges from 7,215 feet at the summit of Olallie Butte, to 1,500 feet at the confluence with the

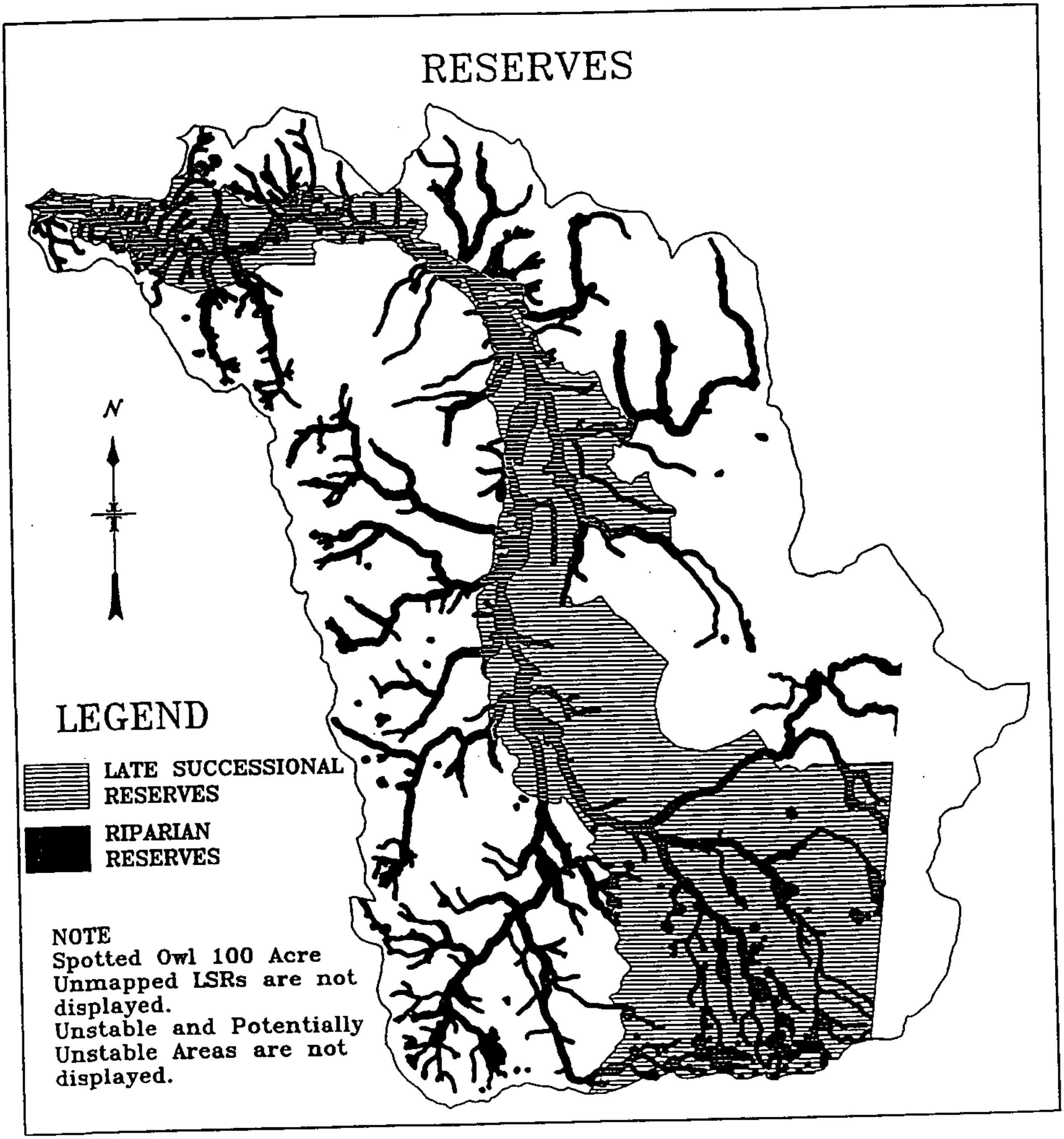
Map 1-1. Mt. Hood National Forest Location Map



Map 1-2. Upper Clackamas Watershed Landmarks.



Map 1-3. Reserves.



Collawash River. There are numerous small lakes in the southern portion of the watershed, the largest which is Fish Lake. Geologically, the area is of volcanic origin. Slopes are relatively gentle, and glaciation has had a major role in shaping portions of the watershed.

The large number of springs in the watershed result in reliable stream flows even during the dry months. The river has 16 major tributaries which are delineated as subwatersheds. Some of the smaller streams and their catchments not contained within the 16 subwatersheds are contained within the 3 segments of the mainstem river. The mainstem segments include the Austin Segment, the Big Bottom Segment, and the Headwaters Segment. These segments will be treated as subwatersheds for the purpose of this analysis. To facilitate analysis, the subwatersheds have been divided into 6 groups of similar hydrologic and geomorphic characteristics. Map 1-4 shows the subwatersheds and their groups.

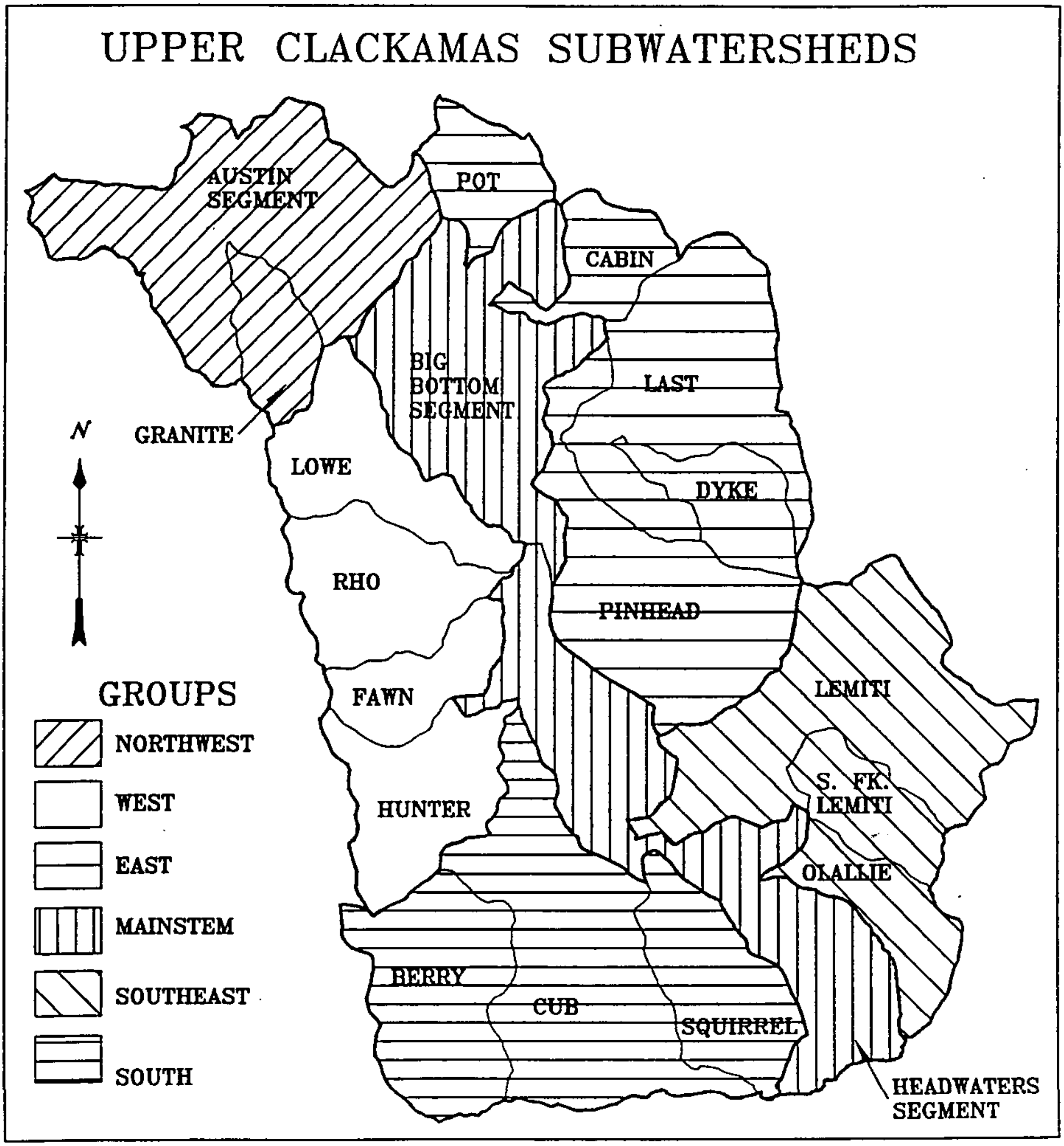
The Clackamas River is designated as a Scenic and Recreational River under the National Wild and Scenic Rivers Act. It is also designated as a State Scenic Waterway. The Forest Service prepared a management plan that describes the outstandingly remarkable values of botany/ecology, fish, wildlife, recreation, and cultural resources (USDA, 1993j).

Since timber harvesting began in the watershed in the late 1940's, approximately 29,000 acres have been harvested. There are two large powerlines that cross from east to west, one each in the northern and southern parts of the watershed. Timber harvest, the powerlines, and roads are the most visible human alterations to the landscape within the watershed.

Relationship to Larger Scales

The Clackamas River subbasin is part of the Willamette River basin, which lies within the Willamette province. The Upper Clackamas watershed encompasses the headwaters of the Clackamas River. Concerns pertinent to the larger scales of the province and basin have not yet been identified. Province level issues may include topics such as terrestrial vertebrate dispersal, because these animals may disperse across watershed boundaries. River basin level issues may include topics such as larger fish populations. For fish, the watershed may contribute to sustaining a subpopulation of the river basin population or may contain populations unique to the watershed. As the ROD is implemented, analyses at the province and river basin level will be completed. Since no province or river basin issues have yet been identified or analyses completed, this analysis will support future larger scale analysis.

Map 1-4. Subwatersheds and Subwatershed Groups.



Chapter 2 - Issues and Key Questions

Watershed analysis focuses on the processes and conditions that affect the issues of most concern. For the Upper Clackamas watershed, these issues were identified as vegetation, fish, and social uses. It is recognized that this list does not include all issues associated with the watershed, but simply identifies the primary issues. Questions regarding processes and conditions related to these issues were developed. This watershed analysis addresses these "key questions". The key questions focus and drive the analysis.

1. Issue: Vegetation

1a. Question: What is the current distribution of seral stages in terms of frequency, patch size, and distribution compared to the range of natural variability?

Context: Humans have modified the landscape in this watershed in several ways. The major modifications have been timber harvest, road construction, and fire suppression. Natural disturbance factors have historically created an ever-changing forest mosaic in which the plants and animals of this area have evolved. It is important to examine the array of human-caused landscape patterns and compare them to the range of conditions that would likely have occurred without these modern day modifications.

1b. Question: What are the processes that affect vegetative condition and distribution?

Context: In this landscape, wildfire is the primary natural disturbance process, but it is closely associated with insect and disease patterns. Fire burned frequently and the vast majority were small, low intensity burns that often did not kill overstory trees. Large stand replacement fires also occurred regularly. These large fires created large patches of early seral stands.

1c. Question: How does vegetative distribution and processes affect old-growth, riparian condition, connectivity, wildlife habitats, and biodiversity?

Context: Vegetative conditions affect habitat availability for wildlife and aquatic species. In this watershed, old-growth and late seral habitats are of particular concern because of the degree of fragmentation. Connectivity of interior habitats via Riparian Reserves and other forests is tenuous in some areas.

2. Issue: Fish Habitat

2a. Question: What are the physical processes that affect fish habitat conditions in the watershed?

Context: There are a number of natural and human-induced factors that affect fish habitat conditions. Natural factors include: a) landform; b) hydrology; c) climate; and d) vegetation pattern. Human-induced factors can change the effect natural factors have on fish habitat conditions. For example, roads affect the sediment and hydrologic regimes in streams which, in turn, could alter fish habitat conditions. The relationship of natural and human-induced factors may vary depending on the location within the watershed. The Clackamas River contains the last native run of lower Columbia River coho salmon. Determining the factors that affect the production of these fish will assist in recovery efforts.

2b. Question: What is the relationship of watershed condition to existing and future fish habitat and fish production?

Context: The Upper Clackamas watershed contains some of the best remaining habitat for the last native run of lower Columbia River coho salmon. The extensive management in the watershed affects fish habitat and fish production. About 490 miles of road currently exist in the watershed. Trees have been harvested on approximately 29,000 acres in the last four decades. These, along with other factors, affect the watershed condition. The current watershed condition affects physical processes that create and maintain fish habitat in the future. The trend of watershed condition based on current and projected future management within the watershed will determine future fish habitat conditions.

3. Issue: Social Uses

3a. Question: What are the recreation opportunities in the watershed?

Context: This area is used for a variety of recreational pursuits including camping, fishing, and hunting. The majority of camping occurs in or near Riparian Reserves, and in the Late-Successional Reserve. Demand for a variety of recreation activities continues to increase. Resource protection requirements may affect the availability of recreation opportunities that can be provided in the watershed.

3b. Question: What are the opportunities to provide commodities?

Context: The watershed is an important producer of timber, firewood and a multitude of special forest products. Local communities benefit from the jobs created and a broader society benefits as forest products are provided.

Chapter 3 - Summary of Past and Current Conditions

This chapter is a short summary of a more detailed analysis that is found in Appendix A. It summarizes past and current conditions in the watershed that are relevant to addressing the key questions identified in Chapter 2. The summary of watershed conditions includes the identification of important processes regulating changes in terrestrial or physical conditions. An understanding of processes interacting in the watershed is essential to determining the relationships between past management actions and current physical and biological conditions. To provide further clarification of the information in this summary, some maps, tables and figures from Appendix A are included. They retain the numbers they were given in Appendix A for reference.

An analysis file containing maps, additional data, and additional information concerning methodology is on file at the Clackamas Ranger District. Much of the mapping and analysis was done through use of the Geographic Information System located at the Clackamas Ranger District.

Vegetation

A. Frequency of Seral Stages

- Currently 27% of the vegetated acres within the watershed are in an early seral condition, 35% in mid seral, and 38% in late. The ROD requires that at least 15% of this watershed should be in a late seral condition. (Map 3-1)

- The current mix of seral stages is primarily the result of timber harvest and fire.

- Pot subwatershed has the largest percentage of early seral (62%) of all of the subwatersheds, primarily due to timber harvest.

- It is estimated that approximately 27% (9,300 acres) of the mid seral stands within the watershed will persist in a mid seral condition (will not develop the structural requirements used here to define late seral stands). These areas occur primarily around Sisi, Lemiti, and in the Olallie area. A large portion of this is within the LSR.

- Thirty-four percent of the watershed is in the western hemlock vegetation series, 36% is in the Pacific silver fir series, and 30% is in the mountain hemlock series.

- Currently 29% of the western hemlock series, 35% of the Pacific silver fir series, and 15% of the mountain hemlock series are in the early seral stage. (Figure 3-2)

- Currently there is more early seral vegetation throughout the watershed than in the estimated range of natural variability. (Figure 3-3)

- The amount of late seral vegetation in the watershed is currently within the range of natural variability (RNV) in the western hemlock series. There is currently 2% more late seral in the Pacific silver fir series than in the natural range, and 11% less late seral in the mountain hemlock series. (Figure 3-4)

B. Vegetation Patterns - Patch Size and Distribution

- The Upper Clackamas is a highly fragmented watershed within a highly fragmented subbasin.

- There are currently 11,100 acres of late seral interior habitat within the watershed. Fifty-five percent of the total interior habitat is in the LSR. The largest and most connected blocks of interior habitat occur within the LSR.

- Mean early seral patch size in the reconstructed historic landscape (circa 1930) was 184 acres. The mean early seral patch size in the current landscape is 64 acres. (Map 3-2)

- Since timber harvest began in the Upper Clackamas watershed in the late 1940's, the trend in the landscape pattern has been:

  Increase in the amount of edge (more edge habitat, less interior habitat, more risk of windthrow). Edge contrast is high, with abrupt transitions between early and late-successional vegetation.

  Fragmentation of mature forest, loss of connectivity and isolation of mature forest blocks.

  Increasing patchiness. Stands are smaller and more uniformly sized than what would be expected under the natural disturbance regime.

  Open patches are more evenly distributed throughout the landscape and are beginning to coalesce.

Map 3-1. Current Seral Stages.

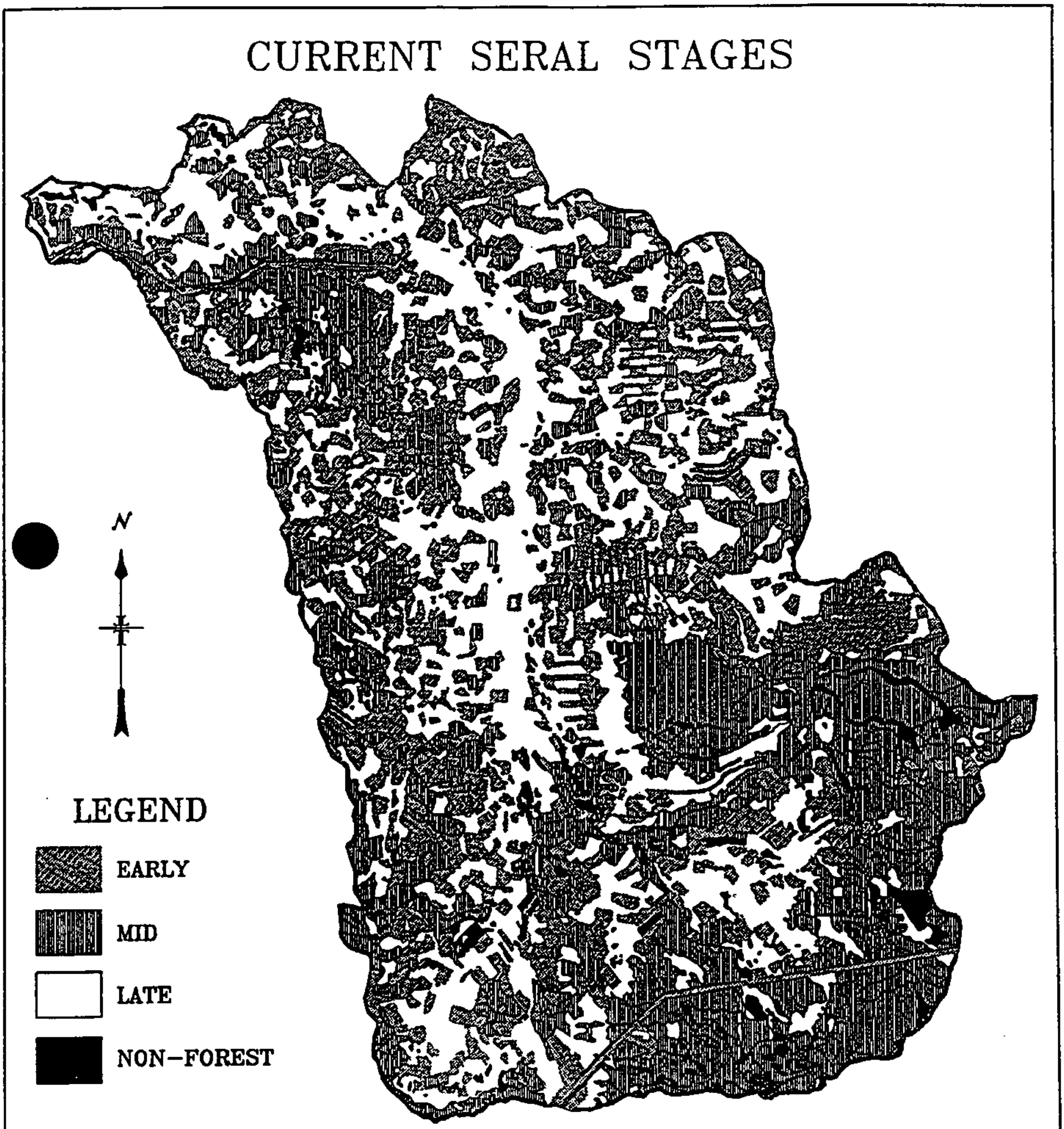


Figure 3-2. Seral stage by forest series. Values shown are percentage of each forest series in early, mid and late seral stage.

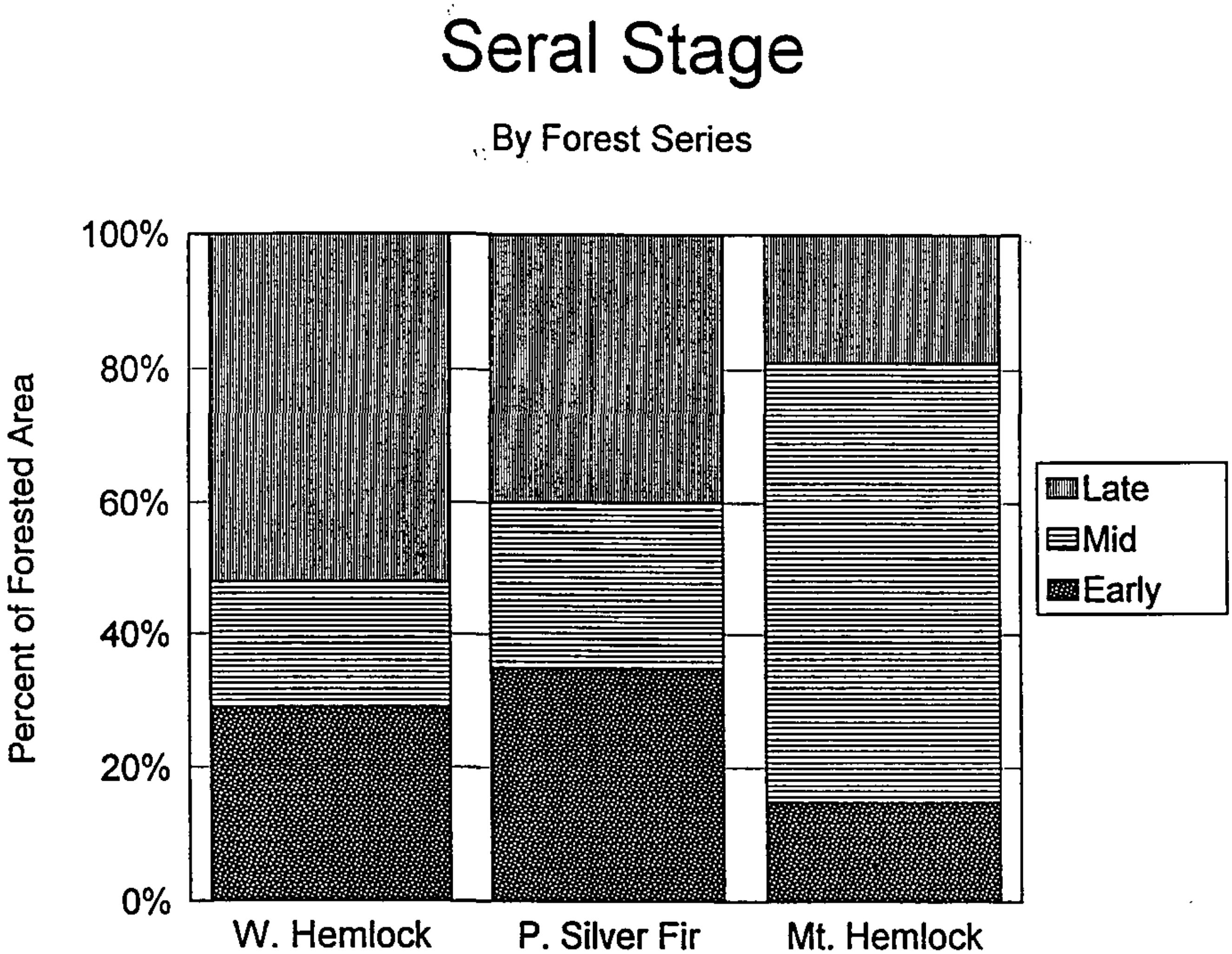


Figure 3-3. Current condition compared to historic range of amount of early seral vegetation. Values shown are percentage of the total area within each forest series.

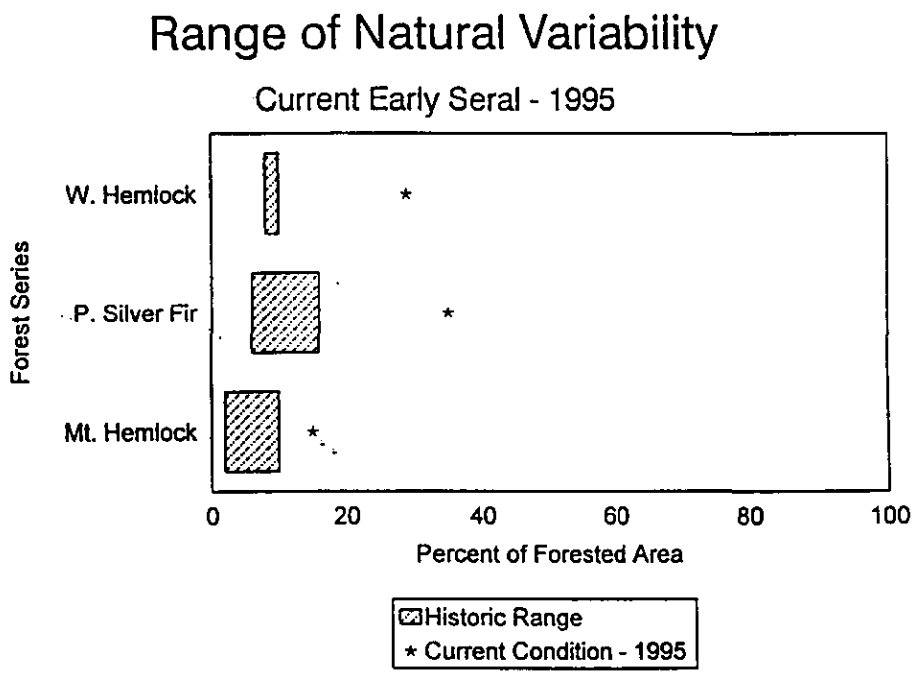
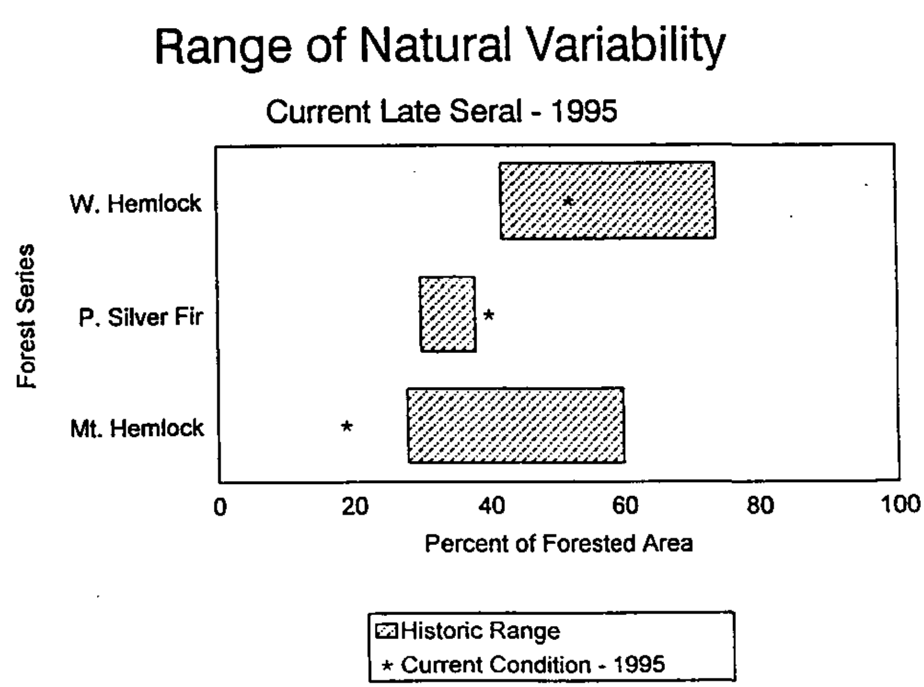
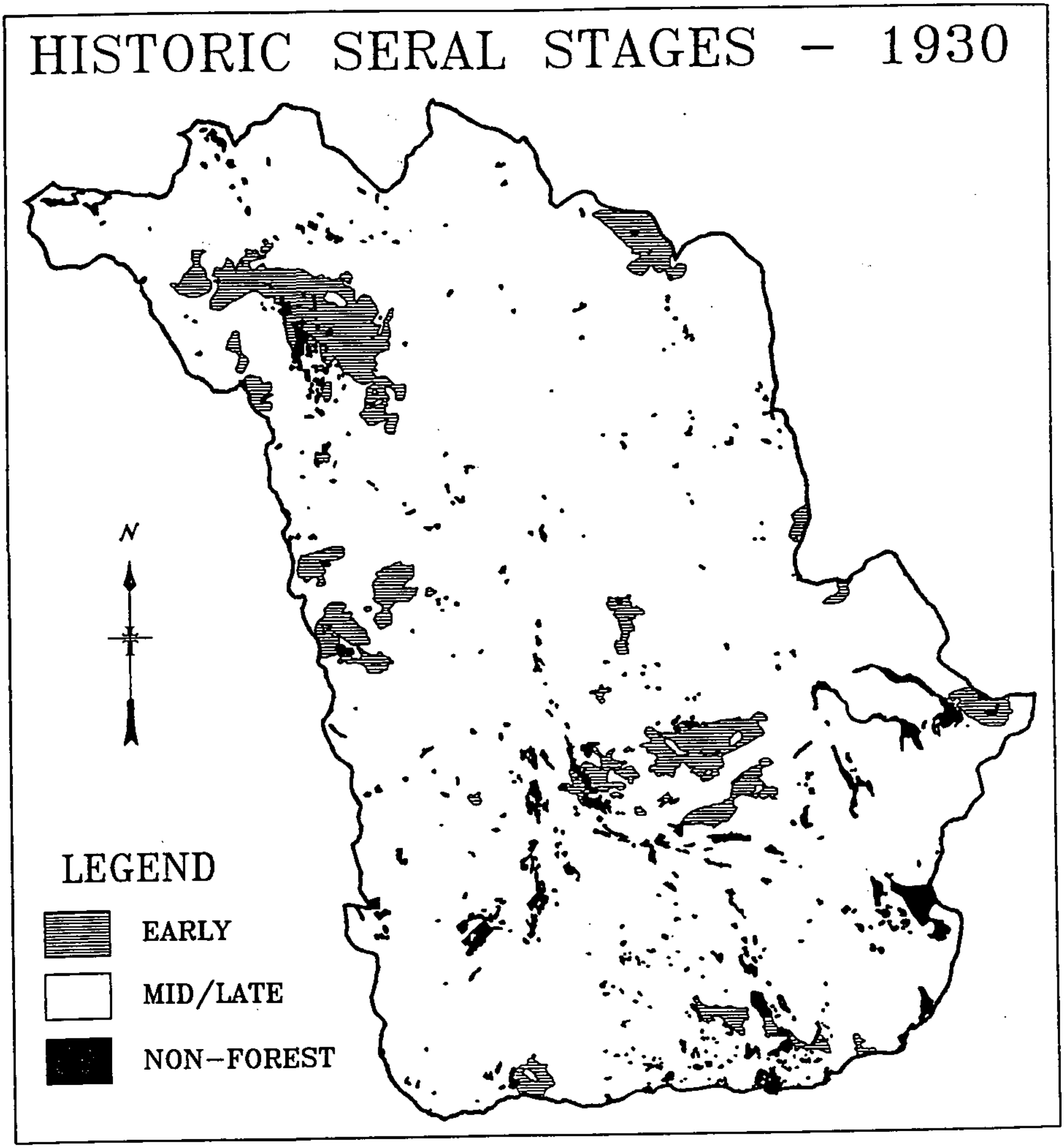


Figure 3-4. Current condition compared to historic range of amount of late seral vegetation. Values shown are percentage of the total area within each forest series.



Map 3-2. Historic Seral Stage - 1930.



C. Riparian Vegetation

- The RNV for early seral riparian vegetation is 5 to 15 percent while the RNV for late seral vegetation is 35 to 80 percent. Currently the Riparian Reserves in the watershed are comprised of 20% early seral and 48% late seral vegetation. This includes the Southeast Group subwatersheds that have 3% early seral and 10% late seral vegetation. Outside of the Southeast Group, the amount of early seral riparian vegetation would be 23% and the amount of late seral would be 53%.

- All the subwatershed groups except for the Southeast and Mainstem groups are above the RNV for amount of early seral vegetation within the Riparian Reserves, primarily due to timber harvest and roads. The East and West groups have the highest amount of early seral vegetation within Riparian Reserves.

- The only group that is below the RNV for amount of late seral vegetation within the Riparian Reserves was the Southeast Group. This is due more to the stand types in this area (stands in the mountain hemlock series that will not develop the structural requirements for late seral) than management-induced disturbance.

- Dispersed camping within riparian areas is one of the key factors affecting riparian vegetation composition along the mainstem Clackamas River. The majority of the dispersed camping occurs from the confluence of Cub Creek downstream to the confluence with the Collawash River. The amount of dispersed camping within this area totals to about 40 acres and typically less than 1 acre per site. The heaviest concentrations occur in Big Bottom.

D. Silviculture

- Site productivity within the watershed is relatively high when compared to Region 6 averages.

- In general, the upper elevation sites are less productive. This is due to the shorter growing season, thinner soils, a regeneration "lag" due to poor survival and growth of seedlings until they grow to above the average snow depth, and the slower growth of the conifer species that are typically found in these areas.

- Frost problems tend to be very site-specific and usually occur where there are depressions in otherwise relatively flat terrain. In these areas, below freezing temperatures occur during the growing season, killing or stunting conifer seedlings.

E. Disturbances - Fire, Wind, Insects and Disease

- Fire suppression and other human activities have altered the natural fire regime. This has resulted in increased fuel accumulation and increased susceptibility of some stands to insect and disease damage. This in turn has increased the chances of fire occurrence. The subwatersheds most affected by this are Olallie, Lemiti, and Sisi.

- Past harvesting patterns have altered the extent and location of windthrow events. Damaging winds in the watershed usually come from either the southwest or east. Clearcut edges and shelterwood units with a south-southwest aspect suffer the most consistent windthrow.

- In the recent past, episodes of windthrow in the watershed appear to occur on a regular basis approximately every five years. Noticeable windthrow events in the recent past occurred in 1978-80, 1984, and 1989-90.

- There are three insect species that have significantly affected the disturbance regimes within the forested areas of the watershed. These are the Douglas-fir bark beetle, the mountain pine beetle, and the spruce budworm.

- The tree disease that has had the most significant effect in the watershed is *Phellinus wierii*, commonly known as laminated root rot.

F. Wildlife

To facilitate discussion of wildlife species habitat, species that have similar habitat requirements have been grouped into habitat guilds. Please refer to Table 3-8 and Table 3-9 in Appendix A for more information about species guilds.

- Two hundred and fifteen vertebrate species potentially occur within the watershed. Vertebrate abundance and diversity is a closely linked to vegetative patterns across the landscape. The current amount and distribution of habitat is significantly altered from conditions in the earlier 20th century.

- Late seral habitats are currently more abundant in the watershed than early seral habitats. Generalist and contrast species have abundant habitat. Lake habitats and certain special and unique habitats (caves and cliffs) are in relatively limited supply within the watershed, as compared to habitats available for terrestrial forest species. The watershed currently provides breeding habitat for certain threatened, endangered and sensitive species.

- The watershed currently contributes a high percentage of the available habitat for TLML (Terrestrial Large home range, Mosaic, Late seral) species on a Forest-wide scale. This species guild includes species such as northern spotted owl, pine marten, and wolverine. There are large blocks of high quality TLML habitat. The largest blocks occur in the LSR, but excellent habitat exists to the east, west and southwest.

- Snag and coarse woody debris densities within managed early and mid seral stands are considerably lower than in late seral stands. The amount of snags within managed early and mid seral stands harvested before 1990 are near or below the minimum levels established under the LMP and ROD.

- Snag densities (decay classes 1, 2, & 3, > 21 inches diameter) measured at a landscape level throughout the Upper Clackamas watershed average greater than 4 snags per acre except in the Lemiti subwatershed. Snag densities in unmanaged stands are higher. These densities exceed the minimum levels established in the ROD and LMP.

- The portion of the LSR that lies within the watershed currently contains 23 of the 52 known owl activity centers in the watershed. The LSR comprises 32% of the watershed. Of the 23 activity centers, 6 are below take thresholds established by the USFWS. Five of the six activity centers below take thresholds are located in the southeast portion of the watershed, where mid seral stands of natural origin are common.

- There are 29 northern spotted owl activity centers in the Matrix. Eight of these are currently below take thresholds established by the USFWS.

- The LSR is one of the narrowest in the region and hence has a very high edge to area ratio. With this shape, late seral population distribution and functioning within the LSR may be strongly influenced by activities outside the LSR. (Map 3-7)

- Currently neither the LSR nor the Riparian Reserves are in a fully functioning condition for late seral associated species, when defined by the amount of early and mid seral habitat.

- Overlap of owl territories is somewhat higher within the LSR and the West and South subwatershed groups, suggesting that owl in these areas are more crowded into the available habitat.

- Dispersal habitat is currently well-distributed and includes much of the Matrix. Currently, 48% the Riparian Reserves in the watershed are providing late seral dispersal habitat. This includes the Southeast Group subwatersheds that have 3% early seral and 10% late seral vegetation. Outside of the Southeast Group, the amount of late seral dispersal habitat in the Riparian Reserves is 53%. Dispersal pathways are most critical towards the west, north and south since other LSRs lie in these directions. (Table 3-11)

Map 3-7. Late Successional Reserves in the Clackamas Subbasin.

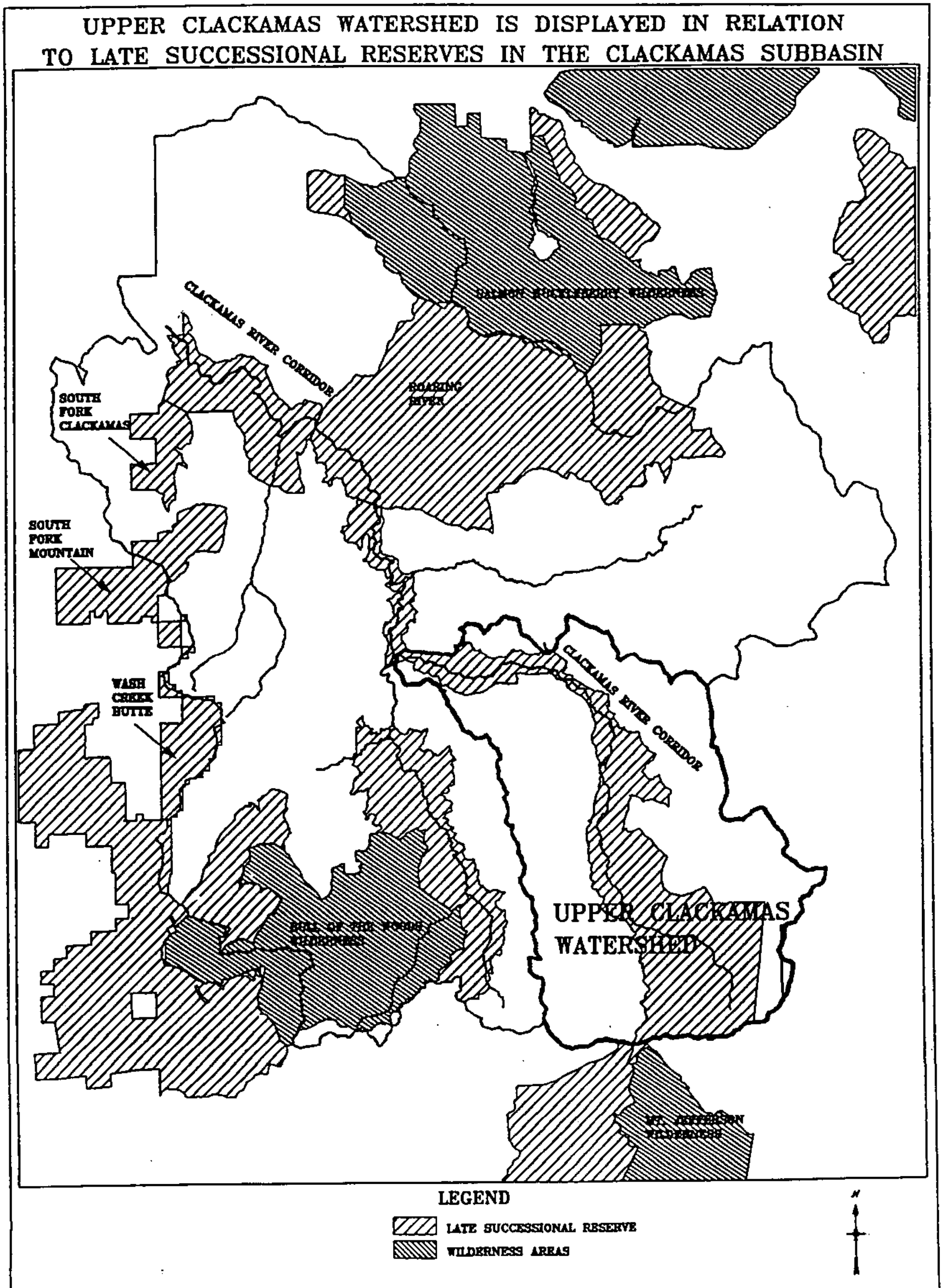


Table 3-11. Owl habitat by allocation.

Land Allocation	Acres of NRF* Habitat	Percent of Allocation	Acres of Dispersal Habitat	Percent of Allocation
Late-Successional Reserves	19,707	61	21,897	68
Riparian Reserves Outside of LSR	6,043	53	6,497	57
Unmapped LSR (Owl 100's)	1,904	89	1,970	92
Matrix	23,630	46	26,569	48

* NRF = Nesting, roosting, and foraging

Fish Habitat

A. Hillslope Processes

Sediment Production and Delivery to Streams

- Landslides in the watershed are strongly associated with weak, pyroclastic rock formations and steep slopes, which occur almost exclusively in the Northwest Group. Some landslides, however, do occur outside this area on talus slopes and landforms of steep slopes with weak or resistant rock types. (Map 3-8)

- Switch, Austin, and the moderate risk portions of Granite and Two Rivers earthflows, all within the Northwest Group, currently do not meet LMP standards for hydrologic recovery (B8-031, B8-032). These earthflows will not recover for 12 to 29 years.

- Most debris slides and debris flows identified in the inventory of the Northwest section of the watershed are associated with either clearcut harvest units or roads. (Table 3-18)

- About twenty percent of the 377 road/stream crossings in the watershed have a high capability to deliver sediment to streams through ditchline flow. Squirrel, Pot, Austin Segment, Berry, and Granite subwatersheds have the greatest concentrations of these crossings. Squirrel and Pot have the highest concentrations of road/stream crossings with native surfaces.

- Fifty-nine miles of road with a potential to deliver sediment from culvert out flow are located within 200 feet of streams. These road segments are well-distributed throughout the watershed.

- Four-hundred thirty-five acres of recently harvested units are located close enough to streams to be a potential source of sediment.

- Lowe, Granite, Last, and the Austin and Big Bottom Segment subwatersheds have the greatest risk for road-related mass movements delivering sediment to streams.

Soil Productivity

- Approximately 3,600 acres out of the 29,760 acres harvested within the watershed have been compacted by non road timber harvest activities. Of this 29,760 acres, about one-third of them do not meet the LMP standard which limits impaired soil condition to no more than 15% of the harvested area. (Table 3-23)

- Seventy-two percent of acres harvested in the watershed are in areas of low soil resiliency. Only 20% of the acres harvested in areas of low soil resiliency were harvested using logging methods that result in low soil disturbance while the rest employed methods that result in high or moderate soil disturbance. (Table 3-24)

- Roads and road clearings occupy approximately 2,000 acres of the watershed.

Map 3-8. Landform Units.

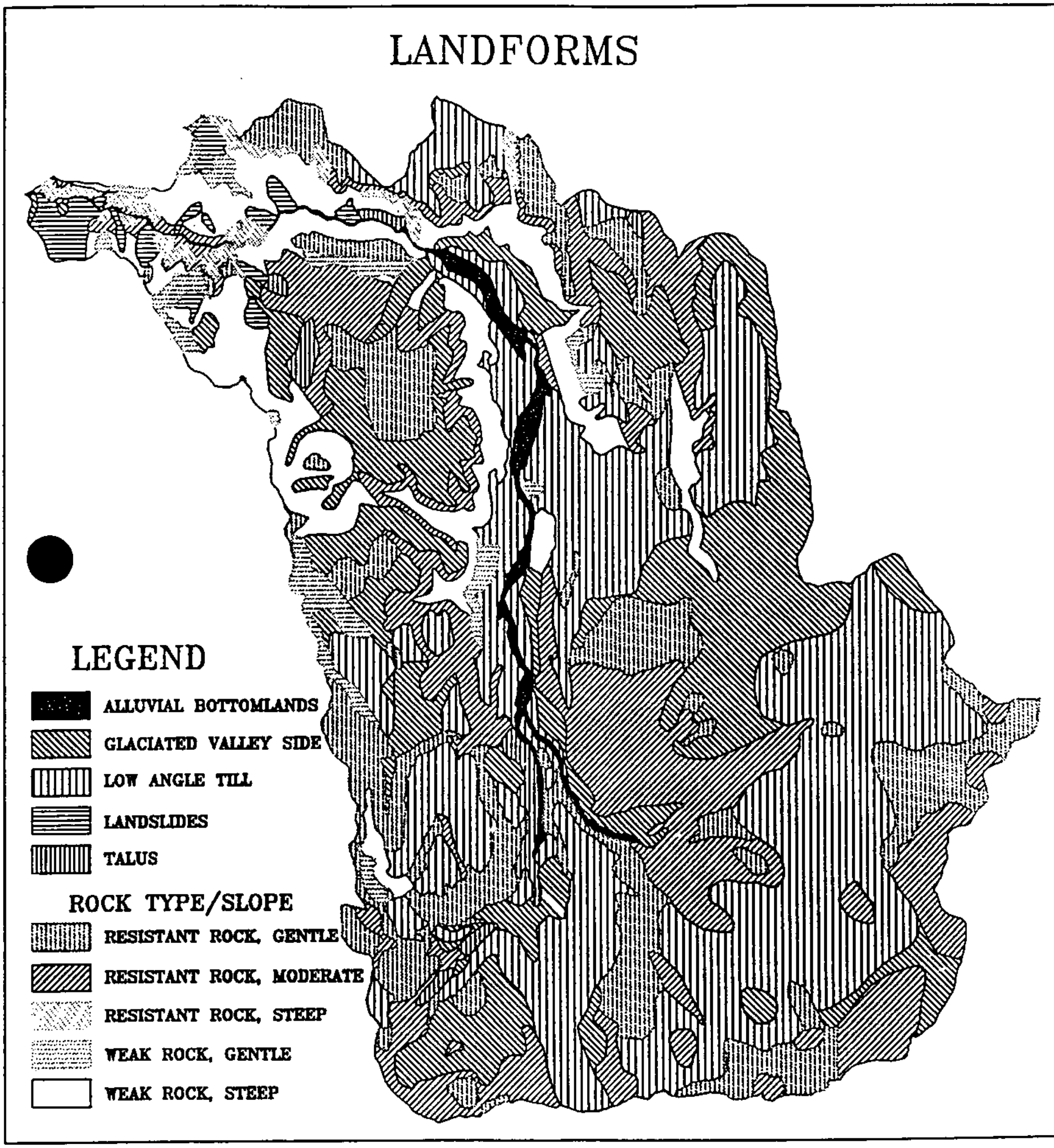


Table 3-18. Landslide occurrence by land use.

Land Use		Landslide Type: Debris Flow	Debris Slide	Earthflow	Slump	Creep	Rock fall	Surface Erosion	Streambank failures	Totals
Managed	Clearcut Units	7	1	1						9
	Roads-USFS		4							4
	Roads-Powerline		3		1					4
Natural	Mature Forest	1	3	3	2				4	13
	Non-Forest									0
Totals		8	11	4	3	0	0	0	4	30

Table 3-23. Acres of compaction by disturbance rating.

Compacted Acres by Disturbance Rating				
Harvest Method	Disturbance Rating	Total Acres	% Activity Area Compacted	Total Acres Compacted
Tractor & Machine Pile	High	9,727	17%	2,140
Tractor Only	Moderate	13,270	9%	1,327
Cable, Skyline	Low	6,763	2%	135
Totals		29,760		3,602

Table 3-24. Acres of harvest type by soil resiliency rating.

Harvested Acres by Disturbance and Soil Resiliency Ratings						
Harvest Method	Disturbance Rating	Soil Resiliency Rating: Low	Moderate	High	Total Acres	% of Harvested Acres
Tractor and Machine Pile	High	7,988	1,691	48	9,727	33%
Tractor only	Moderate	9,060	3,645	565	13,270	44%
Cable, Skyline	Low	4,205	2,157	401	6,763	23%
Total Acres Resiliency		21,253	7,493	1,014	29,760	100%
Resiliency Acres by %		72%	25%	3%		

B. Fisheries

Fish Stocks

- The late-run coho salmon is believed to be the last remaining stock of wild lower Columbia River coho salmon. One of the three brood years is at risk of becoming extinct.

- Native late run coho and spring chinook salmon and winter steelhead have declined in the last couple of decades. Few, if any, native spring chinook salmon exist within the watershed. (Table 3-25)

- The effects of hatchery introductions on native stocks is not clear at this time. Information exists to speculate that there has been interbreeding of native and hatchery introduced stocks. Spring chinook salmon and winter steelhead stocks are probably the most affected by hatchery introductions.

- Bull trout are probably extinct within the watershed.

- The existing quantity and quality of fish habitat in the Upper Clackamas watershed does not appear to limit anadromous fish production as much as other factors. Commercial and recreational fishing and hydroelectric facilities affect the escapement of anadromous fish to the watershed more so than fish habitat. (Map 3-10)

Habitat Condition

- The construction of roads in floodplains reduced the amount of quiet water habitat in greater proportion than other habitat types, in particular the area from Big Bottom downstream to the Collawash River. This reduction affects the production of the native late-run coho salmon, which is at a great risk of becoming extinct within the watershed and in the subbasin.

- Aquatic habitat maintenance and formation differs in the different groups within the watershed. Specific mechanisms affecting aquatic habitat maintenance and formation are described in the analysis. For example, coarse woody debris (CWD) is one of the primary pool forming agents in the East and Southeast groups.

- Group-specific numeric standards for pools and CWD levels were not developed through this analysis due to limited historical information.

- The watershed contains a high density of lakes with most concentrated in the southeast portion of the watershed.

- Some culverts block or hinder fish passage to historical spawning and rearing areas in the watershed. The majority of problem culverts affect resident fish.

Habitat Composition

- Existing aquatic habitat throughout the watershed does not meet the LMP and Policy Implementation Guide numeric standards for habitat composition. (Figures 3-14 and 3-15)

- The standards for habitat composition do not apply uniformly throughout the watershed because of the different stream types.

Fish Utilization and Production

- The existing fish production capability of the watershed is below the estimated historical capability and potential capability. Existing aquatic habitat composition is different from historical conditions, nor would large segments ever return to historical conditions due to maintaining main arterial roads such as Road 46.

- Coho salmon production is higher and steelhead production lower than expected based on estimates from the smolt habitat capability model.

- Big Bottom contains some of the most productive coho salmon habitat in the subbasin upstream of North Fork Dam.

- The most productive coho salmon habitat occurs upstream of the Northwest Group streams. Therefore, there is a low risk of sediment from this area degrading coho salmon habitat.

C. Hydrology

- There are 490 miles of roads in the watershed. About 75% of these have native or aggregate surfaces that could contribute sediment to stream channels.

- There are numerous seeps and springs throughout the watershed.

- The Upper Clackamas watershed is a resilient watershed due to its spring supported hydrology. The analysis did not discern changes in the hydrology of the watershed. The current condition of the landscape does not reflect altered hydrologic regimes. (Figure 3-17)

- Due to the increase in road density and expansion of the stream network from roads, one would expect an increase in peak flows for the lower return interval storm events. Evidence of increased peak flows is not apparent in the channel. Several characteristics that could account for the moderation of the risks associated with rain on snow events in this watershed are:

- relatively gentle sloping topography in the majority of the watershed,
- greater than average infiltration of water during rain/melt events into subsurface or groundwater storage areas, (which subsequently release water through springs), or
- the existence of cooler temperatures in the watershed compared to other areas with similar elevations which would decrease the actual watershed area that experiences a rain on snow event.

- The transport capacity of streams is greater than the sediment delivery throughout the watershed except for the Northwest Group.

- The Pot and Last subwatersheds are the only subwatersheds with aggregate recovery percentage (ARP) values below 70%. The Pot subwatershed is the only subwatershed below the LMP standard of 65% with an ARP value of 60%. (Figure 3-20)

D. Water Quality

- The river and streams have excellent water quality in terms of temperature. Water temperatures meet Oregon Department of Environmental Quality standards and provide desired temperatures for salmonid production.

Table 3-25. Fish species and stocks that inhabit the Clackamas River and their status.

Common Name	Scientific Name	Stock Origin[1]	Status
spring chinook salmon[2]	Oncorhynchus tshawytscha	W/H	Increasing
coho salmon	O. kisutch		
-early run		H	Stable
-late run		W	Declining
winter steelhead[3]	O. mykiss	H W	Stable Declining
summer steelhead	O. mykiss	H	Stable
cutthroat trout	O. clarki	W	Stable
rainbow trout	O. mykiss	H/W	Stable
bull trout	Salvelinus confluentus	W	Unknown Extinct(?)
brook trout	S. fontinalis	H	Unknown

[1] W=wild, native stock; H=hatchery supported or hatchery origin.

[2] Most of the spring chinook salmon in the Clackamas River are either Willamette stock hatchery fish or the genetics of the native stock have been greatly changed by interactions with the Willamette stock.

[3] Two stocks of winter steelhead live in the Clackamas River. The run entering from December through February is a hatchery origin stock. The run that enters the river from late-March through May is an native wild run.

Map 3-10. Stream Network and Fish Distribution.

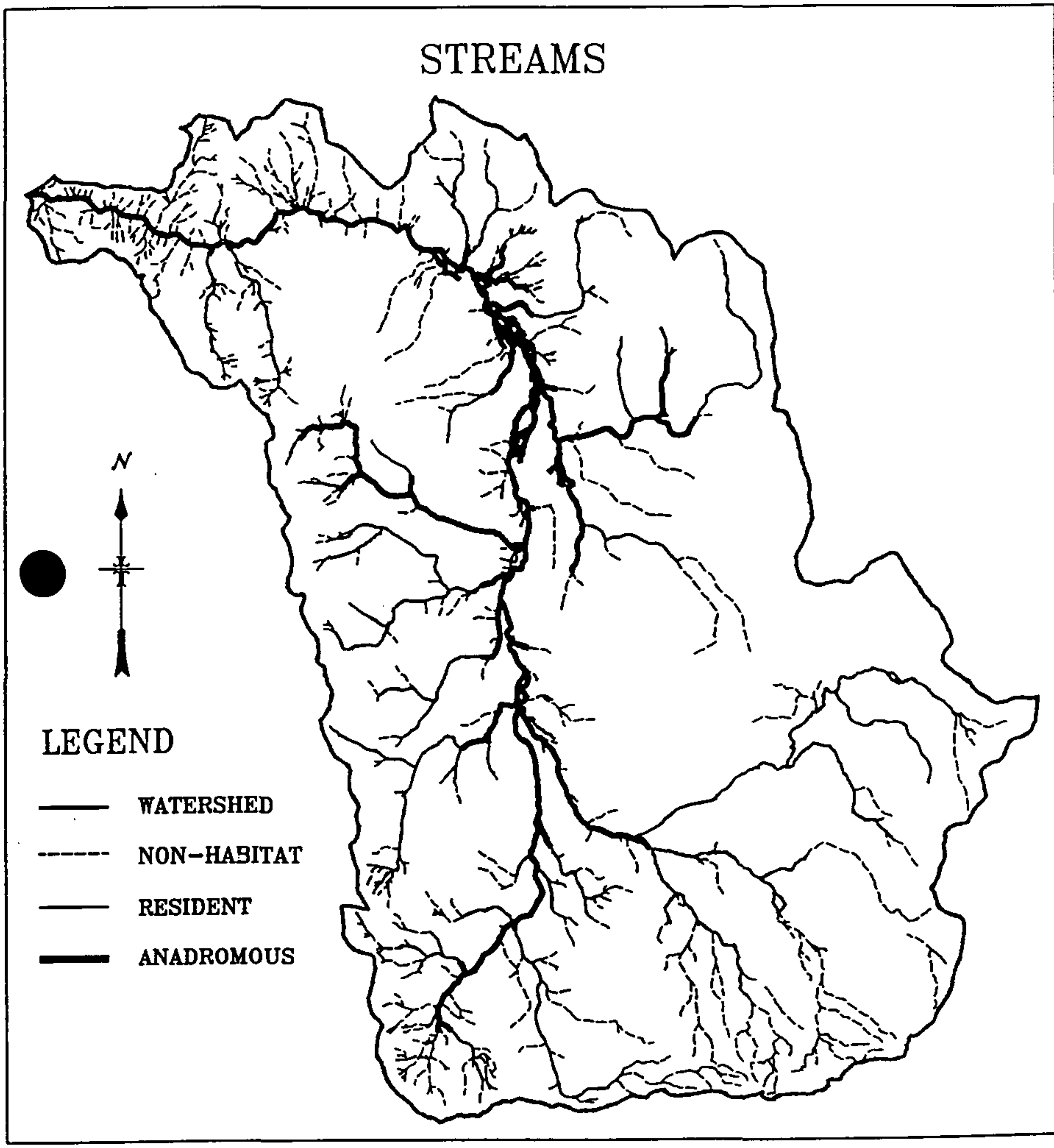


Figure 3-14. Average number of pools per mile for samples streams by natural group with LMP and PIG numeric standards.

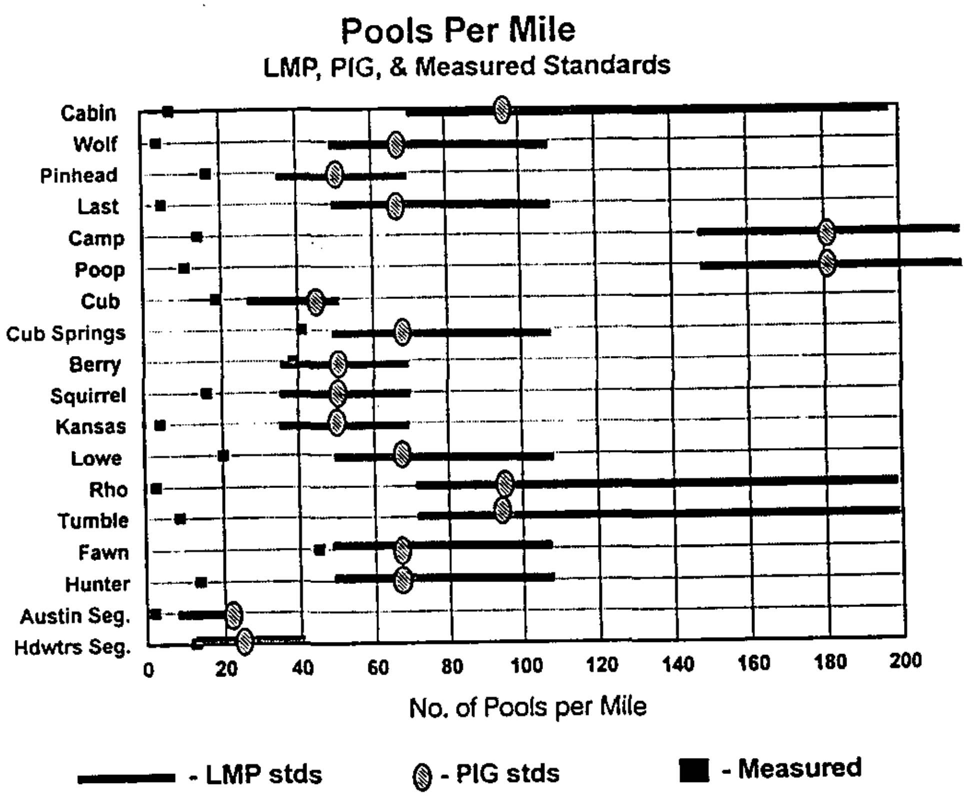


Figure 3-15. Average pieces of coarse woody debris (>36 inches diameter and > 50 feet long) per mile for sampled streams by natural group with LMP and PIG numeric standards.

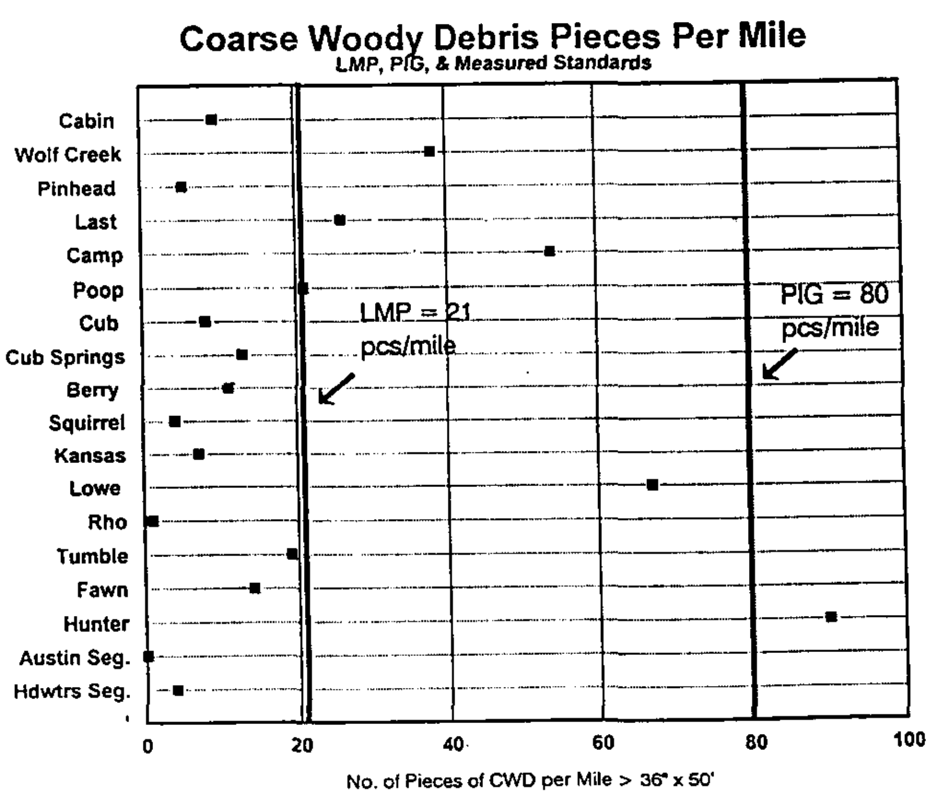


Figure 3-17. Hydrograph of the Clackamas River at River Mile 65.

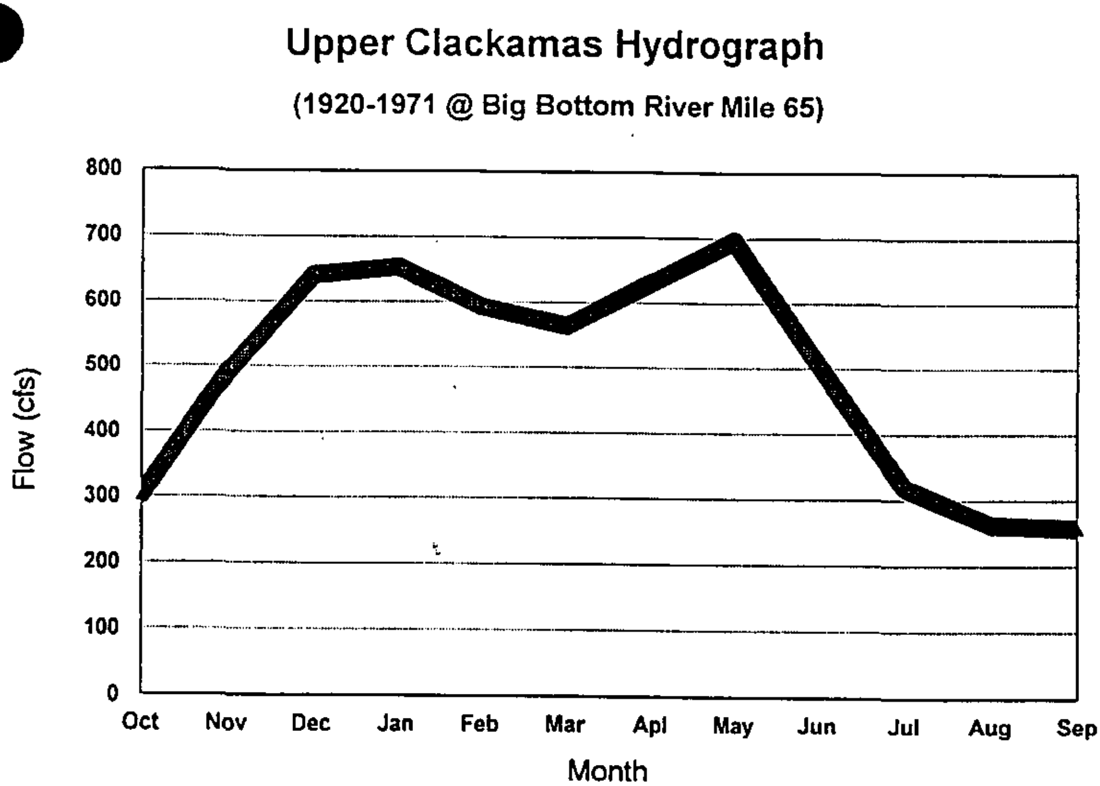
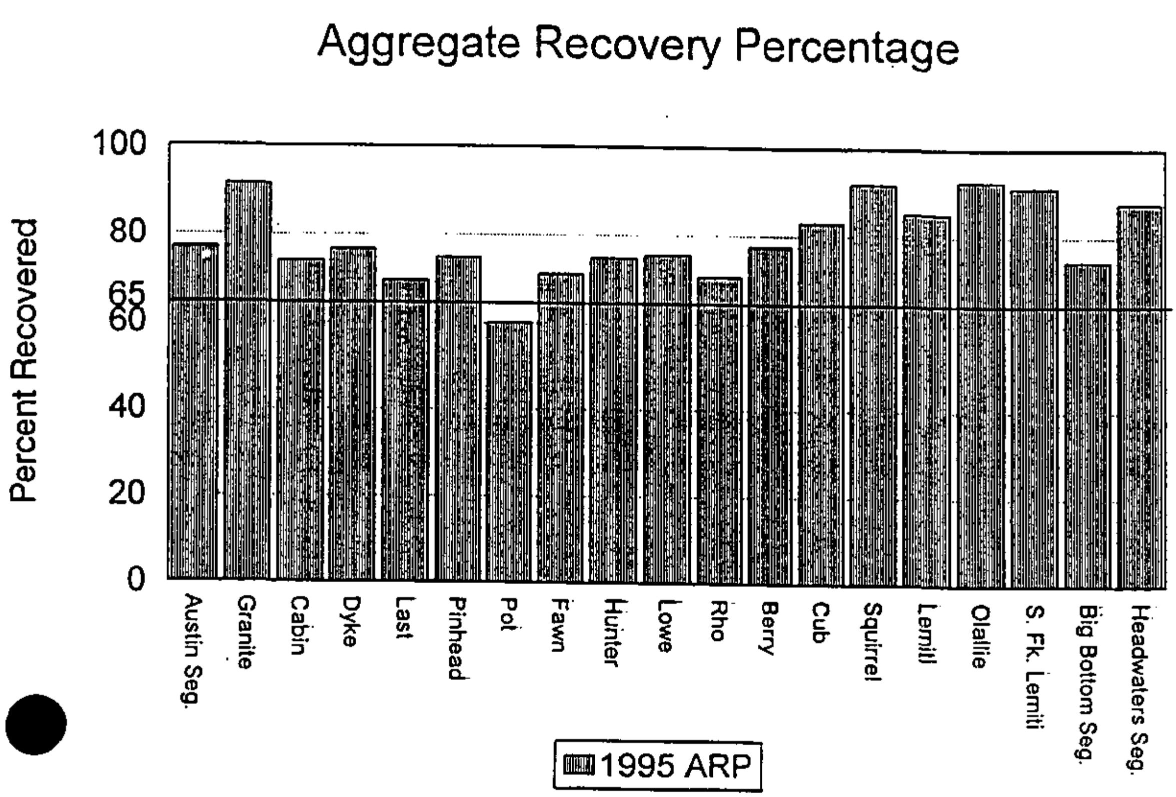


Figure 3-20. Aggregate Recovery Percentage by subwatershed.



Social

A. Commodities

Timber Harvest

- Regeneration harvest, predominantly by clearcut and shelterwood systems, has occurred on over 29% of the watershed which has resulted in the removal of approximately 1.5 billion board feet of commercial timber products. (Table 3-33)

Special Forest Products

- The proximity of the watershed to a large metropolitan area makes it a popular place for people to gather special forest products, and demand for these products is growing each year. This watershed provides a significant portion of the special forest products sold on the Mt. Hood National Forest.

Table 3-33. Historic regeneration harvest.

	1950's	1960's	1970's	1980's	1990-94	Totals
Harvest Acres	880	7,393	6,766	9,828	4,329	**29,196**
Estimated Volume (MMBF)	44	370	338	491	216	**1,460**

B. Recreation

- The Upper Clackamas watershed plays an important role in the provision of dispersed recreation opportunities such as camping, fishing, hiking, hunting, and scenic driving for the Portland metropolitan area and surrounding communities.
- The pattern of recreation use in the watershed is concentrated in the Riparian Reserves of the Clackamas River and in the Olallie Lake Scenic Area. These preferred settings near water are a finite resource. Management of recreation use and its related impacts to riparian resources is the key issue for recreation in this watershed.

- The Clackamas River corridor and a portion of the Olallie Lake Scenic Area are within an LSR. The relationship between recreation use and LSR function is not fully understood.

- Semi-primitive recreation settings, such as in the river corridor, the Olallie Lake Scenic Area, and Rhododendron Ridge, are in the shortest supply and greatest demand both locally and regionally.

- While designated viewsheds in the Clackamas River corridor and the Olallie Lake Scenic Area meet LMP standards, areas outside the foreground of designated viewsheds do not meet current scenic quality objectives.

- Access to and from the Olallie Lake Scenic Area is through the mountain hemlock zone, portions of which have potentially serious forest health problems. As a result, there is an increased fire hazard and a safely risk associated with the evacuation of large numbers of people in the event of a large forest fire.

Chapter 4 - Desired Conditions

Desired conditions are identified in existing management plans. The following discussion is derived from a merging of the land allocations and their desired conditions, from the ROD and the LMP. This merger results in overlapping land allocations, some of which are not compatible with each other, or are only partially compatible. Potential conflicts are identified. Resolution of conflicts may require an amendment of the LMP.

Table 4-1 identifies acreage associated with the new merged land allocations. This table shows acreage with overlaps and they are listed in order of overlap predominance. For example, the Riparian Reserve acreage displayed is only the portion that does not overlap the LSR or the 100 acre owl reserves and the A1 acreage displayed is only the portion that does not overlap all of the columns to the left of A1. A4-Special Interest Areas is not listed since all 6,300 acres are overlapped by the LSR.

The LMP described A8-Northern Spotted Owl Habitat Areas which were deleted by the LMP Record of Decision in favor of Habitat Conservation Areas. These have since been replaced by LSRs. The LMP also allocated land to B5-Pileated Woodpecker and Pine Marten Habitat areas. The ROD recommended that these be deleted unless they are shown to be necessary to meet management objectives for these species (ROD page C-45). B5 acres are not displayed here but the LMP showed 11,123 acres in the watershed. Most of these areas are within the LSRs and Riparian Reserves.

The following is a short synopsis of desired conditions to illustrate potential conflicts. See ROD and LMP for more detail. This chapter does not cover the portion of the watershed that is within the Warm Springs Reservation

Late-Successional Reserve (LSR)

Roughly one third of the watershed is in mapped and unmapped LSR. The ROD allocated land to mapped LSRs and to unmapped LSRs, which are 100 acre reserves around each of the known northern spotted owl activity centers. The desired condition for these areas is to have forests which are late-successional old-growth, and which provide functioning habitats for plants and animals that rely on these forests.

An LSR assessment will be completed at a later date. It was not incorporated here since the LSR is quite large and only a portion of it is within the Upper Clackamas watershed. Discussions of the LSR contained in this document should be considered to be preliminary to the LSR assessment and are included to give a landscape-level view of the watershed.

Table 4-1. Land allocation acres by subwatershed.

Subwatershed	LSR	Owl 100*	Rip Res**	A9	A1	A5	B2	B3	B8	B10	B11	B12	C1	Wspr***	Totals
Austin Segment	4476		887		0		3287		643				828		10121
Berry		135	1394	50			1				471	166	3212		5429
Big Bottom Segment	2620	346	911	9	44		3775						1227		8932
Cabin	154	173	336				131				331		1018		2144
Cub	3233	374	1254	131			2536	615			62	1	868		9074
Dyke	29		77					142					2010		2259
Fawn	311	70	345				441				814		410		2391
Granite	96	102	337				607		52				684		1877
Headwaters Segment	9820					10	131						20	462	10443
Hunter	138	204	720				303				1957		830		4152
Last	1217	148	794					140		43	574		4440		7356
Lemiti	1647	120	532	151		801		262			1468		1567	2875	9422
Lowe	170	194	731				789						2236		4120
Olallie	1104													1571	2674
Pinhead	2411	172	434			1014	850	3			20		2582		7486
Pot	7	5	530		0		435						1304		2280
Rho	59	99	800	102			746				407		1872		4085
S. Fk. Lemiti	1019	8	110					64			394			676	2271
Squirrel	3863														3863
Totals	32372	2151	10191	443	45	1824	14032	1227	696	43	6498	167	25107	5584	100380

Total Reserve Allocations	44714	44.5%
Total "A" Allocations	2312	2.3%
Total "B" Allocations	22662	22.6%
Total "C" Allocation	25107	25.0%
Total Warm Springs	5584	5.6%
Total of All	100380	100.0%

*Owl 100 = Unmapped LSR
**Rip Res = Riparian Reserves; does not include Riparian Reserve acres within LSR
***Wspr = Warm Springs

Potential Conflicts of the LMP with the LSR

A1-Clackamas Scenic and Recreational River. The plan for this river amended the LMP. While it resulted in increased protection for certain resources, it allowed some recreational activities which may not be compatible with the LSR standards. Most of the A1 allocation is overlapped by the LSR.

A10-Developed Recreation Sites. There are 4 campgrounds in the watershed and all of them are in the LSR. While the ROD allows pre-existing facilities to remain in the LSR, increased use and associated maintenance of these campgrounds affects the function of the LSR in those areas.

B3-Roaded Recreation. There are 7,055 acres of roaded recreation within the watershed north of the Olallie Lake Scenic Area and 5,800 acres are in the LSR. The disturbance associated with open roads and motorized recreational vehicles may not be compatible.

B11-Deer and Elk Summer Range. The watershed contains as total of 9,080 acres of B11, 1,234 acres of which overlap the LSR. Certain enhancements for elk and forage area creation could not take place.

Highway 224 and Road 46 have been nominated as a Scenic Byway. These roads pass through the LSR for most of their length. A potential conflict could result if this designation attracts more traffic and recreation use.

Most of the dispersed camping in the watershed occurs in the LSR. Several LMP standards require protection and continuation of this use.

Aquatic Conservation Strategy

The Aquatic Conservation Strategy focuses on maintaining and restoring ecosystem health at watershed and landscape scales to protect fish habitat and other riparian-dependent resources. The four components of the strategy (key watersheds, riparian reserves, watershed restoration, and watershed analysis) provide the land management agencies the tools to maintain and restore the productivity and resiliency of riparian and aquatic ecosystems. This watershed analysis is the first step in implementing the Aquatic Conservation Strategy within the Upper Clackamas watershed.

The following objectives guide land management actions on lands administered by the Forest Service and BLM within the range of the northern spotted owl:

1. Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic system to which species, populations and communities are uniquely adapted.

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

3. Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.

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

5. Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.

6. Maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic, and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected.

7. Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.

8. Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.

9. Maintain and restore habitat to support well-distributed populations of native plant, invertebrate, and vertebrate riparian-dependent species.

The other three components of the strategy address the majority of the factors affecting riparian and aquatic habitat function in the watershed. The upper Clackamas watershed is a Tier 1 Key Watershed. The emphasis within Key Watersheds is to reduce the road mileage and to receive priority in watershed restoration efforts. The Tier 1 Key Watershed boundary for the upper Clackamas River watershed is different than most Key Watersheds because it is not related to the landscape watershed boundary. This should not affect the long term trend in riparian and aquatic habitat conditions because of the riparian reserves and priority for watershed restoration.

All of the above objectives apply to this watershed but the analysis identified conditions that appear to affect meeting particular objectives. Of particular interest to this watershed are objectives 2, 3, 5, 7, and 8. The extensive network of roads, timber harvest, and recreation use along road 46 have the potential to affect the processes and functions related to these objectives. The preceding analysis identified specific areas within the watershed where conditions are different from expected conditions. These conditions include:

The altered sediment regime in the Northwest group (objectives 2, 3, and 5);

The degradation of riparian structure and function and instream habitat caused by roads, (including culverts) and timber harvest throughout the watershed, in particular in the East, West, and South Groups (objectives 2, 3, 5, 7, and 8);

The disruption of habitat connectivity and interaction with the floodplain caused by Road 46 (objectives 3, 5, and 7);

The effect of dispersed camping on riparian habitat structure and function, especially along Road 46 near Big Bottom (objective 8);

Identifying the processes and functions and their effect on achieving the Aquatic Conservation Strategy objectives allows the Forest Service to focus restoration efforts or management actions to mitigate the effects. For example, the Forest Service can implement a variety of management actions ranging from obliterating roads to controlling dispersed camping within the riparian areas along road 46 to restore aquatic and riparian habitat function. Many actions would meet the intent of the Aquatic Conservation Strategy by reducing the effects of certain conditions within the watershed and therefore, lead to improved conditions. The effect of particular roads or dispersed sites on maintaining and restoring aquatic and riparian habitat function would be determined through subsequent project planning.

Riparian Reserves

The ROD established Riparian Reserves which supplement the riparian allocations in the LMP. Riparian Reserves are a part of the Aquatic Conservation Strategy. The objectives are on page B-11 of the ROD. The desired future condition for Riparian Reserves is to attain a fully functional aquatic and riparian habitat and to serve as dispersal corridors for a wide range of species. They are places where small scale natural disturbances might occur to create complexity and diversity and to add woody debris to streams.

The LMP identified 3,022 acres of A9-Key Site Riparian areas. Riparian Reserves overlap most of these, but many Key Site Riparian areas are wider and contain some upland forests which would be managed similar to Riparian Reserves.

The LMP also allocated B7-General Riparian Areas which are totally overlapped by Riparian Reserves. At some point in the future, the Forest will attempt to reconcile the standards of both plans. The more restrictive standards are to apply, but in many cases it is not clear which are more restrictive or provide greater protection.

Potential Conflicts of the LMP with the Riparian Reserves

Recreational uses of the forest are often focused around water. Developed recreation sites and dispersed camping may not meet Aquatic Conservation Strategy objectives.

Matrix

Several LMP standards express desired conditions for forest landscapes. Among them are standards for hydrologic stability, earthflow stability, visual quality, and wildlife habitats. These standards apply to large forest landscapes including the ROD allocations, but they will primarily affect management in the Matrix.

The ROD discusses the importance of late-successional old-growth forests that are Administratively Withdrawn that are in the Matrix. These are the A land allocations. Within the watershed, only 2,312 acres of A allocations occur in the Matrix, and very little of it is late-successional old-growth due to high elevations and harsh growing conditions.

Hydrologic Stability

The LMP contains standards to limit effects to watersheds. LMP standards FW-61 through FW-67 indicate that most of a watershed should contain forests with closed canopies to reduce the risks associated with rain-on-snow events. These standards limit the quantity of created openings.

Earthflow Stability

The LMP contains standards to limit effects to B8-earthflows. There are approximately 1,520 acres of high risk and moderate risk earthflows in the watershed, all of which are in the Northwest Group. LMP standards B8-29 through B8-36 indicate that most of an earthflow should contain forests that are not impacted or are recovered from human caused disturbances. These standards limit the size and quantity of created openings.

Scenic Quality

Much of the watershed is within a designated viewshed (51,274 acres). The viewshed contains portions of the landscape seen from primary viewer positions. Road 46 is the main viewing position because large numbers of visitors drive this road to access other portions of the watershed. Other viewer positions include campgrounds, the Clackamas River, lakes, and trails, including the Pacific Crest Trail. Some land allocations are specifically set up to emphasize scenic quality and recreation. They include A1-Clackamas Scenic and Recreational River, A4-Special Interest Areas, A5-Unroaded Recreation area near Sisi Butte, A10-Developed Campgrounds, B2-Scenic Viewsheds, B3-Roaded Recreation, and B12-Back Country Lakes. Viewsheds should be natural appearing. The degree of naturalness depends on many landscape factors including the distance from a viewing position. All of the other land allocations which are not in a designated viewshed, (B8, B10, B11 and C1) would also be managed to meet certain visual objectives.

Deer and Elk Habitats

The LMP contains standards for managing deer and elk habitats. Thermal cover, optimal cover, forage and open road density are some of the key components, as well as standards which affect the size, shape and distribution of regeneration harvest units. Winter range areas within the watershed are almost entirely within the LSR. The desired condition is to have an appropriate mix of habitat components. The LSR would be dedicated to thermal and optimal cover, and the Matrix would provide forage production by regeneration harvest.

Other Desired Conditions

The ROD directs that 15% of the trees in regeneration harvest units be retained. In addition, a multitude of standards in the LMP protect other resources (i.e. soil, wildlife, water, cultural resources, air quality, recreation opportunities, etc.)

Some LMP standards such as FW-349 through FW-357 and many wildlife standards indicate how patch harvest units are to be sized and separated. Standards FW-158 through FW-160 indicate that large blocks of old-growth forest should be managed to minimize fragmentation.

C1-Timber Emphasis lands are part of the Matrix and encompass 25,103 acres in the watershed. The goal for this area is to provide timber and wood products on a sustained basis, while attaining the Forest-wide conditions described above for landscape patterns.

The desired condition for C1 lands is to have highly productive forest stands of various ages.

Chapter 5 - Future Trends

Introduction

In recent years, management practices within this watershed have changed considerably when compared to the previous 40 years. This is partly due to the completion of the LMP and the implementation of its standards and guidelines. Management practices have also changed due to a gradual change in management philosophy toward ecosystem management with an emphasis on stewardship and restoration.

Since 1990, timber sale planning within the watershed has focused on salvage and thinning. Logs and boulders have been added to many streams to create pools. Four side channel projects have been completed to increase coho habitat along the Clackamas River where the construction of Road 46 caused channel alterations. Many roads have been closed to reduce wildlife harassment and other roads have been ripped and obliterated. Several major dispersed recreation sites along the Clackamas River have been restored in a manner which allows use but restricts vehicular access. Riparian areas have been planted. Trees have been topped to create snags for wildlife within harvested areas. Thinnings have been designed to enhance structural and species diversity. Burning of slash has been reduced. All of these activities are expected to continue into the future.

Purpose

The purpose of this chapter is to examine the future trends of key processes and functions within the watershed over the next 30 to 40 years. Predicting future trends is a necessary step in determining the effects of the management contained within the ROD and the LMP on functions and processes in the watershed. To do this, the watershed analysis team developed a set of assumptions which defined future changes to both the vegetation and the social setting within the watershed. This was done only to test for trends that would assist the team in identifying key findings.

The following assumptions, developed by the watershed analysis team, integrated various resource management issues. These assumptions represent only one alternative scenario of managing the watershed. They attempt to test the scenario which focuses harvest on late seral vegetation since this is one of the most controversial issues within the watershed. The resulting trend analysis attempts to examine the ecosystem sustainability, resource effects related to key questions, and to set a basis for making recommendations for alternative management strategies.

Resource Trend Analysis Assumptions

The following list describes the assumptions used for predicting the changes expected for vegetation, biodiversity, aquatic habitat and commodity outputs:

1. Vegetation changes are based on meeting the Probable Sale Quantity (PSQ) identified in the ROD and disaggregated to the watershed using the FORPLAN model. The PSQ model for this watershed shows that approximately 2,000 acres per decade of late seral vegetation from the Matrix land within this watershed would need to be harvested for the first 3 decades.

2. For the purpose of this analysis it is assumed that no mid seral stands would grow into a late seral condition during the next 4 decades. Most of the current mid seral stands are natural stands which are currently overstocked. Their condition is such that most would still be mid seral in 4 decades.

3. Growth of plantations within the watershed was modeled using the Stand Projection System (SPS) using the average site index found within each vegetation series. Almost all of the plantations that currently exist within the watershed would be in a mid seral condition within 2 to 3 decades.

4. All planned PSQ would come from the Matrix. Any outputs from Late-Successional Reserves or the Riparian Reserves would be a by product of restoration in these areas.

5. Harvesting to meet the PSQ projections would be accomplished in such a way as to minimize the fragmentation of interior old-growth habitat that occurs within the Matrix. The priority for harvest would be isolated patches of late seral habitat and late seral habitat that does not contribute to the connectiveness of interior old-growth habitat.

6. The harvesting needed to meet the PSQ would come from different vegetative series based on their general location within the watershed. It is projected that only 5% of the harvest would come from the western hemlock series (because most of it is within the LSR), 10% would come from the mountain hemlock series (because most of it is also within the LSR), and 85% would come from the Pacific silver fir series (because most of the Matrix lands are in this series).

7. Future condition of the watershed reflects implementing a watershed restoration program as directed by the ROD for Tier 1 Key Watersheds.

8. There will be some thinning of mid seral stands, but this would amount to a minor contribution to PSQ in the first decades.

Vegetation Trends

Frequency

Late seral habitat within the watershed is projected to be reduced by approximately 2,000 acres per decade until the year 2035 (Figure 5-1). This habitat would be converted to early seral stands containing a combination of remnant small patches and scattered individual large trees, as described in the ROD. This means that if timber were harvested entirely from late seral stands, 18% of the late seral stands currently present in the watershed would be harvested within the next 30 years. This equates to approximately 50% of the existing late seral stands in the Matrix, where harvest would be concentrated. There is no expected reduction of late seral within the LSR or Riparian Reserves. Figure 5-1 shows the expected frequency of early, mid, and late seral habitat in the Upper Clackamas watershed for the next 4 decades. Figures 5-2 through 5-4 shows future seral stages within Riparian Reserves, LSR, and the Matrix. It is likely that there would be a combination of thinning and other types of harvest of mid and late seral stands in the future, along with regeneration harvest of late seral stands. This is especially true in later decades when some existing plantations within the watershed may become available for harvest.

Figure 5-5 compares the current frequency of late seral stands and the frequency that is expected in the year 2035 to the estimated range of natural variability (see Chapter 3 for more information pertaining to the range of natural variability). Currently, the frequency of late seral stands within both the western hemlock series and the Pacific silver fir series are within or above the estimated range of natural variability for this watershed. The mountain hemlock series is currently below the estimated levels. By the year 2035, it is projected that the western hemlock series would still be within the historic range, but the Pacific silver fir and mountain hemlock series would be below the historic range. This is because most of the future regeneration timber harvest in the Upper Clackamas watershed would be concentrated in the Pacific silver fir series. There would be little harvest in the western hemlock series (most of it is in the LSR) or in the mountain hemlock series (due to both site conditions and LMP and ROD land allocations).

Figure 5-6 shows current and projected future amount of early seral in relation to the range of natural variability. The frequency of early seral habitat would be reduced by the year 2035. Most, if not all, of the plantations harvested in the last 10 years would become mid seral habitat. The majority of these stands have been or would have been fertilized and thinned for stocking control. By the year 2035, all of the vegetation series within the watershed are projected to be below the range of natural variability for early seral habitat.

The frequency of mid seral habitat is projected to increase over the next 30 to 40 years. This is due to the amount of early seral habitat currently in plantations which are expected to transition to mid seral soon. The majority of stands that are currently in a mid seral condition are overstocked, occur on low productivity sites, and are the result of old fires. In addition, most of them are in the mountain hemlock series and have species compositions that are prone to insect and disease, or are lodgepole pine stands that may never become late seral habitat. On the other hand, many existing plantations that are currently entering the mid seral stage have a high probability of becoming late seral habitat within the next 60 to 100 years.

Figure 5-1. Vegetation trend in the Upper Clackamas watershed.

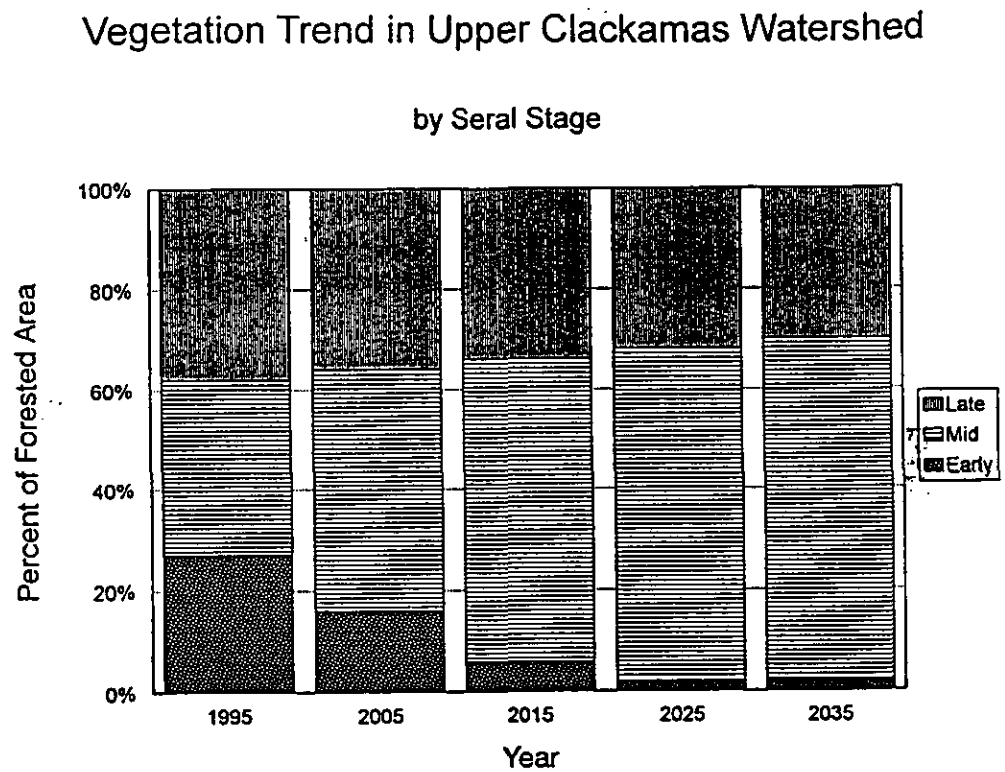


Figure 5-2. Vegetation trend in the Riparian Reserves.

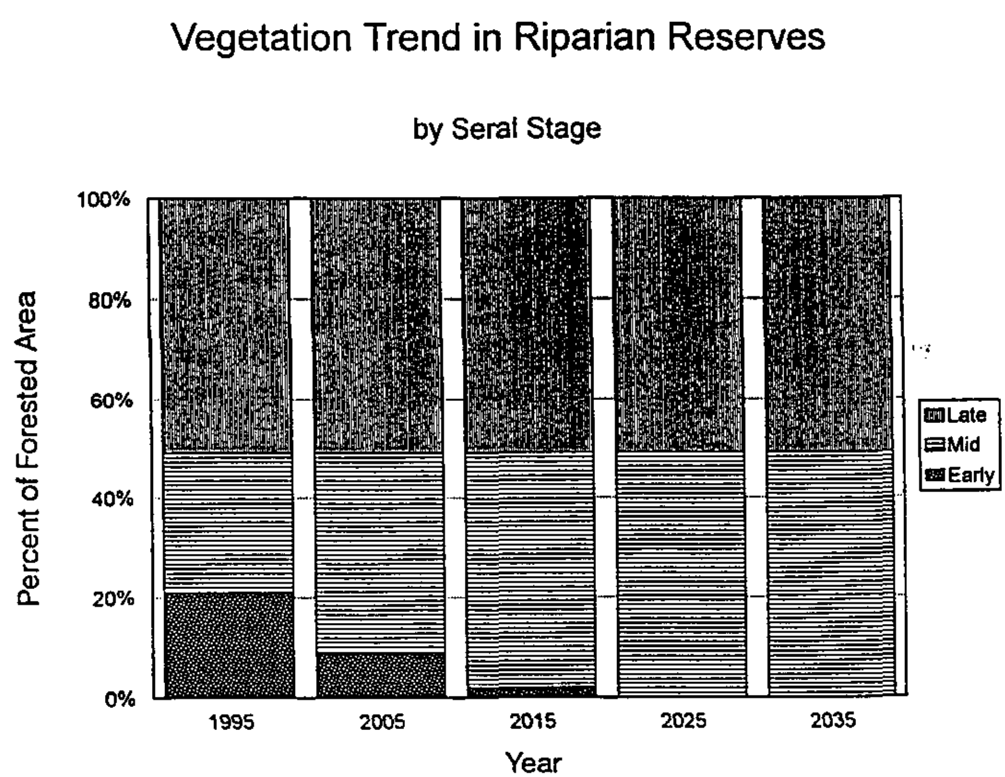


Figure 5-3. Vegetation trend in the Late-Successional Reserve.

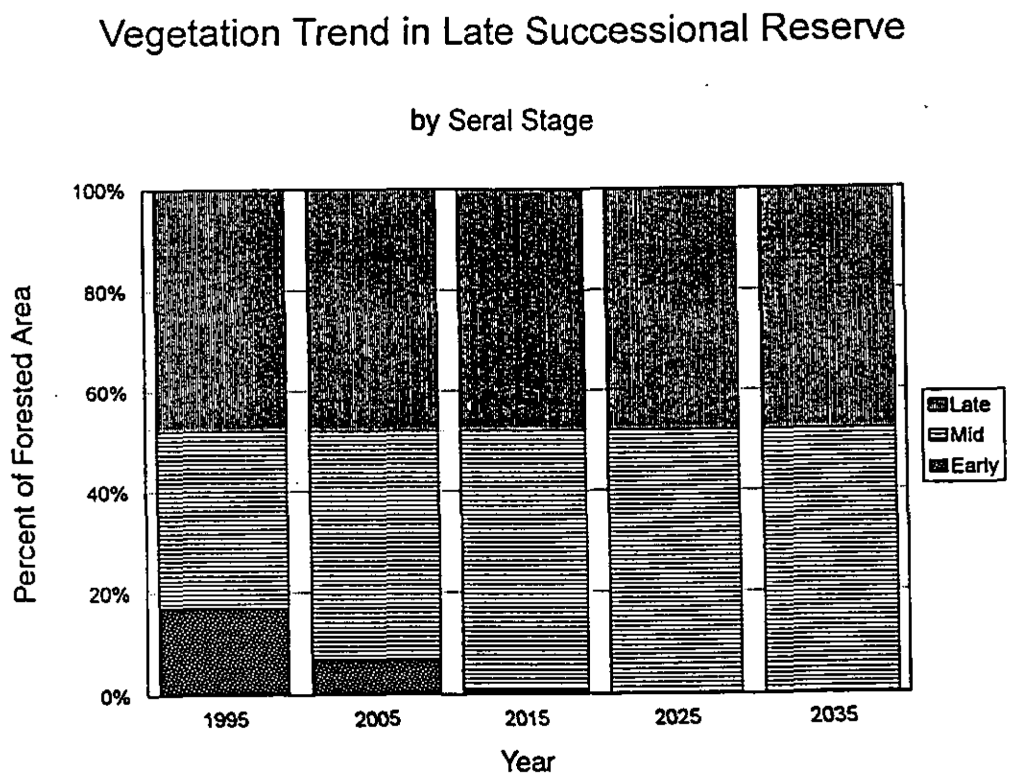


Figure 5-4. Vegetation trend in the Matrix.

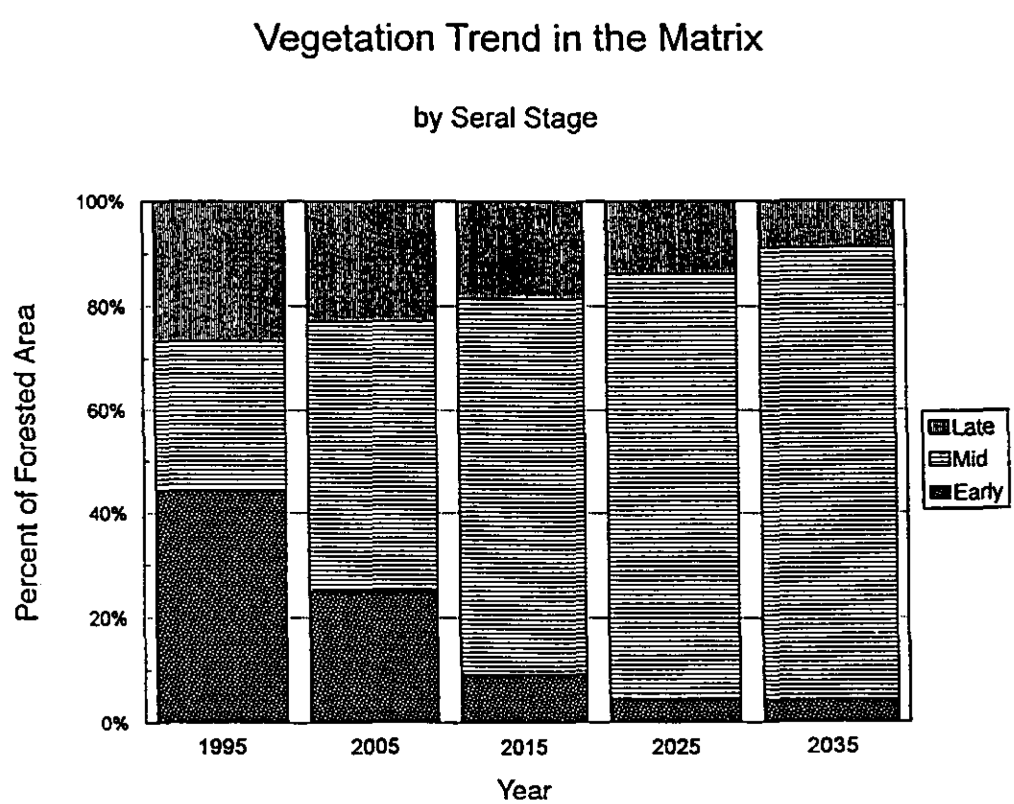


Figure 5-5. Expected frequency of future (year 2035) late seral stands compared with current condition and RNV.

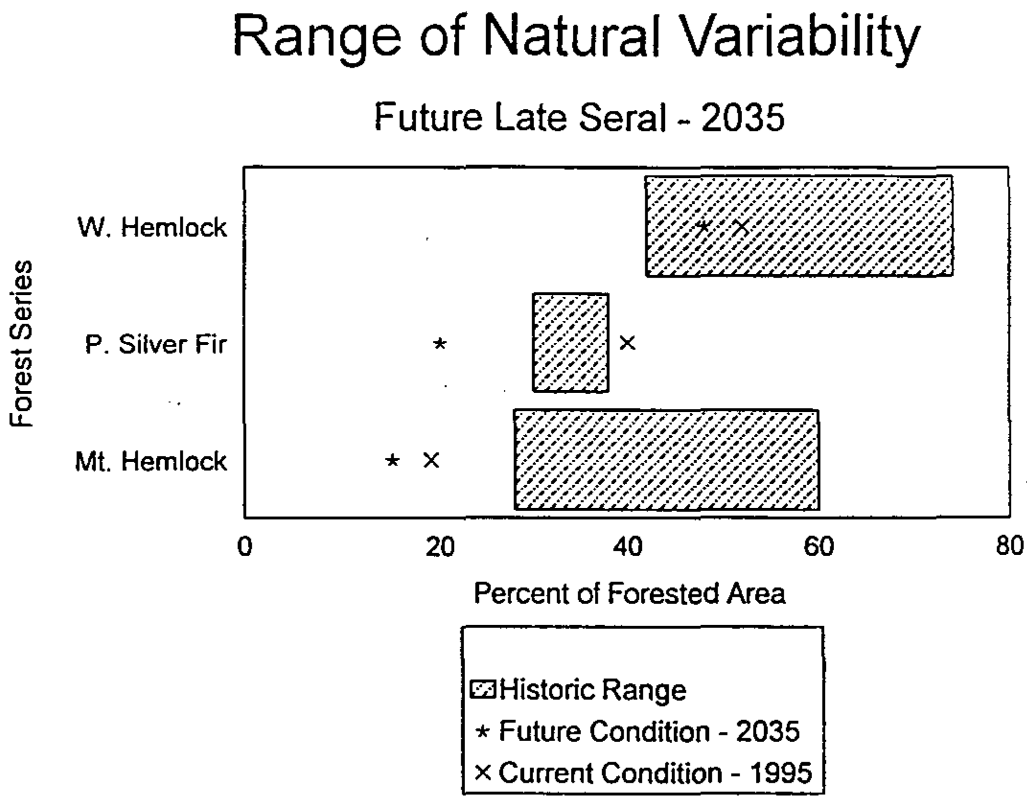
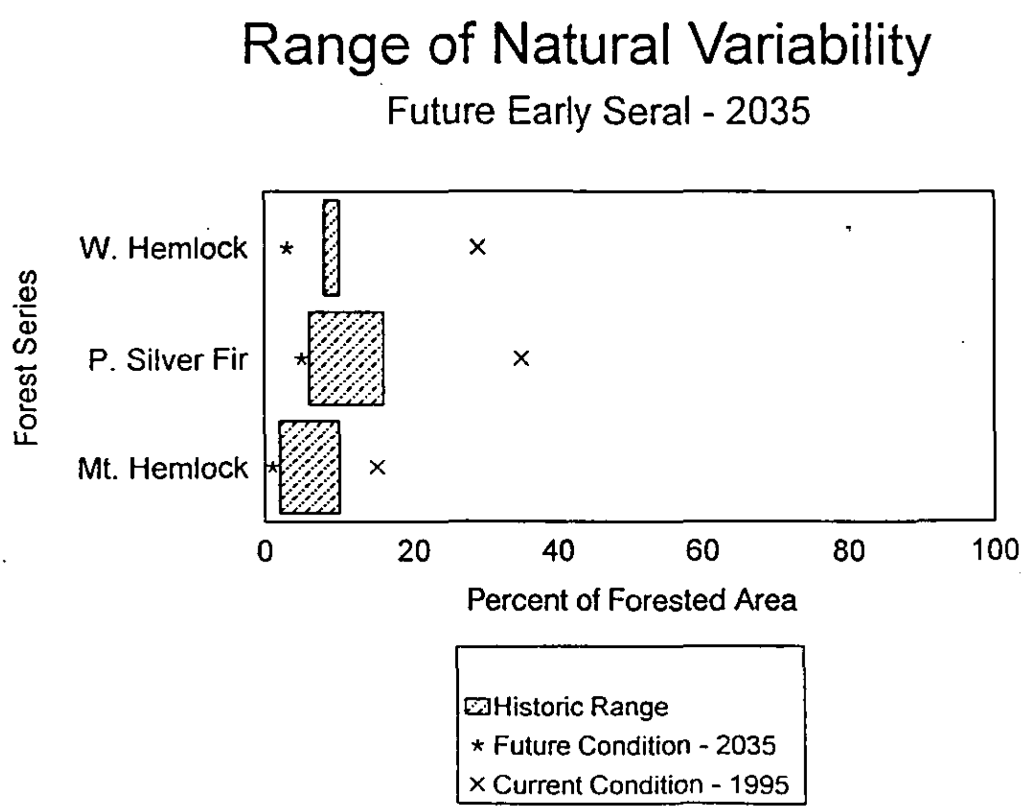


Figure 5-6. Expected frequency of future (year 2035) early seral stands compared with current condition and RNV.



Distribution

The distribution pattern of the early, mid and late seral habitat over the next 30 to 40 years depends on the spatial configuration of future harvesting activities. Opportunities exist, when locating future harvest units in the Matrix, to avoid some of the larger blocks of existing interior habitat and other late seral blocks that are important for connectivity throughout the watershed. Opportunities exist to harvest isolated smaller blocks of late seral habitat and minimize further fragmentation of the watershed.

In the next 30 to 40 years the connectivity of the largest and more well connected blocks of interior old-growth habitat could be maintained. The most connected late seral habitat in the watershed is in the LSR and would remain and eventually increase through time. Some of the larger late seral blocks in the Matrix could become more isolated. In addition to the LSR, the Riparian Reserve network adds to late seral connectivity throughout the watershed. Decisions regarding which late seral blocks would be harvested and which would be retained in the near future should capitalize on the configuration of the reserve system. The less connected late seral patches would be converted to early seral.

Early seral plantations currently have the biggest effect and connectivity and distribution of interior habitat. As the early seral stands grow into mid seral habitat there would be a decrease in edge effect which may increase the amount of interior habitat throughout the watershed, depending on future harvest pattern.

Patch Size

Patch size of early and late seral habitat over the next 30 to 40 years is dependent on the size of future regeneration harvesting and the amount of intermediate or salvage/sanitation harvesting.

The openings in the future would be larger because they would be surrounded by other early seral stands created since the early 1980's. Since the openings would be larger, patch size would tend to be closer to the historic early seral patch size of 184 acres. Mean late seral patch size would also increase, but there would be fewer patches. For both the early and late seral habitat, "patch size" would increase and the number of patches would decrease. Patch size within the watershed would move closer to the range of natural variability.

LSR and Riparian Reserves

The projected trends for vegetation within the LSR and Riparian Reserves are illustrated in Figures 5-2 and 5-3. Within the next 30 to 40 years, most of the existing early seral vegetation would become mid seral. Very little, if any, of the mid seral vegetation is projected to become late seral vegetation within this time frame. No new early seral vegetation is planned to be created. This would only happen through unplanned disturbances such as fire or windstorms.

Silvicultural activities such as stocking control, release, and species selection can significantly influence the ability of forest stands to meet either the objectives of the LSR or the Aquatic Conservation Strategy objectives of the Riparian Reserve network. Site-specific prescriptions for managing vegetation could have a key role in determining future trends for these land allocations.

The Southeast Group of subwatersheds has the highest percentage of the mountain hemlock vegetation series. This area of the watershed has also had the most recurring incidents of disturbances such as fire and insect outbreaks. In general, these stands have low productivity which results in very slow growth rates. The combination of low productivity and recurring disturbances results in mid seral stands that have a low probability of becoming late seral vegetation. Silvicultural treatments could be necessary within these natural stands to meet the objectives of creating late seral conditions.

Currently, 62% of the Riparian Reserves in the Southeast Group are in a mid seral vegetative condition. Only 10% is in a late seral condition. This is the lowest percent of late seral of all the subwatershed groups, even though there has been relatively little timber harvesting in this area.

The LSR within the Southeast Group also contains a large portion of mid seral stands in the mountain hemlock series. Many of these stands are over 80 years old, have high stocking densities, and have a history of spruce budworm infestations. These types of stands are not expected to reach a late seral condition without silvicultural treatments and would also not meet the objectives of the LSR.

Windthrow, Fire, Insects and Disease

The future trends for windthrow, fire, insects and disease within the watershed are unpredictable. What is known is that certain stand characteristics increase the susceptibility to these disturbance agents. Overstocking in mid seral stands in the mountain hemlock series leads to stands that are more susceptible to spruce budworm outbreaks. Windthrown Douglas-fir trees can lead to population increases of Douglas-fir bark beetles, which in turn would increase the amount of standing trees killed by Douglas-fir bark beetles. There would be an increase in this mortality in areas where windthrown trees are not salvages, such as in the LSR and Riparian Reserves. Continued fire suppression activities that lead to excessive fuel loading increase the possibility of wildfires that would create large areas of early seral vegetation. Future management activities would be required to reduce the impacts of these disturbance agents where they are in conflict with the land allocation objectives.

Biodiversity/Wildlife Trends

Habitat Availability by Guilds and Potential Population Trends

Late Seral Associates

As seen in Figure 5-1, over the next thirty years, the watershed would experience a net loss in late seral habitat. Mid seral areas would continue to advance towards late seral conditions but no areas are projected to become late seral by 2025. In the watershed as a whole, late seral habitats would decline by about 18% in 30 years. Late seral habitat within the Matrix would decline by about 50% over the next 30 years.

As a result of the loss of late seral habitat, population decline is anticipated for late seral associates. This would have different implications for late seral associates, depending on their home range sizes and patch associations. Overall, a reduction in population for late-seral associates is expected.

The small home range patch and mosaic species that depend on late seral (TSPL and TSML) would probably disappear from small isolated blocks (those that are left) but would have a low risk of extirpation at the watershed scale because large populations should persist within the LSR and other connected patches.

Functional habitat for large home range mosaic late seral species (TLML) would be greatly reduced in the Matrix. The exact rate of decline in this habitat would depend upon the location of timber harvest units. Available habitat for late-seral associates with medium and large home ranges (TLML and TMML) would be concentrated largely within the LSR. As measured by seral stages, the LSR would not be in a fully functioning condition in 30 years and thus may not be able to support late seral associates at its full potential.

Late seral patches that remain in the landscape would appear to be more connected although the total amount of late seral habitat would decrease.

Currently the watershed contributes a high percentage of the available habitat for TLML species on a Forest-wide scale; thus trends within the Upper Clackamas watershed may have importance Forestwide.

Other Guilds / Special Habitat Components

Contrast habitats which support edge-dependant species are expected to decline throughout the watershed. The LSR will retain virtually no contrast habitats after 10-15 years, except where natural disturbances create openings. Elk populations, which respond to the amount of contrast habitat, are expected to decline.

Early seral associates are also expected to decline because the rate of early seral creation would be less than in the past. Most of the early seral habitat would be found in the Matrix. Early seral associates with medium home ranges (TMPE) may increase, because early seral patches may be larger in the future than at present. This may be a short-term increase, because these early seral patches would eventually become mid seral stands.

Generalist and mid-seral associates would be abundant and well-connected in the future.

Across the watershed, connectivity would decrease for early seral areas (although patch size may be larger).

Aquatic and riparian habitats should improve over time. However, recreation trends, which show a sharp increase in demand for aquatic-based experiences (especially fishing and boating) could cause aquatic and riparian species that are sensitive to human disturbance to abandon some areas. The effects of recreation on wildlife primarily occurs in clumps around lakes in the Olallie area and along the river adjacent to Road 46.

A gradual recovery of snags and down logs within previously harvested areas should occur. In harvest units created in 1995 and beyond, large down logs would be present through the early and mid stages of the rotation. The logs would be derived from those left at harvest and those that may result from windthrow of retention trees. After the first two decades, most available logs would probably be in decay classes 3, 4, and 5.

Special and unique habitat associates should remain relatively stable if efforts are made to conserve these habitats over the next several decades. These habitats may also face some conflicts with recreationists. Wet meadows may require proactive conservation measures, such as burning, to prevent tree encroachment.

Spotted Owls

Take (loss of occupied activity centers) could occur as a result of the harvest projected for the matrix. Harvesting isolated patches that contribute to the nesting, roosting and foraging habitat within a 1.2 mile radius of an activity center first as part of the strategy to minimize fragmentation would almost certainly result in some take (many of the most isolated patches are in areas that are already below the threshold, but where owl activity centers persist). Within 10 to 20 years, conceivably at least seventeen of the Matrix owls could be subject to take. This could potentially affect 37% of the current owl population in the watershed.

Dispersal habitat for the owl would become more "clumped" or concentrated but the number of acres of dispersal habitat is not expected to change significantly. It would take several decades for the Riparian Reserves to become fully functional as dispersal habitat for owls and thus areas in the Matrix are expected to be utilized.

Owls in the LSR could also be affected by timber harvest, since many have territories that theoretically extend into the Matrix (assuming round territories extending 1.2 miles away from the activity center in all directions). Timber harvest in the Matrix near and adjacent to the LSR could result in some LSR owls activity centers having less habitat available than currently. Strategic location of timber harvest units within the Matrix could potentially reduce this concern.

Dispersal Habitat for Late Seral Associates Other than the Owl

Dispersal habitat for other late seral associates is poorly defined. Those species that require late seral habitat for dispersal would be dependent on Matrix lands until the Riparian Reserves grow into late seral stages.

Dispersal habitat is expected to be most limiting within the Southeast and East subwatershed groups.

LSRs and Riparian Reserves

LSRs and Riparian Reserves may not achieve fully functioning condition for 70-100 years. Human recreational and transportational use of the LSR may reduce its effectiveness, although to what degree is unknown.

Much of the LSR is within mountain hemlock series, which may never achieve late seral conditions.

Hillslope Processes Trends

Sediment Production and Delivery

Several sources and processes would continue to deliver sediment to streams in the Upper Clackamas watershed, but the rate and amount would be reduced due to decreased harvest and increased restoration. These sources and processes include:

- Natural slope forming processes of soil creep, surface erosion and mass wasting.
- Elevated rates of surface erosion and mass wasting from past management activities of timber harvest, road construction and recreational disturbances.
- Disturbances associated with future management activities.

Sediment delivered from logging disturbances within harvested areas in the last five years would diminish as vegetative recovery processes occur and ground cover is re-established.

Disturbances at dispersed recreation sites would continue to be a potential sediment source. Future increases in dispersed recreation use would create new disturbances with potential to deliver sediment. Restoration projects would be designed to treat areas that threaten water quality, and management of creation of new dispersed sites could minimize sediment delivery.

Material delivered to stream channel side slopes from recent mass wasting events may continue to ravel and deliver sediment to local streams in the future.

Vegetative succession in harvested areas would promote recovery of slope stability.

The direction of current land management plans emphasizes timber harvest in portions of the Upper Clackamas watershed. Disturbances resulting from harvest activities would be significantly less than in the past. Increased use of helicopter and skyline and a decreased use of tractor systems is anticipated. Road construction within the watershed would be expected to meet the requirements of the Aquatic Conservation Strategy, which includes no net gain of roads within the Tier 1 Key Watershed. If new road construction is necessary, roads would be designed to have a low sediment delivery potential and would not be located in landscape positions that have a high slope instability risk.

Site specific evaluation of slope stability factors and the determination of Riparian Reserve boundaries necessary to protect unstable lands would reduce the incidence of mass wasting associated with any future harvest.

Implementation of direction to reduce total road mileage in Key Watersheds, provide for erosion control, and stabilize road drainage should result in lower sediment delivery rates from roads.

Soil Productivity

Reduction of soil productivity resulting from harvest activities would be significantly less than in the past. It is anticipated that use of helicopters and skyline systems would increase, and use of tractor systems would decrease.

Anticipated restoration projects on roads and within old harvest units would reduce that portion of the watershed in a compacted condition.

Aquatic/Fish Habitat Trends

Riparian and instream habitat condition should improve in the future. The rate of improvement depends on the scheduling and magnitude of a watershed restoration program, including an instream habitat improvement program. Implementing the Aquatic Conservation Strategy would allow riparian areas to recover to more fully functioning parts of the landscape. This, in turn, translates to a more natural interaction with aquatic habitat. Aquatic habitat would improve along with the restoration of riparian habitat function. The rate of improvement depends on management related decisions. These include: 1) removal or retention of existing roads; 2) location and scheduling of timber harvest in the Matrix; 3) location and magnitude of watershed and instream restoration; and 4) managing social expectations related to riparian and aquatic resources.

Certain riparian and aquatic habitat functions can not improve without direct intervention to reduce or eliminate the factors prohibiting achieving improved function. Two notable areas in this category result from this analysis. These are the Northwest Group and the area adjacent to the mainstem Clackamas River paralleled by Road 46. The Northwest Group has the largest amount of unstable landforms. This area also has one of the highest road densities. One would expect there to be a lag time in the recovery of aquatic and riparian dependent habitats, if not a reduction in function in the future, without management emphasis to remove or obliterate roads in the Northwest Group. The roads would continue to accelerate sediment delivery to the streams in this group along with increasing the amount of overland flow and above natural delivery of water to the channels. There would also be a higher risk of landslide events with the existing road network. Thus, there could be a reduction in riparian and aquatic habitat conditions until the Forest Service corrects some of the factors affecting their processes.

Road 46 prevents achieving full riparian and aquatic habitat function because of its location. Road 46 would continue to prevent the river from meandering and thus, perpetuate the higher water velocities and higher than historical channel scour in this stretch. Road 46, by bisecting a large part of the riparian area of the river, creates a linear edge effect. Natural flows in this constrained area would remove a higher proportion of coarse woody debris than occurred prior to constructing Road 46. Coarse woody debris in this section of the watershed is one of the key fish habitat forming elements. Loss of coarse woody debris results in higher water velocities with higher than historical channel scour and a net reduction in fish habitat diversity. Thus, the prevailing channel condition and fish habitat is one of more frequent areas of high water velocities, a loss of potential retention of coarse woody debris, with a net reduction in the amount of slack water areas. These slack water areas are critical to juvenile coho salmon. The river can not cut through Road 46 to the area adjacent to the mainstem Clackamas River to reconnect to historical slack water areas.

Other factors affecting the rate of recovery of the riparian and aquatic habitats include wind events and rain on snow events. The wind events tend to occur episodically and can have locally significant effects. The most susceptible areas are thin leave strips adjacent to clear cuts in the prevailing wind direction. For example, the 1990 windstorm uprooted many of the trees in riparian leave strips. One would expect this to continue to occur until the vegetation within the Riparian Reserves grows to a height that reduces the effects of windstorms on non-windfirm riparian leave strips. Another important factor is to have the resulting riparian vegetation become windfirm. The intent would be to return the rate and magnitude of riparian windthrow to a condition more representative of the RNV.

The potential risks associated with rain on snow events would continue in the future under the ROD and LMP but at a reduced rate than at present. The historical landscape condition of a few large patches of openings would not be replicated under existing management direction. The future landscape would have fewer early seral patches but the seral patches would become larger than at present. Thus, the landscape would move closer to the historical condition. The risk of rain on snow events would decrease similar to the rate the landscape moves towards the RNV for early seral patch frequency and size.

Similar to wind events, dispersed camping within Riparian Reserves would continue to affect achieving riparian and aquatic habitat function. The effects of dispersed camping on riparian and aquatic habitat function would be reduced in the future if existing management of controlling use in riparian areas continues. Dispersed camping would not meet the Aquatic Conservation Strategy objectives if use increases at the rate anticipated without use restrictions.

Fish populations should improve along with the expected improvement in riparian and aquatic habitats and watershed conditions. Resident fish would improve at a faster rate than anadromous fish because their entire life histories occur within the watershed. The rate and magnitude of improvement of anadromous fish stocks may depend on factors other than habitat conditions. Identification and correction of limiting habitat factors an movement towards a naturally functioning aquatic and riparian habitat should increase the productive capability of the habitat in the watershed. Implementing a watershed restoration and instream improvement program, particularly for the late-run coho salmon, would improve critical habitat needs for these fish.

Commodity Output Trends

Assumptions

- All of the assumptions used in the vegetation trend analysis will be used to determine the potential for future commodity outputs.
- Volume projections are based on an average of 50 MBF per acre for all acres in which regeneration harvest is planned.
- The PSQ for the Upper Clackamas watershed is approximately 10 MMBF per year. This is based on models used to project the PSQ under the ROD.

Timber Output Trends

For the purpose of this analysis, it is assumed that timber commodity outputs for the next 3 decades would come from late seral stands using regeneration type harvest. This harvesting is only planned to be accomplished within the Matrix lands of the watershed. Using an average volume of 50 MBF per acre and an annual harvest of 200 acres, this would yield approximately 10 MMBF per year.

The Upper Clackamas watershed has approximately 45,000 acres of Matrix land. Within the Matrix there are about 12,000 acres of late seral stands and 20,000 acres of early seral in plantations. Mid seral stands within the Matrix comprise about 13,000 acres. At the planned harvest level there would be 6,000 acres of late seral in the Matrix in the year 2025.

The watershed PSQ projections plan regeneration harvests of late seral stands. What would actually happen over the next 30 to 40 years is that some thinning of acres in need of stocking control would occur. This would amount to a minor contribution to PSQ in the first decades and would increase as more stands become available for commercial thinning. This would help to offset the need to have regeneration harvesting from late seral stands. Table 5-1 displays a very conservative approximation of the timber outputs that could come from commercial thinning in the future.

This analysis is only an approximation of the volume available for commercial thinning. Regeneration harvest could be prescribed in these mid seral stands in 40 to 60 years. What this analysis shows is that over time the majority of the volume harvested could come from mid seral plantations. This would allow for the retainment of late seral habitat within the Matrix land and still meet the PSQ for the watershed of 10 MMBF/year.

In addition to the volume that would come from the Matrix, there may be overstocked stands within the Riparian Reserves and the LSR. LSR assessments or site specific prescriptions within the Riparian Reserves may identify a need to thin, which may or may not result in commercial timber outputs. Any harvest volume removed from LSRs or Riparian Reserves would only be by-products of restoration projects designed to meet the objectives of these land allocations.

Table 5-1. Projected timber production from commercial thinning in the Upper Clackamas Watershed from the years 2005 through 2045.

Year	2005	2015	2025	2035	2045
Estimated Commercial Thinning (Acres)	5000	7000	9000	9000	9000
Estimated Volume (MMBF/Year) *	2.5	3.5	4.5	6.3	6.3

* Volume per acre for next 3 decades is estimated at 5 MBF/acre. Volume per acre for decades 4 and 5 is estimated at 7 MBF/acre.

Special Forest Products Trends

The harvest of special forest products within the watershed is expected to continue. The demand for most of the known products is expected to increase but based on restrictions within different land allocations, their availability and access to them would generally decrease. The following trend analysis is for the major products that are currently sold for commercial use or harvested for recreational purposes.

Boughs - The availability would increase within the watershed as the noble fir plantations created in the last 15 years grow into a size class appropriate for this type of harvest. Demand is expected to stay the same or increase.

Firewood - In the past, most firewood came as a by-product of timber harvesting. The availability would decrease considerably because of the reduced harvest levels but demand is expected to stay high.

Transplants and cuttings - The availability of these products that come from early seral habitats would reduce while the availability of products that come from mid seral stands would increase. Transplants or cuttings available only from late seral habitats would see a reduction because of restrictions within the LSR's and Riparian Reserves. Demand is expected to increase.

Cedar - The availability of cedar would be reduced. This is due to the fact that the majority of the cedar trees within the watershed are located within Riparian Reserves. Demand for cedar is expected to increase or stay the same.

Beargrass - The availability of beargrass is expected to stay the same. The areas in which most of the beargrass is collected is within Matrix lands. Demand is expected to increase or stay the same.

Mushrooms - The availability of mushrooms would most likely be the same. At this time though, LSR's are restricted from any mushroom collection until more research on the impacts have been analyzed. Demand is expected to increase.

Medicinal Plants - No trends could be determined at this time.

Recreation Trends

The most important factor influencing the trends in recreation use in the Upper Clackamas watershed is population growth. As an urban forest within the Portland Metropolitan region, population growth would affect both demand for recreation resources as well as the condition of those resources. Oregon's state population grew 8% in the 1980's with the majority of the growth occurring in metropolitan areas while rural populations declined. Currently 71% of the state's population live in communities greater than 2,500 people with two-thirds of the population concentrated in just four cities: Portland, Salem, Eugene-Springfield, and Medford. In addition, the increase in Recreational Visitor Day (RVD) demand for the Mt. Hood National Forest from 1987 to 2000 is 57%, from 4,034,010 RVDs to 6,333,398 RVDs. While no studies have indicated how much of this increased use would occur in the Clackamas drainage, it is assumed that recreation use would grow in proportion to the residential growth of Clackamas County.

In 1991, the Oregon State Parks and Recreation Department completed the Statewide Comprehensive Outdoor Recreation Plan (SCORP) which examined user demand, supply, and preferred settings for all geographic regions of the state. The Portland region indicated a general increase in demand for all recreation activities. While all current recreation activities in the Upper Clackamas watershed show a growth in demand. The following summarizes projections for low, medium and high growth potential.

- **High:** Activities which show a demand greater than 50% are non-motorized boating on lakes (77%), fresh water fishing from boats (62%), day hiking (67%), nature/wildlife observation (52%), bicycling on roads (105%) and bicycling on designated trails (93%).

- **Medium:** Activities which have a projected demand between 30% and 50% are tent camping (35%), big game hunting (34%), scenic driving (45%), off highway vehicle use (42%), picnicking (35%) and off road bicycling (38%).

- **Low:** Activities which indicate a lower rate of projected growth are freshwater fishing from banks (21%), Non-motorized river boating (20%), upland bird hunting (3%), bow hunting (5%), and overnight hiking on trails (29%).

*Other activities which have the potential for occurring in the watershed include winter sports like cross country skiing (33%) and snowmobling (8%).

In addition to user demand, the SCORP study also included a needs analysis for Forest Service lands based upon use, user demand for preferred setting (settings defined by the Recreation Opportunity Spectrum or ROS), and supply of settings as allocated in the Forest Plans. The study concluded that the greatest discrepancy between supply and demand occur in the provision of settings on the primitive and semi-primitive end of the ROS settings. The situation is considered most serious in the provision of semi-primitive motorized and non-motorized settings. For the Mt. Hood National Forest the category of semi-primitive motorized show the greatest discrepancy between supply and demand while surpluses occurred in almost every other category. A shortage of semi-primitive settings may shift pressure to more primitive areas and/or intensify use in existing settings. Current management direction which controls access to dispersed camping sites could further limit supply.

In the Upper Clackamas watershed, the preferred settings for recreation, the Riparian Reserves along the river and creeks, the Olallie Lake Scenic Area, and Rhododendron Ridge can be expected to be under even greater demand as Portland's population grows. The landscape features (the river, lakes, and vistas) are in limited supply. Changes in scenic quality would be a function of tree growth and timber production. The progression of early seral stands to mid seral would serve to improve scenic quality as the forest canopy merges and edges between patches become less visually apparent. The types of use; camping, fishing, hiking, and hunting, for example are based upon landscape features which would experience marginal changes, but the rate of use can only be expected to increase. As the population increases, the perception of proximity can also change. Activities which are now marginal in the watershed because of driving distance from Portland like mountain biking could receive increased pressure as people drive further to recreate in their preferred setting. Increased use can also increase the number of social encounters and user conflicts which can also increase the amount of social violence already present in the drainage. In summary, the increased population growth of the Portland metropolitan area can be expected to lead to an increased concentration of use within the existing pattern of recreation use.

Future Trend Summary

Vegetation

A. Vegetation - Frequency of Seral Stages

- It is projected that within the next 30 years early seral vegetation would be below the RNV for all vegetation series.

- It is projected that within the next 30 years late seral vegetation in the within the RNV in the western hemlock series, and would be reduced to levels below the RNV in the Pacific silver fir and mountain hemlock series.

- An estimated 18% of the currently existing late seral vegetation within the watershed would be harvested within the next 30 years, this equates to approximately 50% of the existing late seral stands in the Matrix.

- A large portion of the LSR and some Riparian Reserves are within the mountain hemlock vegetation series in the southeast portion of the watershed. Some of the stands within the mountain hemlock series would not likely achieve late seral characteristics due to the growing climate and disturbance history. These areas are more similar to the drier provinces where regular and frequent fires are a natural part of the ecosystem.

- Many areas of the Riparian Reserves and LSR will not achieve late-seral conditions for 70-100 years. This may affect the functioning of these allocations.

B. Vegetation patterns - patch size and distribution

- For all seral stages, average patch size would increase and the number of patches would decrease. Patch size within the watershed would move closer to the RNV.

- In the next 30 to 40 years the connectivity of the largest and more connected blocks of interior old-growth habitat could be maintained. The most connected late seral habitat in the watershed is in the LSR and will remain and eventually increase through time.

- The less connected late seral patches would be converted to early seral.

C. LSR and Riparian Reserve Vegetation

- Within the next 30 to 40 years, most of the existing early seral vegetation would become mid seral. Very little, if any, of the mid seral vegetation is projected to become late seral vegetation within this time frame.

- Currently, 62% of the Riparian Reserves in the Southeast Group are in a mid seral vegetative condition, and much of this is within the mountain hemlock series. The combination of low productivity and recurring disturbances in these stand types results in mid seral stands that have a low probability of becoming late seral vegetation. Silvicultural treatments could be necessary within these stands to meet the objectives of creating late seral conditions.

- Many of the stands in the portion of the LSR in the mountain hemlock series are over 80 years old, have high stocking densities, and have a history of spruce budworm infestations. These types of stands are not expected to reach a late seral condition without silvicultural treatments and would also not meet the objectives of the LSR.

D. Disturbance Regime

- Windthrow with less aggressive salvage has and will continue to result in increased levels of bark beetle mortality.

- Continued fire suppression and the overstocked condition of stands within the mountain hemlock series would lead to stands more susceptible to catastrophic fire and spruce budworm outbreaks.

E. Wildlife

- Because the watershed contributes a high percentage of the available habitat for TLML (Terrestrial Large home range, Mosaic, Late seral) species on a Forest-wide scale, trends for these species within the Upper Clackamas watershed may have importance Forest wide.

- After 30 years, functional habitat for medium and large home range mosaic late-seral species (TMML and TLML guilds) would be greatly reduced in the Matrix. The rate of decline for these habitat guilds depends upon timber harvest strategies. Available habitat for these guilds would be concentrated largely within the LSR.

- Species within the mosaic guilds: Terrestrial Large home range, Mosaic, Late seral (TLML); Terrestrial Medium home range, Mosaic, Late seral (TMML); and Terrestrial, Medium home range, Mosaic, Early seral (TMME) can aggregate fragmented patches within their home ranges, but they would not likely use patches that are too isolated. Isolated patches are not expected to contribute to population maintenance of mosaic species.

- The TLML (Terrestrial Large home range Mosaic Late seral) map shows where late seral habitat is already connected and functioning well for late seral associates. This habitat could become more important in the future as harvest occurs in the Matrix.

- Spotted owl take, based on USFWS criteria, would occur as a result of the harvest projected for the Matrix. Harvesting isolated patches that contribute to the nesting, roosting, and foraging habitat within a 1.2 mile radius of owl activity centers first as part of the strategy to minimize fragmentation would almost certainly result in some take (many of the most isolated patches are in areas that are already below the threshold, but where owl activity centers persist). Within 10 to 20 years, conceivably at least seventeen of the Matrix owls could be subject to take. This could potentially affect 37% of the current owl population in the watershed.

- Dispersal habitat (11-40 habitat) is projected to be relatively abundant over the next several decades, both within and outside of the Riparian Reserves. Dispersal habitat is expected to be most limiting within the Southeast and East subwatershed groups.

- Owls in the LSR could also be affected by timber harvest, since several owls have territories that theoretically extend into the Matrix on both sides of the LSR (assuming a round territory of 1.2 miles in radius around the activity center). Timber harvest in the Matrix near and adjacent to the LSR could result in some LSR owls activity centers having less habitat available than currently.

- The lack of snags and coarse woody debris in the managed early and mid seral stands would affect early seral cavity nesters and plants and animals that utilize coarse woody debris until these stands create replacement snags and coarse woody debris in the future. A gradual recovery for amounts of snags and coarse woody debris is anticipated across the landscape.

- Contrast habitats which support edge dependant species are expected to decline throughout the watershed. The LSR will retain virtually no contrast habitats after 10-15 years, except where natural disturbances create openings. Elk populations, which respond to the amount of contrast habitat, are expected to decline.

Fish Habitat

A. Hillslope Processes

- Several sources and processes will continue to deliver sediment to streams in the watershed, but the rate and amount is expected to decrease due to reduced harvest and increased restoration.

- Implementation of direction to reduce total road miles in Key Watersheds, provide for erosion control, and stabilize road drainage should result in lower sediment delivery rates from roads.

- Sediment delivery from the unstable areas within the Northwest Group would decrease by implementing the Aquatic Conservation Strategy, in particular by obliterating roads.

- Reduction of soil productivity resulting from harvest activities would be significantly less than in the past.

B. Fish Stocks

- The recovery of at-risk fish stocks, especially the late run coho salmon, would continue to depend on the high quality habitat that currently exists in the watershed.

- The distribution of anadromous and resident fish stocks would return to historical conditions by correcting fish passage problems at culverts

C. Riparian and Aquatic Habitat Function

- Riparian and aquatic habitat conditions would improve by implementing the Aquatic Conservation Strategy, in particular the Riparian Reserves and a watershed restoration program. Concurrent with this improvement would be an improvement in fish habitat capability throughout the watershed.

- Fish habitat capability would increase but would not achieve pre-management levels due to retention of some of the major arterial roads, such as Road 46.

- Coho salmon habitat would increase along the Clackamas River by reconnecting historical meanders and side channels currently blocked by Road 46.

- CWD recruitment and function in streams within the East and West groups would increase as the early seral vegetation attains mid seral characteristics.

- Controlled use and restoration of dispersed sites within Riparian Reserves would meet the intent of the Aquatic Conservation Strategy.

- Dispersed camping is expected to increase in the future along the mainstem Clackamas River, but it would have a minimal effect due to mitigation measures employed in order to meet the intent of the Aquatic Conservation Strategy.

D. Hydrology

- The hydrograph of the Clackamas River in the watershed would move toward more natural conditions by obliterating roads and incorporating Riparian Reserves into management strategies.

Social

A. Commodities

- In the short term, harvesting from late seral stands would be needed to meet the expected timber commodity output levels. After 30 years, the majority of the timber commodities could come from commercial thinning or regeneration harvest of mid seral stands.

- Demand for most special forest products is expected to increase, but based on restrictions within different land allocations their availability will generally decrease.

B. Recreation

- Demand for semi-primitive recreation settings for camping, fishing, hiking, hunting and scenic driving would increase as the population of the Portland metropolitan area increases.

- Although new recreation activities could develop in the future, it is expected that the current pattern of recreation use would continue at an increased rate of use. The riparian areas in the Clackamas River corridor and the Olallie Lake Scenic Area would continue to receive a high level of recreation demand.

- The proposed Urban Link Trail and associated developed trailheads on Rhododendron Ridge would attract increased use.

- Currently Road 46 is nominated as a Scenic Byway. Designation of Road 46 as a Scenic Byway will attract increased use to the Clackamas River corridor.

Chapter 6 - Key Findings and Recommendations

The key findings address the broad issues identified for this analysis. This chapter describes these findings as well as recommendations specific to those findings.

Vegetation

Fragmentation

The late seral habitats in the watershed have been fragmented to the point that connectedness of interior habitats is a concern.

The quantity and arrangement of existing late seral habitats in combination with various strategies for future harvest is the focal point of this finding statement. There would be tradeoffs involved with any type or level of harvest, and meeting the PSQ level would certainly involve tradeoffs, and resource impacts. However impacts can be minimized by adopting the integrated recommendations found below.

A habitat model was used that examines wildlife species by guilds. The team focused on TLML (Terrestrial Large home range Mosaic Late seral) guild, which includes the northern spotted owl. The watershed has a large portion of the Forest's TLML and the most intact block of it is in the LSR. The watershed contains 52 owl activity centers, 23 of which are in the LSR.

A strategy was developed by the interdisciplinary team, (guided by Forest Plan standard FW-158), to prioritize harvest in a way that minimized the fragmentation of interior old-growth habitat by focusing on isolated patches. It is hoped that this strategy would complement the LSRs and Riparian Reserves to reduce the loss of important interior blocks and benefit an entire guild of species. It incorporates long-term habitat needs on a landscape level.

This strategy may result in "take" of owls. The owls are so widely distributed that it would be difficult to avoid their home ranges. Their home ranges overlap in some areas. Seventeen activity centers are currently close to or below the threshold of "take." An alternate strategy of avoiding "take" would force harvest into interior blocks, further reducing the quantity and quality of TLML.

Owl dispersal habitat is not a problem in this watershed but connectivity between interior blocks is still a concern for other species. Riparian Reserves meet some of the connectivity needs but there are areas where connections are tenuous.

Even though this analysis used an assumption of regeneration harvest for assessing future trends, there are many other harvesting techniques that would be available.

- Thinning is often considered a low impact technique for mid-seral stands, but it may potentially affect hydrologic conditions and thermal cover. A considerable quantity of mid-seral stands have been thinned or planned for thinning in the past few years. There still remain some opportunities for thinning, and as plantations grow, more and more acres would become available for thinning in future decades. Within 4 decades thinning volumes available may amount to about 6 MMBF per year.

- Salvage of dead or down timber minimizes cutting of live trees and can be designed to leave the appropriate level of snags and coarse woody debris.

- There is also the opportunity to develop partial cutting techniques for older stands to retain a forest canopy while creating an understory layer and developing stand structural diversity.

The use of these strategies is limited to certain appropriate sites and low volumes per acre would result in large acreages treated if they were relied on to meet PSQ goals.

Recommendations for Fragmentation

1. Identify key interior old-growth patches and augment the Riparian Reserves with a connectivity network which links key interior patches with each other and the LSR. Minimize fragmentation of these interior patches.

2. The following mix of harvest opportunities should be considered during landscape design and project planning. Most of this harvest would come from the Matrix, but under certain circumstances, some of them such as the thinning, may be appropriate in the LSR or Riparian Reserves. This priority scheme is intended to be flexible, and some harvest types are not permitted in certain land allocations.

    Thinning of plantations.

    Thinning of natural second-growth stands.

    Salvage of dead or downed trees.

    Regeneration harvest of mid or late-seral islands or peninsulas.

    Regeneration harvest of mid or late-seral stands which do not directly buffer important interior patches.

    Partial harvesting in connectivity network to retain canopy cover while enhancing structural diversity and secondary canopy development.

3. Given the above recommended types of harvest, the following would be secondary priorities for locating them on the landscape.

    Harvest outside of owl home ranges.

    Harvest in owl home ranges that are already in "take" status.

    Harvest in owl home ranges that are above the "take" threshold.

Avoid bringing areas in the Northwest Group below the threshold level for hydrologic recovery.

Mountain Hemlock East/West Transition Zone

A large portion of the mountain hemlock vegetation series within this watershed has had recurring disturbances (from fire, insects and disease) and is on sites with low productivity. This combination of factors significantly limits the frequency and the distribution of late seral vegetation within the mountain hemlock series. Due to this, much of the Late Successional Reserve and the Riparian Reserves within the southeast portion of the watershed do not contain late seral vegetation.

The southeastern portion of the watershed contains many stands greater then 80 years old that are classified as mid seral vegetation based on their structural characteristics. These stands are primarily located within the Southeast Group of subwatersheds. This entire area appears to have experienced repeated disturbances from insects, disease and fire which has led to a mosaic of stands with different ages, species and structure. Due to the disturbance history of the area and the low site productivity, it is estimated that approximately 9,300 acres of mid seral vegetation within the watershed will not grow into late seral vegetation without some type of management intervention.

A majority of these types of stands are located within the southern portion of LSR #207 and the associated Riparian Reserves. The objective for both of these land allocations is to promote and maintain late seral vegetation. There is a basic expectation to grow and maintain stands with large diameter trees that have multiple canopy layers. At present, these stands are overstocked and are affected by numerous tree diseases. Many of them have been recently infested with the spruce budworm and are considered at a high risk for a stand replacement fire. These stands have the same attributes of the eastside stands that are considered to have serious forest health problems. Stocking control through thinning would be required within stands greater then 80 years old to create late seral vegetation. This need may be inconsistent with the standards and guides for Late Successional Reserves.

Though these stands may not be considered late seral vegetation or have the potential to become late seral vegetation, the area currently provides a refuge for many wildlife species. This could be due to the fact that very little timber harvesting or road construction has occurred in the area. Wildlife sightings and surveys in this area continue to report bear, elk and pine marten. Management proposals that would include silvicultural treatments to improve stand health and grow late seral vegetation may have an effect on the value of the wildlife habitat in this area.

The Southeast Group of subwatersheds are also the entry corridor for more then 30,000 forest visitors per year. These people come to recreate in the Olallie Lakes Scenic Area. Maintaining the scenic quality of the area is very important. Reducing the potential for a large stand replacement fire is also important for both scenic quality and visitor safety. Maintaining scenic quality and reducing the risk of large fires would require stocking control treatments that may be inconsistent with the standards and guidelines for Late Successional Reserves.

Recommendations for Mountain Hemlock Transition Zone

The key finding is primarily related to the management of LSR #207. The following recommendations should be considered during the LSR assessment.

1. Develop a management strategy which would move the southeast portion of LSR #207 toward a fully functioning condition. This strategy needs to consider the disturbance regimes and the current vegetative condition of the mid seral stands which are unlikely to achieve a late seral condition without management intervention.

2. Improve the health of the stands in the mountain hemlock series along the road to the Olallie Lake Scenic Area. The objective is to maintain/improve the scenic quality and to provide for visitor safety in the case of a catastrophic stand replacement fire within the area.

Fish Habitat

The water quality and aquatic habitat do not reflect the expected conditions typically attributed to the amount of timber harvest and road construction that has occurred in the watershed. The Upper Clackamas watershed contains some of the highest quality spawning and rearing habitat for the at-risk fish stocks, particularly the late run coho salmon. Therefore, it can serve as a cornerstone in recovery efforts for this stock.

Road construction, timber harvest, and recreation within riparian areas have changed water quality, aquatic habitat quality, and riparian function within the watershed compared to historical levels. The gently topography, landform, soil types, and spring fed hydrology have partially compensated for the management induced disturbance factors. Water quality, aquatic habitat quality, and riparian function have been compromised by the management induced disturbance factors but the magnitude of the degree is not discernable in the watershed. There is evidence of locally altered conditions such as noticeable turbidity due to roads, loss of CWD in the streams and riparian areas due to timber harvest, and degradation of riparian areas due to dispersed camping. Outside of the local effects, these actions have not yielded noticeable cumulative changes in aquatic and riparian habitat function or capability.

The hydraulic transport capacity of streams within the watershed appears to exceed the sediment delivery rates. Channel form remains relatively unchanged during flows with return intervals of 2 years or greater, which are recognized as common channel forming events. Current fish habitat capability, an outcome of aquatic and riparian habitat conditions, is less than historical levels. The capability can increase above existing levels by implementing the Aquatic Conservation Strategy, in particular road obliterations and riparian reserves. Fish habitat capability potential can not achieve historical levels due to continued presence of an extensive road network necessary to meet other expectations. For example, the most noticeable effect on coho salmon habitat quantity and quality is the presence of Road 46 along the mainstem Clackamas River. Road 46 connects to State Highway 224 and is the main route through the watershed accessing other desirable commodities within and outside the watershed. Some effects of the road can be mitigated through restoration but not completely eliminated.

The watershed contains some of the best remaining fish habitat within the subbasin, in particular Big Bottom and its tributaries. The most concentrated areas having the highest potential for delivering sediment to the streams occurs downstream of the highest quality coho salmon habitat. Outside of roads, the most noticeable effect on riparian habitat within the range of coho salmon would be dispersed camping along Road 46 and in Big Bottom. Outside of the range of coho salmon, roads and timber harvest have reduced the habitat capability of the streams.

Aquatic Conservation Strategy

The analysis determined that the ROD directed riparian reserve widths generally meet the intent of the Aquatic Conservation Strategy except for a few clarifications. These clarifications apply to riparian reserve widths for intermittent streams in the east and southeast groups, unstable and potentially unstable areas and wetland less than 1 acre. A complete description of the riparian reserves necessary to meet the intent of the Aquatic Conservation Strategy for all the categories follows in Chapter 7.

The following recommendations would accelerate the rate of recovery of aquatic and riparian processes identified as being outside of the expected range of natural variability and are necessary to meet the intent of the Aquatic Conservation Strategy. The other actions described in the ROD would ensure that general management activities not specifically linked to processes found to be outside of the expected range of natural variability identified through this analysis would meet the intent of the Aquatic Conservation Strategy.

Recommendations for Fish Habitat

1. Emphasize fish habitat restoration within the Tier 1 Key Watershed and the range of the late-run coho salmon, focusing on reconnecting the mainstem river to the historical floodplain along road 46.

2. Continue managing dispersed recreation sites within the watershed to ensure compliance with the Aquatic Conservation Strategy objectives.

3. Road management within the Key Watershed and within the Northwest Group would be to reduce effects on riparian and aquatic habitat function.

4. Fish habitat restoration outside of the range of the coho salmon should concentrate on restoring habitat capability within the East, West and South groups by increasing the amount of CWD in the channel through riparian silviculture and direct input of CWD.

5. The Forest Service should develop a new standard or model instead of the existing ARP model that accounts for the hydrologic resiliency of the watershed for all areas except the Northwest Group.

6. Replace or remove culverts that block fish access to historical spawning and rearing areas. Emphasize culverts not meeting fish passage criteria within the range of coho salmon.

Chapter 7 - Other Management Recommendations

This chapter includes information to guide future management actions in the Upper Clackamas watershed. The following recommendations link the ecosystem management objectives contained in the ROD and LMP to the ecosystem processes and functions operating in the Upper Clackamas watershed. The following recommendations relate to the Key Findings described in Chapter 6. The guidance is separated into the following categories:

- Riparian Reserves
- Restoration Opportunities
- Transportation Planning
- Monitoring
- Information Needs
- Management Plan Recommendations
- Other Management Recommendations

Riparian Reserves

The ROD designates Riparian Reserves at the margins of all standing and flowing water, intermittent stream channels and ephemeral ponds, and wetlands, including unstable and potentially unstable areas affecting riparian and aquatic habitat function of these water bodies. Riparian Reserves generally parallel the stream network but also include other areas necessary for maintaining hydrologic, geomorphic, and ecologic processes. The ROD established criteria for delineating Riparian Reserves for five categories of streams or water bodies prior to management activities (Table 7-1). The ROD further directs the Forest Service to identify critical hillslope, riparian, and channel processes through watershed analysis in order to assure maintenance and restoration of riparian and aquatic functions.

Given the relatively stable geology and moderate hydrology, the site-potential tree heights would adequately maintain and restore riparian and aquatic habitat function. The site-potential tree height for the western hemlock series is 210 feet. For fish bearing streams, the Riparian Reserve would be 420 feet on each side of the stream. The Pacific silver fir series and mountain hemlock series have a shorter site-potential tree height of 160 feet. These areas tend to occur in the more gentle slopes and more stable landforms.

There are no proposals to reduce the size of the Riparian Reserves due to the uncertainty involved with the Survey and Manage provision for the Table C-3 species identified in the ROD and for the dispersal habitat needs of a variety of terrestrial species. An opportunity exists to reduce the width of Riparian Reserves in the East and Southeast groups for intermittent streams that would meet the Aquatic Conservation Strategy objectives. This would only occur following an analysis of the habitat needs for the ROD Table C-3 species and dispersal habitat needs of other terrestrial vertebrates, and after conducting site-specific analysis for projects. The intermittent streams within the East and Southeast groups flow through relatively flat topography some of the more stable areas within the watershed. Thus, the ROD prescribed width of 160 feet is more than necessary to meet the Aquatic Conservation Strategy objectives for these two groups of subwatersheds.

Subsequent project planning would yield site-specific information to design appropriate Riparian Reserves that would meet the criteria outlined in this watershed analysis. Site-specific information is required when including unstable and potentially unstable areas within the Riparian Reserves and determining site-potential tree heights. Any information developed during site-specific analysis that nullifies the assumptions or changes the information used in this watershed analysis must be considered in the final determination of the Riparian Reserves through the National Environmental Policy Act (NEPA) process.

Table 7-1. Riparian Reserve criteria. These criteria only apply if these provide greater protection than the other criteria defined in the ROD.

Category	Western Hemlock Series	Pacific Silver Fir and Mt. Hemlock Series
Fish Bearing Streams	420 feet slope distance from edge of channel.	320 feet slope distance from edge of channel.
Non-Fish Bearing Perennial Streams	210 feet slope distance from edge of channel.	160 feet slope distance from edge of channel.
Constructed Ponds, Reservoirs, and wetlands greater than 1 acre	210 feet slope distance from the edge of the wetland or maximum pool elevation.	160 feet slope distance from the edge of the wetland or maximum pool elevation.
Lakes and Natural Ponds	The body of water plus 420 feet slope distance.	The body of water plus 320 feet slope distance.
Intermittent Streams	210 feet slope distance from edge of channel.	160 feet slope distance from edge of channel.
Wetlands less than 1 acre and unstable and potentially unstable areas	See the following text.	See the following text.

Fish Bearing and Permanently Flowing Nonfish Bearing Streams

The ROD provided guidance that post-watershed analysis Riparian Reserve boundaries for permanently flowing streams should approximate the prescribed boundaries. The analysis showed that the prescribed widths for these two stream types would maintain and restore riparian and aquatic habitat function within the Upper Clackamas watershed.

Constructed Ponds and Reservoirs, and Wetlands Greater Than 1 Acre

The analysis did not generate any evidence that the prescribed widths would not maintain and restore riparian and aquatic habitat function for these water bodies. Thus, applying the prescribed width for these water bodies would meet the Aquatic Conservation Strategy objectives.

Lakes and Natural Ponds

The analysis showed that the majority of the natural lakes and ponds occur in the relatively stable south portion of the watershed. Thus, the prescribed widths would maintain and restore riparian and aquatic habitat function, and meet the Aquatic Conservation Strategy objectives.

Wetlands Less Than 1 Acre

The ROD prescribes that Riparian Reserves for wetlands less than 1 acre include: the extent of unstable and potentially unstable areas; and the wetland and the area from the edge of the wetland to the outer edges of the riparian vegetation. The Upper Clackamas watershed contains numerous wetlands associated with springs. Typically, these occur in small pockets among the typical forest vegetation making it difficult to identify riparian vegetation without noticeable drainage to or from the wetland. For wetlands not connected to unstable and potentially unstable areas, the Riparian Reserve should include a protective buffer that prevents ground disturbance of the wetland along with sufficient vegetation to shade the wetland. Most of these wetlands occur in groups and become more dense immediately upstream of continuous flowing water; thus, most would be included within the Riparian Reserve for the perennial stream.

During project layout for small springs and wetlands isolated within the Matrix, the layout of a cutting unit should emphasize including the wetland and Riparian Reserve within the 15% green tree retention areas. The layout should try to connect the 15% retention block in a connected downslope pattern to try to protect any unidentified underground spring flow. In instances where a number of these springs occur in a harvest unit, the 15% retention block should be designed to connect the wetlands and springs within a contiguous clump of trees. This may require leaving trees in addition to the 15% retention in order to protect the hydrologic integrity of the wetlands and springs.

Seasonally Flowing or Intermittent Streams

The prescribed width of one tree height would adequately protect riparian and aquatic habitat function and would meet the Aquatic Conservation Strategy objectives. The analysis showed that a large portion of the watershed is relatively stable and that there is low risk in applying the prescribed Riparian Reserve widths.

Unstable and Potentially Unstable Areas

Recommendation: Include unstable and potentially unstable areas within Riparian Reserves.

Unstable lands can occur on the landscape in positions removed from riparian ecosystems, yet these areas provide the important linkage mechanism for interaction of terrestrial uplands on the riparian and aquatic ecosystems. Mass movement events deliver large wood, sediment, and nutrients to aquatic systems. The intent of developing Riparian Reserves for unstable and potentially unstable areas is to ensure the rate and distribution of sediment delivery does not alter stream channel forming processes or impair aquatic ecosystem functions.

Certain geologic conditions within the northwest portion of the Upper Clackamas watershed are prone to produce instability. Unstable areas occur in many different landscape positions. Debris flows often originate in these areas and field investigations of length of travel of these debris flows will help define Riparian Reserve widths.

Unstable Geologic Factors

An estimated 11% of the watershed occurs in unstable geologic areas with a high potential to deliver sediment to streams. They principally occur in the Northwest and West Groups. Field investigations are necessary to identify and assess conditions contributing to slope instability. Field investigations and professional judgment provide some details for identifying the spatial distribution of possible unstable areas. The following sites or conditions help to define slope-forming and geomorphic processes that may require the protection of Riparian Reserves. Additional information on location of unstable and potential unstable areas can be derived from the geology, landform and candidate land for unstable and potential unstable designation maps in the analysis file and from field verification.

- Contacts between weak rock and resistant rock. Changes in permeability at these contacts often result in springs or shallow groundwater tables. Altering the ground water conditions in these areas can trigger debris slides and debris flows. Important contacts include the following:

- Contacts between weak rock (WRSS) and resistant rock (RRSS) on steep slopes.

- Contacts between the Rhododendron Formation (Tr) and Beds of Bull Creek Formation (Tbc)

- Contacts between the Older basalt (QTb) and the Rhododendron Formation (Tr).

- Contacts between lava-flow and pyroclastic rock types within the Rhododendron (Tr) and Beds of Bull Creek Formations (Tbc).

- Around the edges of intrusions. Intrusions are shown as Ti, Tipa, or Tiha on the geologic map (see Analysis file). The heat from these intrusions has often altered and weakened the adjacent rock making it more prone to mass wasting.

- Along the margins of dikes and sills. Similarly to intrusions, the heat associated with dike and sill emplacement has often altered and weakened the adjacent rock making it more prone to mass wasting. The dikes and sills are not shown on the maps.

- On slopes with gradients in excess of 60% where shallow soils overlie less permeable materials. Although these conditions may be met on many landforms, they are most common on landform types RRSS, WRSS, and GVSS. These areas are prone to shallow failures.

- Along the margins of ancient landslides or earthflows. Changes in ground water levels near these margins often trigger debris flows, debris slides, and slumps. Factors to be considered:
  - vegetative indicators of kind of movement
  - vegetative indicators of presence of high water table
  - presence of radial cracks.
  - nature of movement (gullying or complex)
  - stream system as a support release mechanism

- On the scarps of ancient landslides. These areas are steep, have shallow soils, and are prone to debris slides and debris flows. The scarps are not designated on any maps. Factors to be considered:
  - unvegetated surface
  - vegetated surface
  - distance to ridge
  - nature of upslope condition
  - presence or absence of tension cracks
  - height of escarpment
  - presence or absence of seeps or springs

- Within the main bodies of the ancient landslides. Many of the ancient landslides are largely stable, but have smaller areas within their boundaries that are unstable or potentially unstable. These areas could occur almost anywhere within the landslide. In general, the steeper the slope, the greater the risk. Factors to be considered:
  - vegetative indicators of kind of movement
  - vegetation indicators of presence or absence of high water tables
  - presence or absence of water-filled depressions or 'sag' ponds
  - overall slope configuration
  - perimeter channel
  - slope gradient
  - presence or absence of transverse cracks

- At the headlands of tributaries with steep gradients. Historically, many such areas have experienced debris flows, and those presently filled or filling with colluvium may fail with the slightest provocation.

There is some overlap among the geologic conditions listed above. The presence of these geologic conditions does not automatically mean that the area is unstable. Investigation of site-specific factors critical to slope stability would occur during the planning phase of individual projects. Results from site-specific investigations would provide the basis for including unstable and potentially unstable areas within Riparian Reserves to maintain aquatic and riparian functions.

Restoration Opportunities

The ROD includes watershed restoration as one of the four key components of the Aquatic Conservation Strategy. Restoration opportunities are identified though the watershed analysis process and are prioritized to give the greatest likelihood of success to aid in the recovery of aquatic, riparian, and associated habitats, as well as maintain and restore water quality. Restoration within the Upper Clackamas watershed would focus on restoring natural ecosystem processes and functions that currently are not in line with desired future conditions or the range of natural variability, have the highest potential for success, and have potential benefits to affect resources tied to the issues of this analysis. The ROD identifies the most important components of a restoration program are to control and prevent road related runoff and sediment input, restore riparian vegetation, and restore instream habitat complexity. Other restoration needs have been identified within the Upper Clackamas watershed that do not directly address the components listed above, however they are in line with restoring ecological diversity and function of the entire watershed.

Table 7-2 displays watershed key issues, altered processes, restoration objectives, location priorities, and restoration opportunities. Restoration opportunities, emphasis areas, and objectives are combined into the major altered processes found within the watershed. Restoration opportunities may benefit one or all of the objectives listed for that process. These processes are grouped into two of the three major key issues identified for this analysis. Many restoration opportunities address different altered processes and issues, for example, riparian thinning accelerates both potential instream CWD input as well as late seral connectivity. Table 7-2 includes the key processes and functions identified through this analysis and identifies priority areas or processes for restoration. Specific restoration projects are not limited to this list of opportunities. Individual projects not found within this list but support the processes and objectives found within the watershed analysis can be implemented based on priority and funding.

Table 7-2 contains restoration opportunities to restore ecological function in the watershed. Table 7-2 does not contain recommendations for restoration opportunities for recreation. Restoration to restore ecological function in the watershed can benefit recreation settings and opportunities. For example, successful restoration of anadromous fish stocks at risk in the future to levels where harvest can occur, will increase recreational fishing opportunities. Restoration of habitat connectivity and complexity can benefit the degraded scenic viewsheds and recreation setting. Maintenance of special habitats like meadows can enhance the opportunities for nature study and wildlife observation as well as benefit scenic quality. Improvements in riparian habitats can also benefit dispersed recreation by enhancing scenic quality, solitude, and interaction with nature. Decommissioning roads in conjunction with habitat improvements can benefit hunting opportunities, road-to-trail conversions, and the provision of semi-primitive settings for recreation.

Table 7-2 contains restoration opportunities but does not provide relative priorities. The following list prioritizes restoration opportunities across issues and restoration objectives. There is a high

Table 7-2. Restoration opportunities.

Issues	Altered Process	Restoration Objectives	Emphasis Areas	Restoration Opportunities
Vegetation	Biodiversity/ Connectivity	Accelerate development, complexity, function and connection of late-seral habitat in the LSR.	LSR	• Thin, underplant, decommision roads
		Accelerate development, complexity, function and connectivity of riparian reserve vegetation.	Riparian Reserves within East, West and South groups	• Thin, underplant
	Disturbance Regime	Reintroduce the role of fire in the ecosystem.	Southeastern portion of watershed.	• Underburning, broadcast burning
		Improve forest health	Mountain hemlock stands	• Thinning to control stocking and fuel levels.
Fish Habitat	Hydrologic Regime/ Sediment Delivery	Reduce erosion, road failure, increase infiltration.	RR and LSR in NW portion of watershed	• Deep scarifiction of roads, skid trails and landings, Decommission roads, fill slope pullback, erosion control.
		Reduce risk of rain-on-snow events.	Throughout the watershed	• Accelerate early and mid-seral stands by planting or thinning.
	Riparian & Aquatic Habitat Function	Improve aquatic and riparian habitat function, complexity, and connectivity	Riparian Reserves	• Add Coarse Woody Debris (CWD) to streams thinning, planting.
		Restore side channel and floodplain function	Austin Segment for coho	• Reconnect and restore side channels and floodplain function
		Improve fish passage.	Range of late-run coho	• Replace culverts or remove and restore road crossing.

likelihood that some of the lower priority projects could be implemented before higher priority projects because of the funding mechanisms of the Forest Service.

Priorities for Restoration

1. Reconnect and restore side channels and floodplain function within the range of the late run coho salmon, particularly along Road 46.

2. Decommission non-arterial roads within the LSR and Tier 1 Key Watershed.

3. Decommission roads within the Northwest portion of the watershed.

4. Accelerate development of late seral habitat within the LSR and Riparian Reserves, particularly along streams within the East, West, and South groups.

5. Develop late seral stand structure, where lacking, in areas connecting key interior habitat late seral patches.

6. Improve instream habitat structure within streams in the East, West and South groups.

7. Correct fish passage problems at culverts within the range of the late run coho salmon.

8. Continue managing dispersed sites within the watershed.

9. Establish and maintain dispersal habitat for late seral dependent species.

Other Restoration

The following is a list of other restoration opportunities and enhancements which are likely to occur in this watershed but are not listed in the restoration table because they are not specifically relevant to the key findings.

Control of noxious weeds
Forage seeding
Burn meadows to enhance forage and reduce conifer encroachment
Close roads to reduce wildlife harrassment
Increase productivity by deep scarification of compacted skid trails, roads and landings
Modify visually offensive straight edges through timber harvest and other techniques
Thin roadside trees to enhance health and visual diversity
Thinning to enhance structural, spatial and species diversity
Close and revegetate unneccessary rock quarries
Convert lodgepole pine plantations to more appropriate native tree species

Transportation Planning

The ROD identified that one of the primary objectives of road management in Tier 1 Key Watersheds is to reduce the amount of existing system and non-system roads. The standards and guidelines for LSRs include recommendations for removing roads. The Upper Clackamas watershed has approximately 490 miles of roads. This section outlines access and travel management by discussing priorities for keeping roads open, road closure, and information for decision making on pertinent roads to close.

The goal of the access and travel management plan for the Upper Clackamas watershed is to reduce the effects of roads on the ecological health of watersheds and aquatic ecosystems and LSR function while maintaining the necessary transportation system to meet other expectations. This includes reducing the effects of roads on water quality, hydrologic function (physical impacts), and deer and elk habitat (biological impacts) while facilitating administrative, commodity and recreational uses. Future timber harvest may require constructing new roads.

Roads to Keep Open

The following priorities are suggested in determining the importance of maintaining current roads in the transportation system.

<u>High</u>--Arterial or collectors that access the Matrix and major traditional and recreational uses.

Moderate--Access to restoration projects. Roads left open with the primary purpose of accessing restoration projects should be closed after completing the projects.

Moderate--Access to the south end of the watershed for fire suppression.

Low--Access to the balance of the watershed for fire suppression (most of the roads meeting other criteria will presumably take care of this priority).

Low--Access for special forest products.

Roads to Close

Emphasize closing or decommissioning roads within Riparian Reserves, the LSR, and within the Key Watershed boundary. The motivation for the ROD standards and guidelines for roads stems from the physical and biological effects on the target resources (i.e. spotted owls, anadromous fish stocks at risk, and watershed health). Thus, road closure or decommissioning within the Riparian Reserves, LSR, and Key Watershed can be a function of ROD direction and the physical and biological effects to the objectives of the Riparian Reserves, LSR, and Key Watershed.

The following lists the priorities for closing roads within the Upper Clackamas watershed.

High--Roads within the LSR not needed to access the Matrix or other important recreation areas.

High--Roads within Riparian Reserves that do not meet Aquatic Conservation Strategy objectives and for which alternative routes exist to the Matrix and other important recreation areas.

High--Roads that are detrimentally affecting hillslope hydrology, either by channeling surface or subsurface water flow.

High--Roads with a high density of road stream crossings.

High--Road segments in the high and moderate sediment delivery capability classes.

High--Roads that occur on landform types with high sediment delivery risk for landslides or roads that have a high cutslope erosion hazard (i.e. WRSS landform type).

Moderate--Roads that affect wildlife security and contribute to exceeding LMP road density standards for wildlife.

Moderate--Roads near to the Warm Springs Reservation that invite intrusion by unauthorized vehicles.

Moderate--Close or decommission roads where reduced road density is needed to meet recreation objectives.

Low--Roads that no longer serve a management purpose.

Funds for completing maintenance operations on roads in the Upper Clackamas watershed are declining due to a decrease in revenue generating timber harvest. Several roads in the watershed have been closed and are currently not being monitored for possible drainage problems. In developing the restoration program in the Upper Clackamas watershed, closed roads need to be inventoried and their ability to handle high energy storm runoff evaluated. All roads in the watershed could be inventoried for road surface drainage, adequacy of culverts to function during high energy storm events and potential to concentrate runoff onto unstable slope positions or heads of streams.

Monitoring

The ROD and LMP provide monitoring guidance. The LMP outlines a monitoring program focusing on Forest level issues and standards and guidelines. The ROD clarifies the relationship of implementation, effectiveness and validation monitoring. The ROD states that formal research will address some effectiveness and most validation monitoring.

The following recommendations focus on monitoring the key findings and critical assumptions used in this analysis. Implementation monitoring will be determined following site-specific consideration of projects through the NEPA process. The key findings and critical assumptions generated in this analysis will guide much of the implementation monitoring.

Vegetation

1. Objective: Delineate mountain hemlock stands within the LSR that are unlikely to reach a late seral condition due to fire, insects, and site capability.

Wildlife

1. Objective: Determine status and distribution of other late seral associated species, guilds or groups of species, including lichens, fungi, and bryophytes, emphasizing the ROD, Table C-3 species.

2. Objective: Determine the effect of forest users at and traveling to and from recreation destination sites to wildlife.

Fish Habitat

Instream Habitat

1. **Objective:** Determine the relationship of channel forming and maintenance processes and the resulting instream channel conditions. Determine the rate of recovery and effectiveness of the proposed Riparian Reserves on riparian and aquatic habitat function within each of the subwatershed groups.

2. **Objective:** Determine baseline sediment levels and sediment delivery rates in streams by "subwatershed group."

3. **Objective:** Update hydrograph(s) for the watershed.

Fish Production

1. **Objective:** Develop subwatershed specific fish production capability estimates and watershed specific limiting factors for the recovery of the native late-run coho salmon and winter steelhead.

2. **Objective:** Determine effects of wind on Riparian Reserves and CWD levels.

Hillslope Processes/Sediment Delivery

1. **Objective:** Locate active landslides.

Recreation

1. **Objective:** Develop baseline use information at dispersed sites to determine capacity and changes in use patterns and the effect of human waste at dispersed sites on water quality.

Information Needs

Vegetation - Disturbance

1. Assess the current fire risk, especially within the LSR.

2. Refine the fire history information for the watershed.

Wildlife

1. Determine dispersal habitat needs and dispersal capabilities for wildlife other than the northern spotted owl.

Riparian and Aquatic Habitats

1. Develop channel cross section profiles to determine the transport capacity of streams.

Recreation

1. Develop a centralized databank of public response to management activities in the dispersed recreation sites and road closures.

Land Management Plan Recommendations

1. Delete the two B3-Roaded Recreation areas which are overlapped by the LSR. The small portion of B3 that does not overlap is not a manageable unit by itself. Most of the objectives of the B3 allocation are not compatible with LSR objectives.

2. Modify Forest Wide standards FW-451, 452, 458, and 463 which indicate that dispersed recreation sites shall be protected or restored. Since most dispersed recreation sites within the watershed are in the Riparian Reserve and the LSR, many of them may need to be modified or restored and use may be limited.

3. Modify FW-64, B8-31, and B8-32. With these standards, thinning or partial cutting which brings the canopy closure to less than 70% has been interpreted as having an equivalent effect to clearcutting. This should be changed to reflect a more realistic hydrologic condition.

5. Delete B5-Pine Martin and Pileated Woodpecker Management Areas. The habitat needs for these and other species would be met in Late-Successional Reserves, Riparian Reserves, and the A land allocation areas. In addition, there would be areas of late-seral habitat retained in other parts of the watershed as part of the strategy described in Chapter 6.

6. Delete the A9-Key Site Riparian land allocation along Cub and Berry creeks. Most of this allocation in this area is within Riparian Reserve, and the small portion outside of the Riparian Reserve is not necessary for protection of aquatic resources.

Other Management Recommendations

1. Pursue management strategies to accelerate development of late seral habitat conditions in appropriate areas of the LSR and Riparian Reserves. Focus activity in Riparian Reserves that would provide connections to neighboring LSRs.

2. Pursue strategies to improve the quality of early seral habitats for valued or rare early seral associates (e.g. elk, bluebird, willow flycatcher).

3. Most of the harvest and collection of special forest products would occur in the Matrix. Seek ways to meet firewood demand from nontraditional sources such as utilizing precommercial thinning wood or removing standing trees to meet silvicultural objectives.

Appendices

Appendix A - Past and Current Conditions

This appendix describes past and current conditions in the watershed that are relevant to addressing the key questions identified in Chapter 2. The description of watershed conditions includes the identification of important processes regulating changes in terrestrial or physical conditions. An understanding of processes interacting in the watershed is essential to determining the relationships between past management actions and current physical and biological conditions. Chapter 3 is a summary of the information contained in this appendix.

Due to the complex and lengthy nature of some analyses, some results are summarized but not fully displayed within this document. An analysis file containing maps, additional data, and additional information concerning methodology is on file at the Clackamas Ranger District. Much of the mapping and analysis was done through use of the Geographic Information System located at the Clackamas Ranger District.

Vegetation

Forest Series

Vegetation composition within the Upper Clackamas watershed varies by forest series. Three forest series occur within the watershed: western hemlock (*Tsuga heterophylla)*, Pacific silver fir (*Abies amabilis*), and mountain hemlock (*Tsuga mertensiana*) (Halverson et al., 1986, Hemstrom et al., 1982). A forest series (or vegetation zone) is the area within which a particular tree species is projected to dominate stands in a theoretical climax condition (Daubenmire, 1968). They represent major differences in ecological factors such as growing season length, snow accumulation, forest community composition, productivity (particularly, the maximum size attained by mature trees), and wildlife use patterns (Diaz and Apostol, 1992). The western hemlock series occurs at lower elevations, occupying approximately 34% of the Upper Clackamas watershed. Thirty-six percent of the watershed is in the mid to higher elevation Pacific silver fir series, and approximately 30% of the watershed is in the high elevation, mountain hemlock series.

Western Hemlock Series

Extensive stands of Douglas-fir *(Pseudotsuga menziesii)* dominate the existing forest overstory in the western hemlock series. Other tree species include western hemlock, red alder and bigleaf maple. A diversity of understory plant communities are present, varying with differences in soil productivity, moisture and elevation. At lower elevations within the western hemlock series, Oregon grape *(Berberis nervosa)*, vine maple *(Acer circinatum)*, twinflower *(Linaea borealis)* and bracken fern *(Pteridium aquilinum)* are common species that can be found on a variety of sites, depending on the successional stage. On moist, nutrient-rich sites, swordfern *(Polystichum munitum)*, oxalis *(Oxalis oregana)* and vanilla leaf *(Achlys triphylla)* are characteristic. Indicators of drier and less nutrient-rich sites are salal *(Gaultheria shallon)* and huckleberry *(Vaccinium sp.)*.

Rhododendron *(Rhododendron macrophyllum)* and big huckleberry *(Vaccinium membranaceum)* dominate the shrub layer on higher elevation sites within the western hemlock series. The herbaceous layer changes with the dominance of beargrass *(Xerophyllum tenax)* and the corresponding decrease in swordfern. The coolest sites within the western hemlock series are dominated by golden chinkapin *(Castanopsis chrysophylla)*, grouse huckleberry *(Vaccinium scoparium)*, rhododendron and other evergreen shrubs.

Atypical sites within the western hemlock series may produce situations where hemlock is not the climax species. Examples include: very wet sites where western redcedar *(Thuja plicata)*is dominant; and concave sites with thin soils where grand fir *(Abies grandis)* is the climax tree species.

The Big Bottom section of the Upper Clackamas watershed is a vegetatively unique area within the western hemlock series. Here, geomorphological features have created a low gradient hydrological system composed of numerous meandering side channels and back water ponds. The high water holding capacity of Big Bottom has led to a stable relatively undisturbed habitat. Large scale vegetative disturbance from fire was infrequent and peak water flow disturbance of the floodplain was minimal due to the low hydrological gradient. Because of these features, a wide spectrum of habitat types is available for various habitat specific plant species. Subsequently, vegetative diversity in terms of number of species and overall species abundance is higher than in upland or other associated riparian areas within the watershed.

The plant species composition of Big Bottom is also notable for the presence of cold-water corydalis *(Corydalis aquae-gelidae)*. Cold-water corydalis type locality is from the Clackamas River and it is estimated that one-third to one-half of the worlds population can be found in Big Bottom. The plant prefers partially shaded gravel bars and deposition zones of cold temperatured streams. It is strictly a riparian species that depends on specific riparian conditions for growth, maturation, and fecundity. The presence of such rare plant species is again the product of the unique assemblage of habitat features in big Bottom.

Pacific Silver Fir Series

The dominant tree species in the Pacific silver fir series include noble fir, Douglas-fir, Pacific silver fir and mountain hemlock. Soil productivity is lower than in the western hemlock series and the growing season is shorter. Virtually all of the understory communities within this series have big huckleberry as an important component. At upper elevations on typical soils, huckleberry becomes almost the only shrub and is often associated with a thick carpet of beargrass. Herbaceous species on more productive sites include dogwood bunchberry *(Cornus canadensis)*, starry solomonplume *(Smilacina stellata)*, twinflower, queen's cup beadlilly *(Clintonia uniflora)*, and vanilla leaf. Rhododendron is the dominant shrub on northern slopes, often exceeding 50% cover.

Mountain Hemlock Series

The overstory in the mountain hemlock series is primarily dominated by mountain hemlock and Pacific silver fir. Several other tree species, including lodgepole pine, western white pine, western hemlock, Engelmann spruce, noble fir, Douglas-fir and subalpine fir, may be locally common. This series receives most of its precipitation as snow, has a very short growing season and has some of the least productive soils in the watershed. The mountain hemlock series is much less diverse than the lower elevation western hemlock and Pacific silver fir series. The understory is typically dominated by big huckleberry and occasionally grouse huckleberry with beargrass in the herbaceous layer. Lupine *(Lupinus sp.)*, dwarf bramble *(Rubus lasiococcus)* and violets *(Viola sp.)* are found on the more productive sites. Bigleaf huckleberry, pine-mat manzanita *(Arctostaphylos nevadensis)* and Oregon boxwood *(Pachistima myrsinites)* are found on the highest elevation, least productive sites within the watershed.

Extensive stands of lodgepole pine *(Pinus contorta)* are found within the mountain hemlock series in the southeastern portion of the watershed. These lodgepole pine stands are unique. They are part of the only representation of a large block of eastside forest type which occurs predominantly on the west side of the Cascade crest. Although dense, these stands do not have the density problems of most eastside lodgepole stands.

Very little understory exists in these stands, but where it is present there is a component of shade tolerant trees developing. These stands consist of mountain hemlock and true firs. Understory vegetation consists predominantly of big huckleberry, grouse huckleberry, Dwarf Oregon grape, prince's pine, dwarf bramble, and beargrass.

Stands of pure lodgepole pine develop in areas of low summer rainfall, wide diurnal temperature fluctuations in summers, and relatively short growing seasons. Past fire events, insect and forest pathogens, plus the cold, dry environment where they exist have played a role in the development of these lodgepole pine stands. The age of the stands within the watershed range from about 70 to 150 years old.

Plant Species of Concern

There are documented populations of sensitive plants within the watershed. Sensitive plants are those species that are federally listed or are candidate species and those species the Oregon Natural Heritage Data Base has listed as endangered, threatened, or limited in abundance throughout their range. Highest probability habitat for sensitive plants is found in riparian and rocky areas, which occur throughout the watershed.

As mentioned previously, populations of cold-water corydalis (*Corydalis aquae-gelidae*) grow along the Clackamas River and some tributaries. It is a sensitive species and a candidate species proposed for federal listing. A rare species of aster (*Aster gormanii*) that is only found on a few high ridges in northern Oregon grows in several locations in the Rhododendron Ridge area. *Aster gormanii* is also a candidate species proposed for federal listing. There are four other sensitive plant species that have documented locations within the watershed. These are pale blue-eyed grass (*Sisyrinchium sarmentosum*), mountain grape-fern *(Botrychium montanum)*, fir club-moss (*Lycopodium selago)*, and lesser bladderwort (*Utricularia minor*).

Seral Stages

Forested areas within the Upper Clackamas watershed vary not only by forest series, but also by seral (or successional) stage. Seral stages within the watershed can be grouped into three broad developmental stages: early, mid and late seral. The late seral category includes both old-growth and mature stands that have not yet developed all of the old-growth characteristics. The three seral stages vary with both species composition and structure of the vegetation. Seral stage is an important ecological driver within the watershed affecting a variety of ecosystem functions, including: wildlife species use and migration, nutrient cycling, hydrologic function, production of snags and coarse woody debris, and disturbance processes (fire, insects, disease, and windthrow), among many others.

Three critical aspects of the composition of seral stages within the Upper Clackamas watershed that were determined to be driving issues are: frequency, distribution, and patch size.

Frequency

For this analysis, seral stages were defined according to stand structure rather than stand age. Late seral stands were defined as stands dominated by conifers at least 21 inches in diameter (these stands are generally older than 80 years). The mid seral category included closed sapling/pole stands (average stand diameter less than 8 inches, dense canopy) and small sawtimber (stands dominated by conifer trees ranging from 8-21 inches in diameter). A problem with this definition is that some late-successional stands on poorer, high elevation sites are included in the mid seral category. The early seral category consists of grass/forb/shrub stands (primarily recent clearcuts that have not yet advanced to the sapling/pole stage), shelterwood and leave tree stands, and open sapling/pole stands (conifers greater than 10 feet tall, less than 60% canopy cover).

Currently, 27% of the vegetated area in the Upper Clackamas watershed is in an early seral condition, 35% in mid seral, and 38% in late (Map 3-1). The current mix of seral stages is primarily the result of timber harvest and fire. Timber harvest began in the Upper Clackamas in the late 1940's. Early seral stands in the watershed are almost entirely the result of harvest activities, primarily clearcutting. For further information on this topic, refer to the commodities section. Mid seral stands in the watershed include older plantations, stands resulting from stand replacement fires over the last 100 years, and slow-growing stands on poorer, high elevation sites. The mid seral, unmanaged stands throughout the northern and western portion of the watershed originated from stand replacement fires that occurred within the last 100 years. The lodgepole areas around Sisi Butte and Lemiti are also included in the mid seral category. These areas appear to have experienced repeated burning (along with mortality due to insects and diseases), and there is a mosaic of stand ages present in the area.

The southeastern portion of the watershed contains many older stands on poorer, slow-growing sites. These stands are classified as mid seral, based on their structural characteristics. There are similar areas along Rhododendron Ridge. It is estimated that approximately 27% (9,300 acres) of the mid seral stands within the watershed will stay in a mid seral condition (will not grow into the structural requirements used here to define late seral stands). These areas occur primarily around Sisi, Lemiti, and in the Olallie area.

Map 3-1. Current Seral Stages.

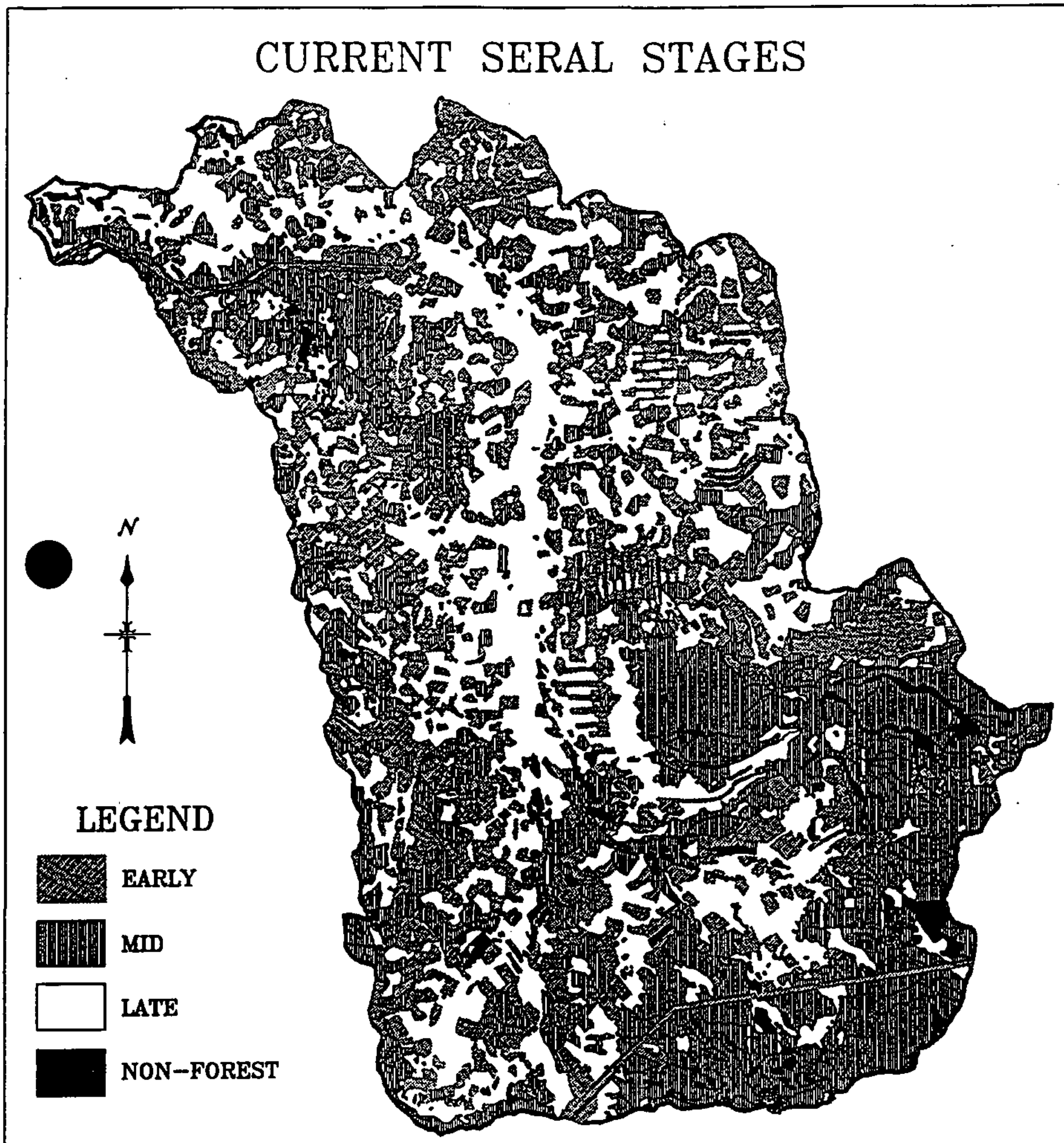


Figure 3-1 shows the percentage of each subwatershed in early, mid, and late seral. Pot subwatershed stands out as having the largest percentage of early seral (62%) and the lowest amount of mid (8%). The subwatersheds in the Southeast Group (Lemiti, Olallie, S. Fk. Lemiti) along with Squirrel also stand out due to the large amount of mid seral in these subwatersheds. This is due to the stand conditions previously described.

Figure 3-2 shows the percentage of each forest series within the various seral stages. Thirty-four percent of the Upper Clackamas watershed is in the western hemlock series, 36% in the Pacific silver fir series, and 30% in the mountain hemlock series. Figure 3-2 shows the percentage of each forest series within the various seral stages. Currently, 29% of the western hemlock series is in early seral, 19% in mid, and 52% in late. This is similar to the Pacific silver fir series which has 35% in early, 25% in mid, and 40% in late. The lower percentage of late seral in the Pacific silver fir series is due to the slightly higher percentage of early (result of timber harvest), coupled with a higher percentage of mid (result of fire history). The mountain hemlock series is quite different from the other two, with 15% in early, 66% in mid, 19% in late seral. The high percentage of mid is the result of poorer growing conditions and the disturbance history. There has been less timber harvest, as demonstrated by the low percentage of early seral, than in the other two series.

Figure 3-1. Seral stage by subwatershed. Values shown are percentage of each subwatershed in early, mid, and late seral stage.

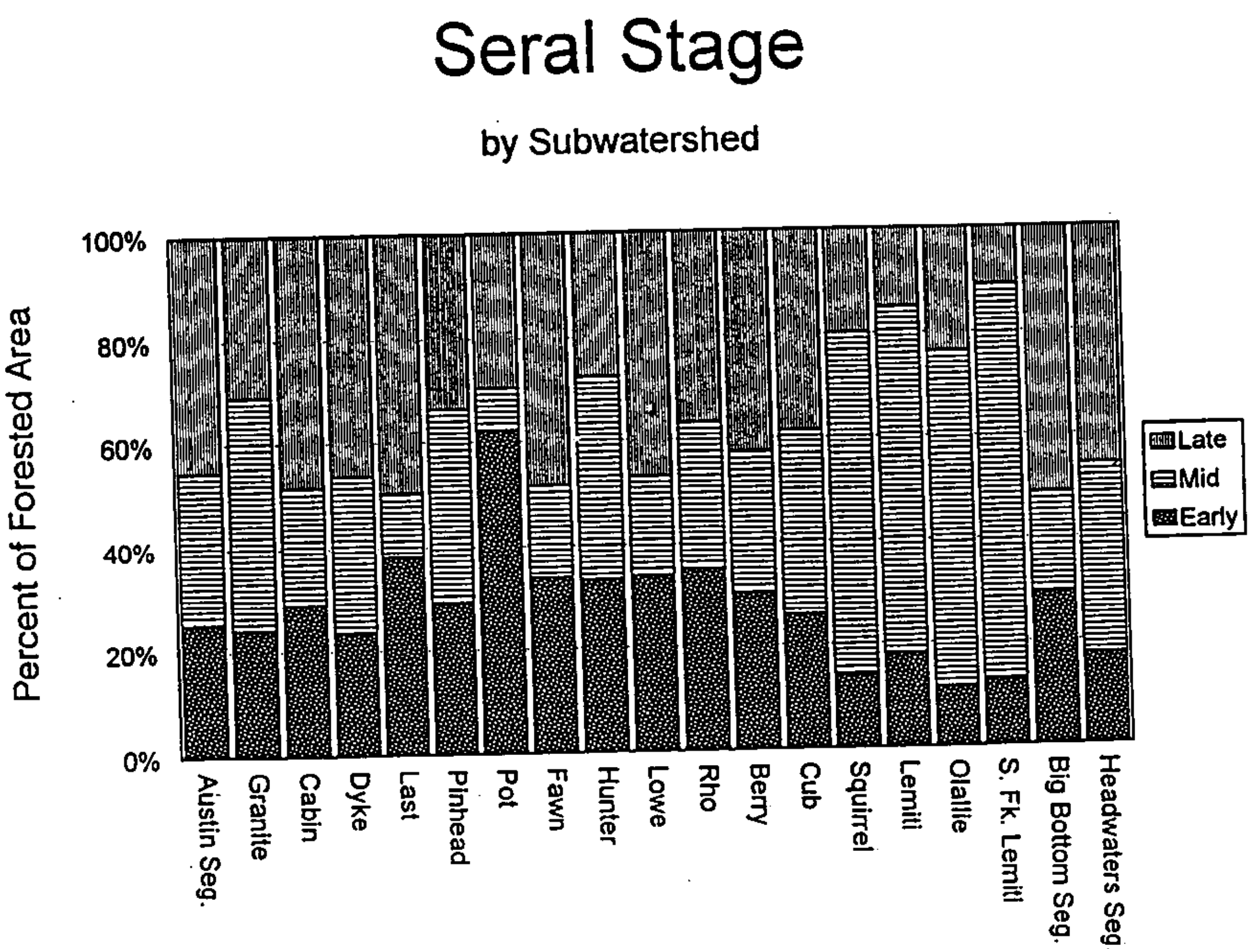
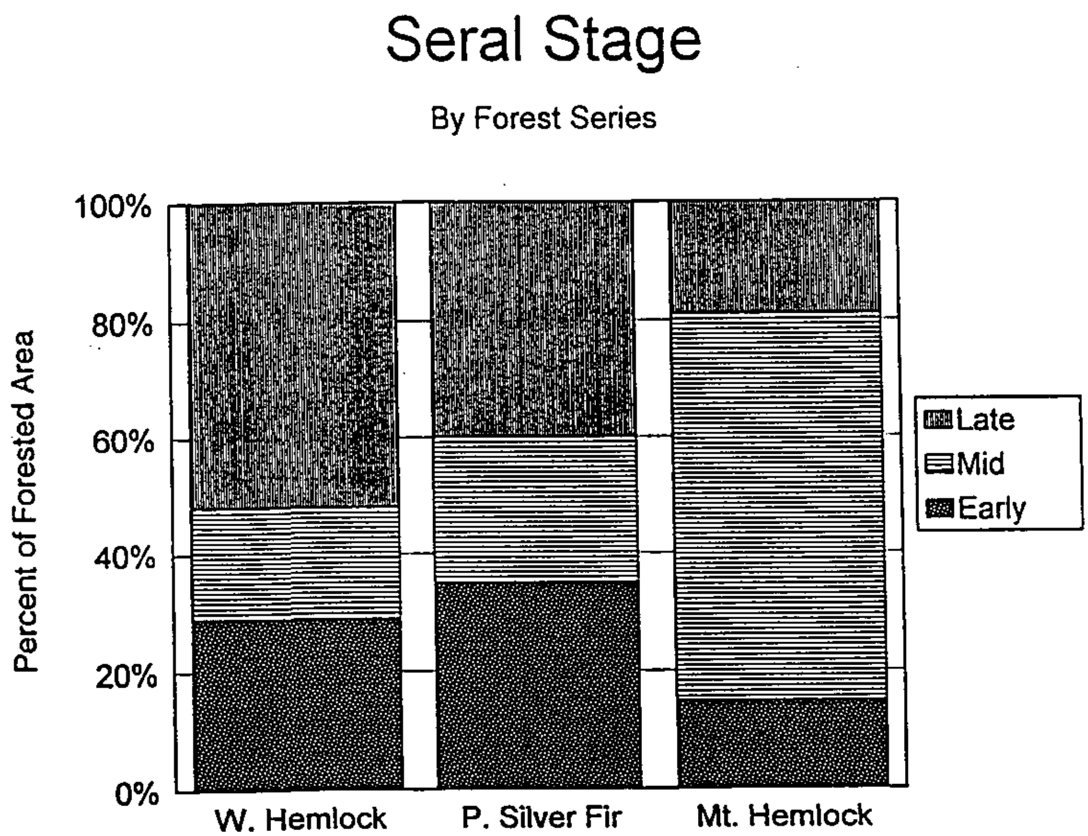


Figure 3-2. Seral stage by forest series. Values shown are percentage of each forest series in early, mid and late seral stage.



Range of Natural Variability

The idea of the range of natural variability (RNV) is based on the concept that ecosystems are not static and that they vary over time and space. The dynamic nature of ecosystems exemplifies the need for us to consider ranges of conditions under natural disturbance regimes, rather than single points in time. A key assumption of this concept is that when systems are "pushed" outside the range of natural variability there is a substantial risk that biological diversity and ecological function may not be maintained.

In 1993, the Pacific Northwest Region undertook an assessment of the range of natural variability for a number of key ecosystem elements, elements that are believed to be key to ecosystem health and sustainability. The Regional Ecological Assessment (REAP) analysis was done at the subbasin scale (USDA 1993b).

Figures 3-3 and 3-4 show the relationship between the current condition of the Upper Clackamas watershed and the estimated range of natural variability in the Clackamas subbasin (from REAP) for two of the identified key ecosystem elements, amount of early and late seral vegetation. These numbers are expressed as percent of the total area (either watershed or sub-basin) within each forest series.

Figure 3-3. Current condition compared to historic range of amount of early seral vegetation. Values shown are percentage of the total area within each forest series.

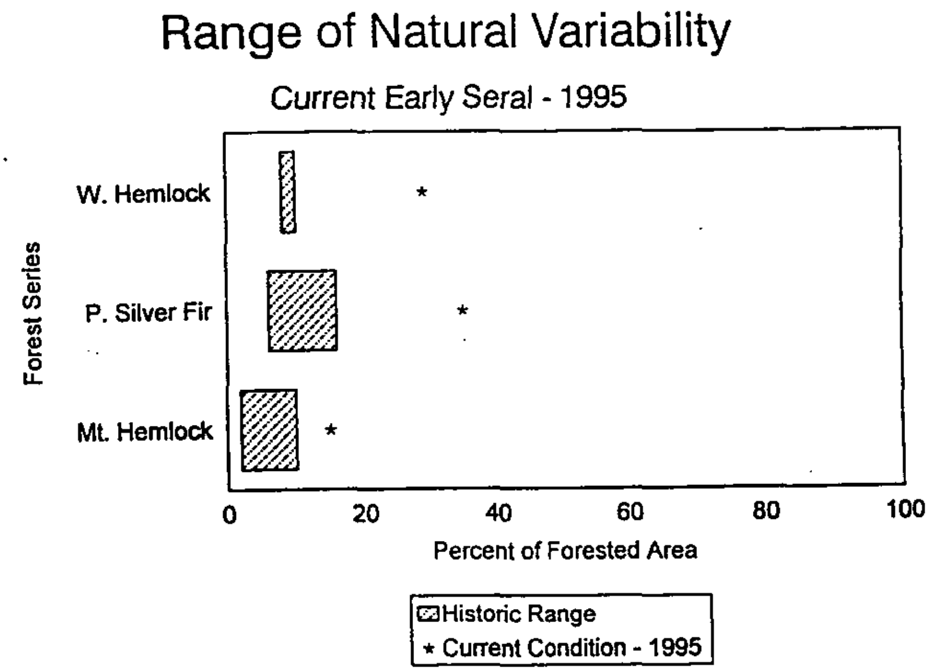


Figure 3-4. Current condition compared to historic range of amount of late seral vegetation. Values shown are percentage of the total area within each forest series.

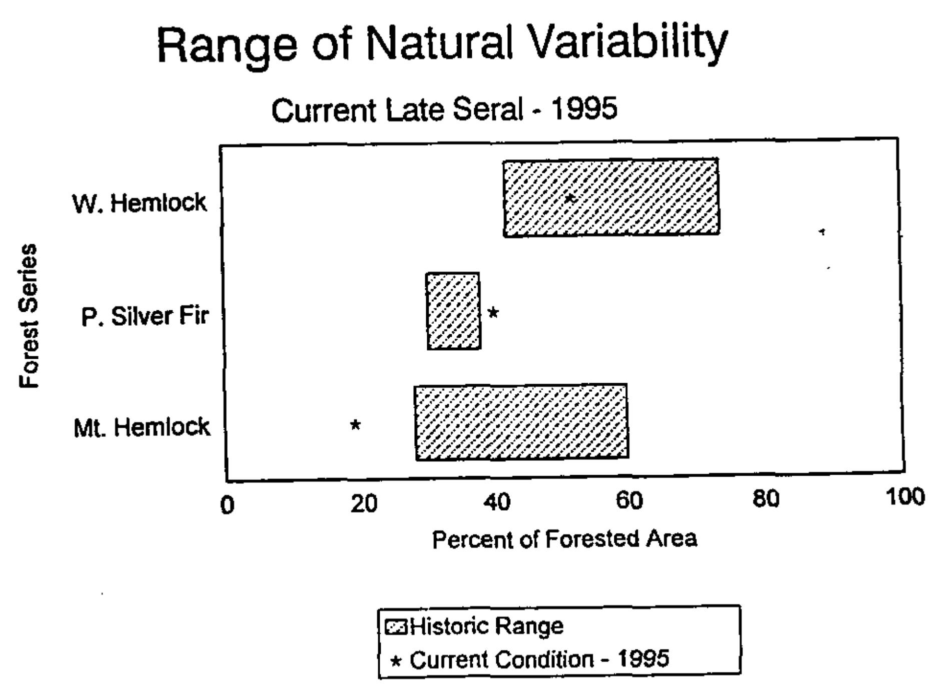


Figure 3-3 shows that all three forest series are outside of the natural range of variability in terms of amount of early seral vegetation. There is currently 19% more early seral within the western hemlock series than would be expected under the natural disturbance regime, 19% more in the Pacific silver fir series, and 5% more in the mountain hemlock series. This is due almost entirely to timber harvest and some associated blowdown, there has been very little recent disturbance from fire within the watershed. The most significant recent fire within the watershed was the Multnomah fire in 1992, which burned 150 acres along the eastern boundary of the watershed.

Figure 3-4 shows that the amount of late seral vegetation in the Upper Clackamas is currently within the range of natural variability in the western hemlock series. There is currently 2% more late seral in the Pacific silver fir series than in the natural range. It is important to note that for the Clackamas subbasin the Pacific silver fir series had a very narrow estimated range, compared to the other forest series. The mountain hemlock series currently has 11% less late seral than in the natural range. This is due to the large amount of mid seral within this series, resulting from both growing conditions and disturbance history. It is estimated that within the Upper Clackamas watershed 32% of the mountain hemlock series will remain in the mid seral category and will not grow to meet the structural definitions of late seral.

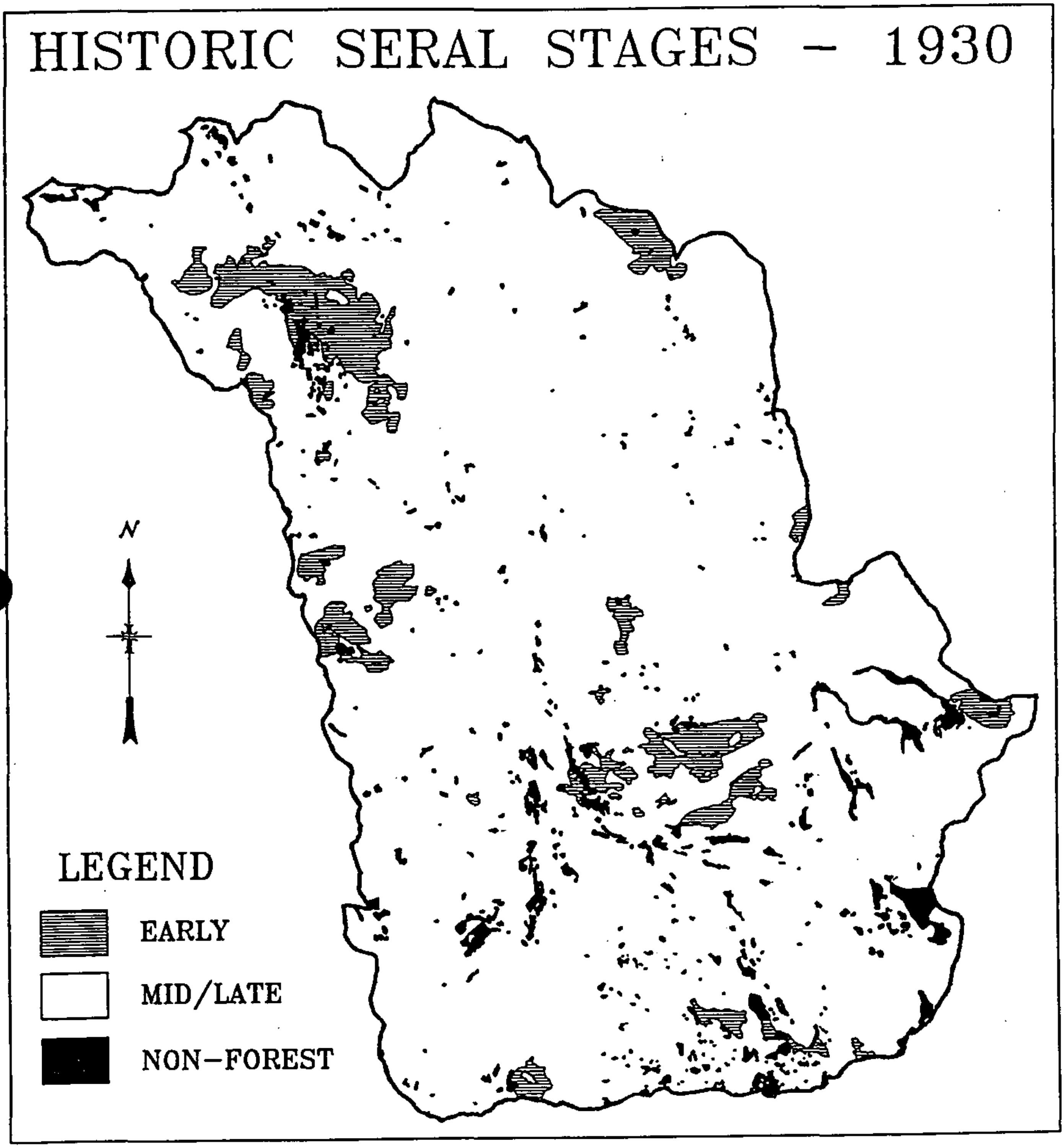
Disturbance

Reconstructed Historic Landscape -- 1930

Fire is the dominant landscape pattern-forming disturbance in this portion of the Cascades. The last major fire events in the Upper Clackamas occurred in the early 1900's. Map 3-2 is a reconstruction of the Upper Clackamas landscape in 1930. The landscape pattern was reconstructed using 1946 aerial photographs, current age class information, and panoramic photographs taken from lookouts in the early 1930's. This was done in order to get a better idea of what the distribution of seral stages and landscape pattern would be like under the natural disturbance regime. Map 3-2 shows that approximately 6,250 acres (6% of the watershed) was in an early seral stage at the time. It is acknowledged that this is only a single point in time, and that to get a true picture of "natural" conditions, many other points in time would need to be examined. An additional problem with this representation of the "natural" fire pattern is that although timber harvest had not yet begun in the watershed in 1930, fire suppression had. This is a conservative estimate of the total amount of early seral in the watershed. Only stand replacement fires were mapped, and some smaller fires were probably missed.

Only stands that were in an early seral condition in 1930 were mapped. At that time there were also many areas in a mid seral condition. Only areas that had an open canopy in 1930 were included in the reconstruction. Sisi and Lemiti appear to have had multiple burns, producing a mosaic of stand ages. Different aspects within the same fire also had different regeneration times, leading to portions of fire areas staying in an early seral condition longer. Much of the Sisi and Lemiti areas are currently lodgepole pine stands. The Olallie area also has a complicated fire mosaic, with many small, patchy burns and returns. A number of brush rock faces along the Clackamas River corridor are thought to be maintained by fire due to the presence of snags observed in the 1930's panoramic photos. This type of fire-generated pattern would fit with the surrounding landscape due to the south/southwestern exposures of the rocky bluffs.

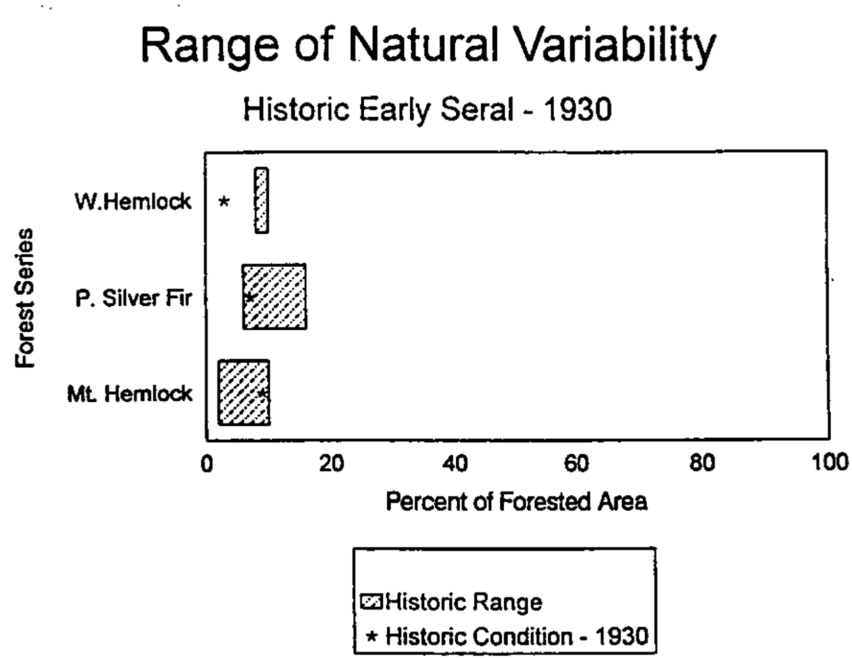
Map 3-2. Historic Seral Stages - 1930



Comparison to Range of Natural Variability

Figure 3-5 shows the relationship between the historic (1930) amount of early seral in the Upper Clackamas watershed and the estimated natural range of variability in the Clackamas subbasin (USDA 1993b). Both the Pacific silver fir and the mountain hemlock series are within the historic range. There was 5% less early seral in the western hemlock series in 1930 than in the historic range.

Figure 3-5. Historic (1930) condition compared to historic range of amount of early seral vegetation. Values shown are percentage of the total area within each forest series.



Fire Regimes

The Mt. Hood National Forest has been divided into eleven fire ecology groups based on vegetation, fire frequency and behavior (Evers et al., 1994). The Upper Clackamas watershed contains four of these fire ecology/fire regime groups.

Fire groups 7 and 8 are the dominant fire regimes within the Upper Clackamas watershed, covering most of the drainage. Fire group 7 is titled the "cool associations often dominated by lodgepole pine" and lies in the southeastern (Lemiti/Olallie) portion of the watershed. This area has an average fire frequency of 100-300 years. Fire group 8 is dominant throughout the remaining portion watershed and is known as the "warm, moist western hemlock and Pacific silver fir" group. It has an average fire frequency of 50-300+ years. Stand replacement crown fires are the presettlement and current fire behavior in both of these fire groups.

Fire group 6 is found in the higher elevations along the Rhododendron Ridge/Granite Peaks area on the southwestern edge of the watershed. This is the "cool, moist lower subalpine" fire group. It has an average fire frequency of 170-430 years and the current and presettlement fire behavior is crown fires, with torching, spotting, and lethal underburning. These areas tend to be somewhat drier than fire group 8, and are areas of prolonged snow pack.

Fire group 9 is the fourth regime found within the Upper Clackamas watershed. It is termed the "dry western hemlock and westside Douglas-fir" group. It has a more frequent fire frequency of 25-150 years and the fire behavior is primarily underburning, with some crown fire. This fire group is found in areas with rock outcrops and talus slopes. These areas are assumed to have reburned frequently with below canopy ground fires. These stands have a different fire regime due to their steepness, wide spacing of trees, thin soils, and the high percentage of exposed rock.

Overall percentage of the area within various seral stages is not the only factor that has been altered by management activities, it has also greatly affected the pattern of the vegetation.

Pattern (Distribution and Patch Size)

Overall percentage of the area within various seral stages is not the only factor that has been altered by management activities, it has also greatly affected the pattern of the vegetation. Landscape pattern is a critical determinant of landscape-scale ecological processes. Forested landscapes in the Pacific Northwest are typically dominated by interconnected closed canopy stands of mid to late-successional forest, interspersed with natural and created non-forest openings. The spatial characteristics of the closed canopy forest stands are crucial because of the control they exert over landscape dynamics (Forman and Godson, 1986). Some ecologically important features of landscape pattern are: amount of edge habitat, degree of fragmentation of late-successional forest, amount of interior habitat, and degree of patchiness.

Fragmentation is one aspect of landscape pattern that has recently received a great deal of attention. As fragmentation of a landscape increases, the amount of interior forest habitat decreases and the amount of edge habitat increases. Increasing edge benefits some species and is detrimental to others (Marcot and Meretsky, 1983; Rosenberg and Raphael, 1986; Temple and Cary, 1988; Yahner, 1988). Amount of edge habitat within a landscape, therefore, has important implications for biological diversity. Degree of fragmentation not only effects species presence, but also microclimatic factors such as air temperature, relative humidity, and wind speed (Spies et al., 1990). As fragmentation increases, the amount of interior forest habitat decreases, impacting organisms which require large patches of interior quality habitat to survive (Franklin and Forman, 1987).

The Upper Clackamas is a highly fragmented watershed within a highly fragmented subbasin. Landscape patterns were assessed at the Forest scale (PULSE) and are defined in Table 3-1. Most of the watershed is classified as "fragmented". Early seral is beginning to aggregate in Pot subwatershed and part of Austin. Unfragmented blocks in the watershed are primarily large blocks of mid seral including: Sisi, Lemiti, West Pinhead, Granite Peaks, and Olallie. Significant blocks of unfragmented late seral are found along the lower portion of the Clackamas River and along Rhododendron Ridge. Big Bottom also stands out within the drainage as a large block of late seral which is classified as "perforated", high connectivity with only 20%-30% of the area in openings.

Table 3-1. Landscape pattern definitions.

Landscape Pattern	Percent of Landscape in Closed Canopy Forest	Description
Unfragmented	≥ 85%	Open patches are primarily natural in origin, and are relatively permanent. There is a high degree of connectivity of closed canopy forest, and a large number of core habitat areas.
Perforated	70-80%	Closed canopy forest is "perforated" by fairly uniformly dispersed harvest units. Connectivity of closed canopy forest is still quite high.
Fragmented	60-70%	Open patches are evenly dispersed. Connectivity may begin to be significantly impaired at below 60% closed canopy forest.
Aggregated	< 50%	Open patches dominate the structure and function of the landscape. Few closed canopy forest core areas.

Interior Habitat

Map 3-3 shows the current interior habitat that is present within the watershed. Interior habitat was defined as late seral stands that are at least 500 feet from any opening (natural or created). Five hundred feet is used as a convention, actual width of a functional edge varies due to many site specific factors. Mid seral stands, roads, and the watershed boundary were not counted as edge were not counted as edge for this analysis.

Table 3-2 shows the amount of interior habitat by subwatershed. A total of 11,124 acres (11% of the Upper Clackamas watershed) is in interior habitat. The Mainstem Group contains the most interior habitat of all of the subwatershed groups (18%).

Map 3-3. Interior Habitat

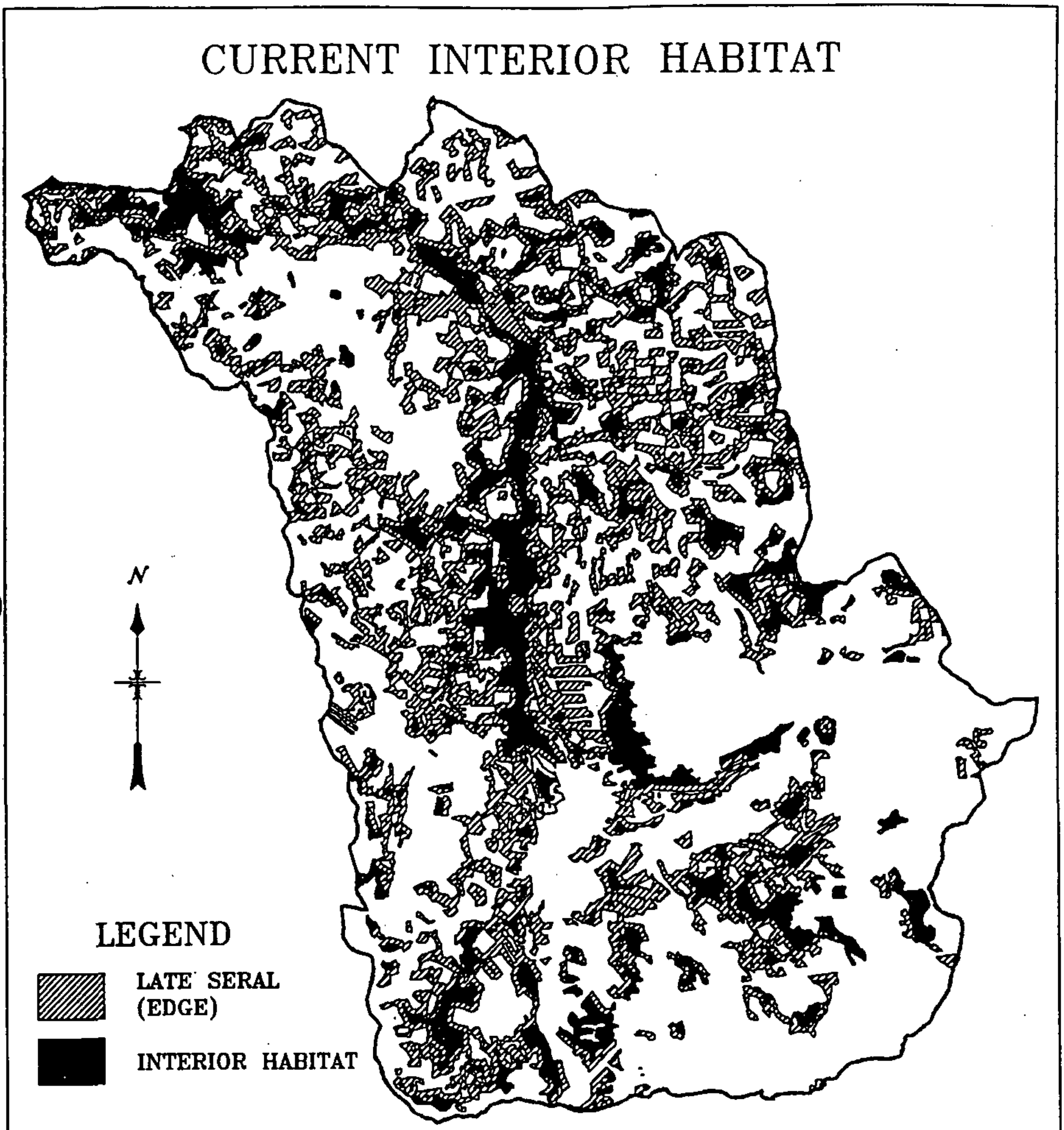


Table 3-2. Interior habitat by subwatershed group.

Subwatershed	Acres	Interior Habitat Acres	Percent of Subwatershed In Interior Habitat
Austin Segment	10123	1441	14.2%
Granite	1878	117	6.2%
Northwest Group Totals	12000	1558	13.0%
Cabin	2144	292	13.6%
Dyke	2258	389	17.2%
Last	7355	646	8.8%
Pinhead	7486	560	7.5%
Pot	2281	64	2.8%
East Group Totals	21523	1951	9.1%
Fawn	2391	290	12.1%
Hunter	4151	243	5.9%
Lowe	4120	433	10.5%
Rho	4086	237	5.8%
West Group Totals	14747	1203	8.2%
Berry	5430	650	12.0%
Cub	9074	1059	11.7%
Squirrel	3863	148	3.8%
South Group Total	18367	1857	10.1%
Lemiti	9422	589	6.3%
Olallie	2675	308	11.5%
S. Fk. Lemiti	2271	104	4.6%
Southest Group Totals	14368	1001	7.0%
Big Bottom Segment	8931	1489	16.7%
Headwaters Segment	10443	2065	19.8%
Mainstem Group Totals	19375	3554	18.3%
Totals	100380	11124	11.1%

Late-Successional Reserve

The intent of the LSR system is to maintain a functional, interconnected late-successional ecosystem. Currently, 17% of the LSR is in early seral, 35% in mid, and 48% in late (Figure 3-6). Outside of the LSR, 32% of the landscape is in early seral, 33% in mid and 35% in late. Map 3-3 shows that the most connected blocks of interior habitat are included in the LSR. Twenty percent of the vegetated acres within the LSR (6,140 acres) are interior habitat, compared to 8% (4,984 acres) outside of the LSR (Figure 3-7).

Figure 3-6. Seral stage inside and outside of the LSR. Values shown are percent of each area in early, mid, and late seral.

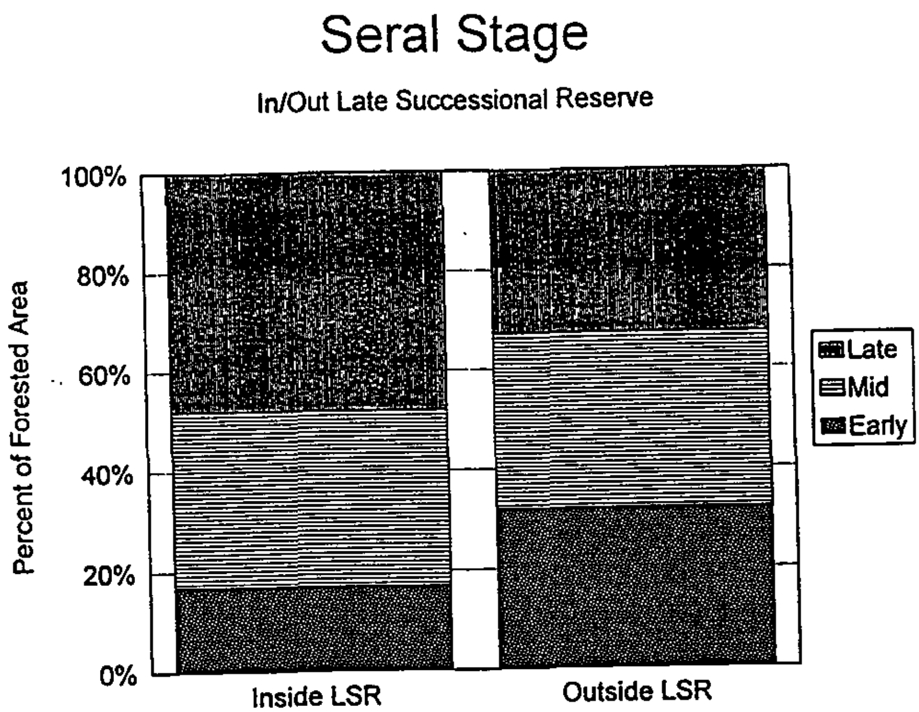
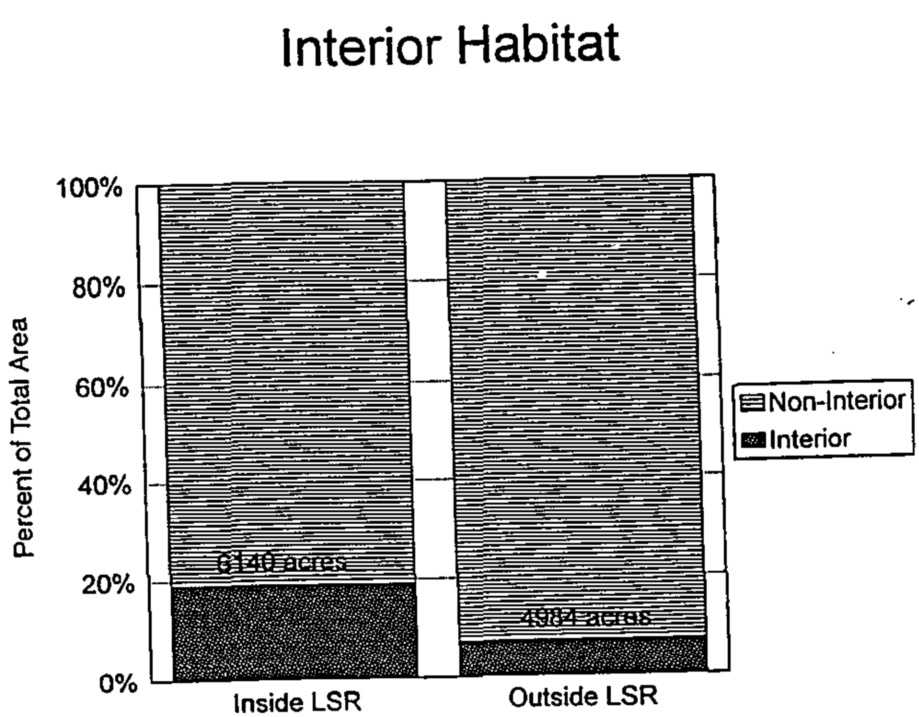


Figure 3-7. Interior habitat inside and outside of the LSR.



Landscape Pattern Spatial Analysis

Current and historic (1930) landscape patterns were evaluated using spatial statistics (FRAGSTATS, McGarigal and Marks). Map 3-4 shows the current and historic landscapes. The analysis was performed on a simplified landscape, focusing primarily on the character of the closed canopy forest. The white area represents the closed canopy forest and the shaded areas are the open patches. Patches were defined as any open area in the landscape, whether an early seral patch created by harvest or fire, or a natural opening such as a rock outcrop or meadow. Open patches in the current landscape can be aggregates of adjoining harvest units. Roads were not mapped as patches. Natural non-forest patches were assumed to have remained stable over the last 64 years.

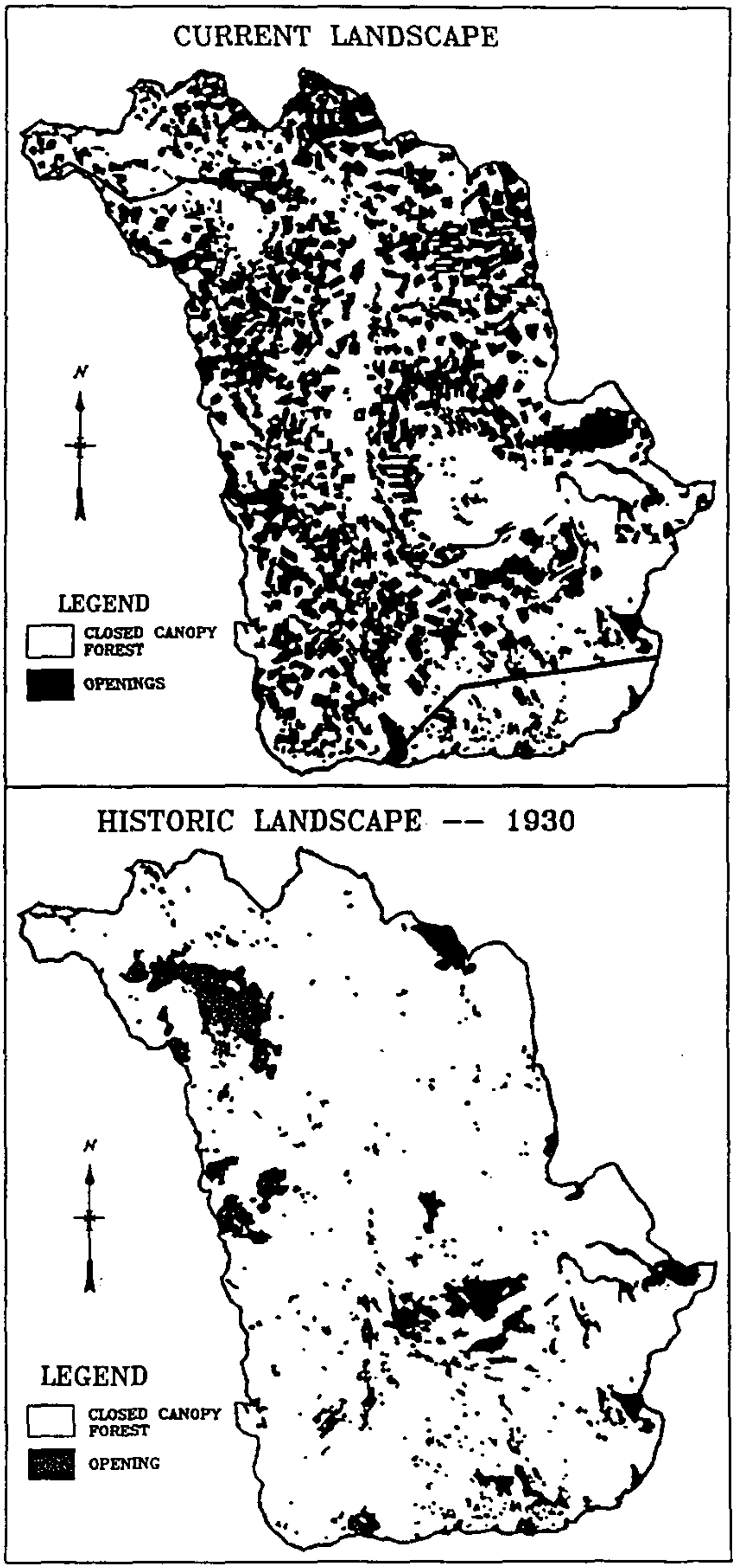
Landscape level

Landscape level statistics (Table 3-3) reveal that there are more total stands (both closed canopy forest and open patches) in the current landscape than in 1900, and that they are smaller. Stand size standard deviation indicates that the stands are more uniformly sized (variability has decreased), although there is still a high degree of variation. Stand density, a measure of landscape heterogeneity, has increased. There has also been an increase in the amount of edge.

Table 3-3. Landscape level statistics, current and reconstructed historic (1930) landscapes.

Landscape	Total Acres	# of Stands	Mean Stand Size (Acres)	Stand Size Standard Deviation	Stand Density # Per 100 Acres	Edge Density (Ft./Ac.)
1930	100,380	467	215	4,211	.47	20.9
Current	100,380	887	113	2,177	.88	61.2

Map 3-4. Current and Historic Landscapes.



Patch Level

Table 3-4 presents patch level statistics for the closed canopy forest, and Table 3-5 presents patch level statistics for the open patches in the current and historic (1930) landscapes.

Table 3-4. Patch-level statistics for the closed canopy forest of the current and reconstructed historic (1930) landscapes.

Landscape	Total Acres	Mean Forest Patch Size (Acres)	Number of Forest Patches	Total Forest Core Area * (Acres)	Number of Forest Cores
1930	91,241	6,517	14	73,753	27
Current	71,116	1,226	58	29,750	295

* Core area is defined as the area within a stand that is inside a 500 ft. buffer.

Table 3-5. Patch-level statistics for the open patches in the current and reconstructed historic (1930) landscapes.

Landscape	Total Area (Acres)	Mean Open Patch Size (Acres)	Number of Open Patches	Total Open Core * Area (Acres)	Number of Open Cores
1930	9,139	20	453	2,701	49
Current	29,250	35	829	3,459	302

Patch level statistics reveal that closed canopy forest patch sizes have decreased. Currently there are a greater number of closed canopy forest patches and much less core area than in 1930. This reflects a higher degree of fragmentation of the closed canopy forest. There has been an increase in the number of open patches and the size of the openings has increased. Mean open patch size in the historic landscape (1930) is highly variable, with a preponderance of very small patches (lakes, meadows, rock outcrops, etc.). Patch shapes are very irregular. Open patches in the current landscape are more regular in shape, and more evenly distributed throughout the watershed. The total area in open patches has greatly increased. The total core area in open patches has also increased, as patches have coalesced in the landscape.

Early Seral Patch Size

Both non-forested, natural openings (rocks, lakes, meadows) and early seral stands were included as openings in the analysis. Both types of openings contribute to the total edge in the watershed. Inclusion of natural openings, however, decreases the mean open patch size in the watershed. Mean early seral patch size in the reconstructed historic landscape (1930) is 184 acres, mean early seral patch size in the current landscape is 64 acres.

Summary of Pattern

The results in the Upper Clackamas landscape spatial analysis are nearly identical to those found in the REAP analysis for representative watersheds throughout Region 6 (Diaz et al. 1993). The Upper Clackamas watershed fits with the trend in landscape pattern changes found throughout Oregon and Washington. Since forest management began in the Upper Clackamas drainage during the late 1940's, the trend in the landscape pattern has been:

- Increase in the amount of edge (more edge habitat, less interior habitat, more risk of windthrow). Edge contrast is high, with abrupt transitions between early and late-successional vegetation.
- Fragmentation of mature forest, loss of connectivity and isolation of mature forest blocks.
- Increasing patchiness. Landscape patches (both closed canopy forest and openings) are smaller and more uniformly sized than what would be expected under a natural disturbance regime.
- Open patches are more evenly distributed throughout the landscape and are beginning to coalesce.

Riparian Vegetation

The subwatersheds within the watershed were grouped based on stream density, gradient, habitat composition, hydrology, coarse woody debris, and substrate. Map 1-4 displays the subwatersheds within these groupings. The 1993 REAP analysis defined the RNV for riparian vegetation within the Clackamas subbasin (USDA 1993b). The RNV for early seral riparian vegetation is 5 to 15 percent while the RNV for late seral vegetation is 35 to 80 percent. Following is a discussion of the condition of riparian vegetation within each subwatershed group.

Mainstem Group

Riparian areas along the Clackamas River fall within the RNV for amount of late seral vegetation. Big Bottom has the highest percent of late seral vegetation (72%) within riparian areas of the watershed (Table 3-6). Late seral vegetation comprises about 54% of the riparian vegetation within the Headwaters Segment. This number probably reflects more the vegetation series rather than management history. The majority of the Headwaters Segment is within the mountain hemlock vegetation series. As discussed above, this series has a more frequent disturbance history and poor growing conditions. Thus, riparian vegetation does not grow into late seral condition in the mountain hemlock series as frequently as in the other vegetation series.

Table 3-6. Riparian Reserve seral stage summary.

Subwatershed	Acres	Riparian Reserve Acres	Percent Riparian Reserve	Percent Riparian Reserve By Seral Stage			
				Early	Mid	Late	Non-Forest
Austin Segment	10123	2854	28%	18%	17%	62%	3%
Granite	1878	436	23%	27%	41%	30%	2%
Northwest Group Totals	12000	3290	27%	20%	20%	58%	3%
Cabin	2144	448	21%	21%	12%	65%	2%
Dyke	2258	85	4%	24%	3%	69%	4%
Last	7355	1091	15%	25%	12%	61%	2%
Pinhead	7486	914	12%	38%	16%	46%	0%
Pot	2281	537	24%	55%	13%	33%	0%
East Group Totals	21523	3075	14%	34%	13%	52%	1%
Fawn	2391	509	21%	26%	7%	67%	0%
Hunter	4151	869	21%	21%	39%	35%	5%
Lowe	4120	892	22%	33%	5%	61%	2%
Rho	4086	867	21%	31%	12%	52%	5%
West Group Totals	14747	3137	21%	28%	17%	52%	3%
Berry	5430	1430	26%	25%	16%	56%	3%
Cub	9074	2094	23%	23%	32%	36%	9%
Squirrel	3863	1251	32%	6%	62%	17%	15%
South Group Totals	18367	4775	26%	19%	35%	37%	9%
Lemiti	9422	1269	13%	2%	67%	6%	26%
Olallie	2675	435	16%	8%	42%	29%	21%
S. Fk. Lemiti	2271	336	15%	2%	72%	2%	24%
Southeast Group Totals	14368	2040	14%	3%	62%	10%	24%
Big Bottom Segment	8931	2426	27%	17%	10%	72%	0%
Headwaters Segment	10443	1988	19%	8%	33%	54%	6%
Mainstem Group Totals	19375	4414	23%	13%	21%	64%	3%
Totals	100380	20730	21%	20%	26%	48%	6%

Northwest Group

Riparian Reserves in the Northwest Group are within the RNV for the amount of late seral and above the RNV for the amount of early seral vegetation. The early seral composition reflects management and natural disturbances. This area tends to be naturally unstable and there has been a considerable amount of road building and timber harvest within the subwatersheds in this group. Roads make up about 160 acres of openings within this group and occupy 46 acres within Riparian Reserves (Table 3-7). Roads occur at a density of 3.3 miles/square mile within the group and 3.2 miles/square mile within the Riparian Reserve (Table 3-7).

Southeast Group

Riparian Reserves make up about 14% of this group (Table 3-6). The majority of the riparian vegetation along the southeast tributary streams is in a mid seral condition (Table 3-6). Late seral vegetation comprises about 10% of the riparian vegetation while early seral vegetation accounts for 3% along southeast tributary streams. These streams flow through the mountain hemlock vegetation series for most of their length. The combination of vegetation series and natural disturbance history affects the size of the trees in the riparian areas. The relative proportion of early, mid and late seral stages is important to project future coarse woody debris levels. The seral stage values reflect more of the vegetation series and natural disturbance regime rather than management history. Older trees within this series do not typically meet the definition of late seral vegetation. Roads make up about 6.7 acres of openings and occur at a density of 1.1 miles/square mile within the Riparian Reserves (Table 3-7).

South Group

Late seral vegetation makes up about 37% and early seral vegetation makes up 19% of the riparian vegetation within Riparian Reserves along south tributary streams (Table 3-6). Roads make up 35.3 acres of openings and occur at a density of 1.9 miles/square mile within the Riparian Reserve (Table 3-7). Most of the Riparian Reserves in the south tributaries occur within the western hemlock vegetation series. The current amount of early seral vegetation within the Riparian Reserves is above the RNV for riparian vegetation. The amount of late seral falls at the lower end of the RNV. The higher than expected value for early seral reflects the effects of management induced disturbances. This can be either from direct removal of vegetation for road construction and maintenance, timber harvest, or blow down events resulting from clearcuts adjacent to streams or a combination of the above.

East Group

The amount of late seral vegetation in the Riparian Reserves is within the RNV at 52% and above RNV for early seral vegetation at 34% (Table 3-6). Management-induced disturbance and vegetation series both contribute to the lower than expected amount of late seral and higher than expected amount of early seral vegetation. Roads make up about 47.8 acres of openings within the Riparian Reserve and occur at a density of 3.8 miles/square mile (Table 3-7). The upper segments of streams in this group fall within the mountain hemlock vegetation series.

Table 3-7. Road information by subwatershed group.

Subwatershed	Total Roads in Subwatershed			Roads w/in Riparian Reserve			Stream Network Expansion Related to Roads			
	Total Acres in Subwatershed	Percent of Subwatershed	Total Road Mi./Sq. Mi.	Total Acres in Rip. Res.	Percent of Rip. Res.	Rip. Res. Road Mi./Sq. Mi.	Stream Crossing	Natural Streams	Expanded Length	Percent Change
Austin Segment	142.0	1.4%	3.6	42.7	1.5%	3.4	64	50.6	55.4	9.6%
Granite	15.3	0.8%	2.2	2.9	0.7%	1.8	12	8.0	8.9	11.4%
Northwest Group Totals	**157.3**	**1.3%**	**3.3**	**45.6**	**1.4%**	**3.2**	**76**	**58.6**	**64.3**	**9.8%**
Cabin	31.6	1.5%	3.9	9.8	2.2%	5.5	9	5.3	6.0	12.8%
Dyke	30.1	1.3%	3.6	0.3	0.3%	0.8	1	1.6	1.6	4.9%
Last	116.8	1.6%	4.1	17.1	1.6%	3.6	13	13.5	14.5	7.3%
Pinhead	101.4	1.4%	3.4	14.1	1.5%	3.6	13	12.9	13.9	7.6%
Pot	38.7	1.7%	4.8	6.6	1.2%	3.3	11	7.3	8.1	11.4%
East Group Totals	**318.6**	**1.5%**	**3.9**	**47.8**	**1.6%**	**3.8**	**47**	**40.6**	**44.1**	**8.8%**
Fawn	40.3	1.7%	4.1	7.4	1.4%	3.6	10	7.3	8.0	10.4%
Hunter	62.4	1.5%	3.8	8.9	1.0%	2.6	19	13.5	14.9	10.7%
Lowe	59.7	1.4%	3.6	9.1	1.0%	2.7	18	14.6	16.0	9.3%
Rho	48.4	1.2%	3.0	4.9	0.6%	1.4	7	12.6	13.1	4.2%
West Group Totals	**210.7**	**1.4%**	**3.6**	**30.3**	**1.0%**	**2.5**	**54**	**48.0**	**52.0**	**8.5%**
Berry	69.4	1.3%	3.3	15.2	1.1%	2.7	59	28.0	32.5	15.9%
Cub	101.7	1.1%	2.9	15.6	0.7%	1.8	36	29.5	32.2	9.3%
Squirrel	25.1	0.6%	1.8	4.6	0.4%	1.1	10	19.2	20.0	3.9%
South Group Totals	**196.2**	**1.1%**	**2.8**	**35.3**	**0.7%**	**1.9**	**105**	**76.74**	**84.7**	**10.4%**
Lemiti	66.4	0.6%	1.9	3.8	0.3%	0.9	6	16.6	17.1	2.7%
Olallie	7.8	0.3%	0.9	0.8	0.2%	0.6	3	5.8	6.0	3.9%
S. Fk. Lemiti	11.0	0.5%	1.7	2.2	0.7%	2.9	1	4.9	5.0	1.5%
Southeast Group Totals	**85.2**	**0.5%**	**1.7**	**6.7**	**0.3%**	**1.1**	**10**	**27.3**	**28.1**	**2.8%**
Big Bottom Segment	154.8	1.7%	4.2	35.6	1.5%	3.3	54	40.7	44.8	10.0%
Headwaters Segment	109.0	1.0%	2.6	23.7	1.2%	3.0	31	29.3	31.6	8.0%
Mainstem Group Totals	**263.7**	**1.4%**	**3.3**	**59.3**	**1.3%**	**3.1**	**85**	**70.0**	**76.4**	**9.2%**
Totals	**1231.7**	**1.2%**	**3.2**	**225.0**	**1.1%**	**2.7**	**377**	**321.14**	**349.7**	**8.9%**

West Group

West watershed tributary streams are above the RNV for amount of early seral and are within the RNV for amount of late seral vegetation within Riparian Reserves (Table 3-6). Removal of riparian vegetation, road construction, and blowdown within riparian areas appears to be the factors causing the change in habitat composition from the RNV. Roads make up about 30.3 acres of openings within the Riparian Reserve and occur at a density of 2.5 miles/square mile (Table 3-7).

Summary of Riparian Vegetation Condition

The 1993 REAP analysis found that the current mode of early seral vegetation falls within the RNV while the current mode for late seral vegetation is below the RNV within the Clackamas subbasin (USDA 1993b). Although the early seral falls within the RNV, it is at the upper end. The RNV for early seral riparian vegetation is 5 to 15 percent while the RNV for late seral vegetation is 35 to 80 percent (USDA 1993b).

The results of this analysis shows that all the groups except for the Southeast and Mainstem groups have higher than expected early seral vegetation within the Riparian Reserves as defined by the RNV. The analysis also shows that the only group having lower than expected amounts of late seral vegetation was the Southeast Group. The lower than expected amount depends more on the vegetation series rather than management-induced disturbance in the Southeast Group. The other notable area for late seral vegetation within riparian areas was the South Group. In this group, roads and timber harvest contributed to the amount of late seral vegetation falling to the lower end of the RNV.

Dispersed camping within riparian areas is one of the key factors affecting riparian vegetation composition along the mainstem. Dispersed campsites typically have compacted soils and reduced understory vegetation due to compaction from vehicles and campers. The resulting effects can be increased runoff and erosion off of the hardened surfaces and reduction in future large woody debris recruitment. Dispersed campsites tend to be less than 1 acre in size, primarily occur along the mainstem Clackamas River near Big Bottom, and occur in a patchy distribution along the linear length where the roads, in particular road 46, parallel the mainstem. The distribution of these sites depends on topography. The most frequently used areas occur in flat, wide portions of the floodplain. Dispersed campsites prevent the local areas from functioning in a natural state due to the effects described above.

- Southeast Group Riparian Reserves will not meet the RNV for amount late seral due to natural factors.

- Riparian Reserves in the South, East, Northwest, and West Groups are above the RNV for amount of early seral vegetation.

- The East and West Groups have about two times the RNV amount of early seral vegetation, principally due to roads and timber harvest.

Silviculture

Timber Site Productivity

Site productivity within the Upper Clackamas watershed is relatively high when compared to Region 6 averages. Site index ranges from a low of 80 feet in 50 years to a high of 120 feet in 50 years. Over 60% of the stands within the area have a site index of 100 feet in 50 years. The mean annual increment for these average sites is approximately 130 cubic feet/acre/year (or 700 board feet/acre/year) at culmination.

In general, the upper elevation sites are less productive. This is due to the shorter growing season, thinner soils, a regeneration "lag" due to poor survival and growth of seedlings until they get above the average snow depth, and the slower growth of the conifer species that are typically found in these areas. Plantations on these sites exhibit productivity that is about 10 to 20 years behind the growth predicted by computer models.

In addition to these high elevation sites, there are other areas within the watershed that have frost problems. Frost problems tend to be very site-specific and usually occur where there are depressions in otherwise relatively flat terrain. In these areas, below freezing temperatures occur during the growing season, killing or stunting conifer seedlings. When this problem is encountered after clearcut harvesting, a species conversion to lodgepole pine is the most successful method of re-establishing conifers on the site. Converting stands to lodgepole pine has a net effect of reducing productivity because it is an economically less productive species. Shelterwood harvesting has been very successful when these frost pocket areas are identified before harvest. This silvicultural method tends to reduce the effects of frost damage which allows the site to be regenerated with the same species that was removed.

Silvicultural Treatment History

When clearcut harvesting first started in this watershed, silvicultural treatments were much less intense then they have been for the last 10 years. The first harvested areas were left to naturally reseed or were aerially seeded if needed, with no precommercial thinning planned. The expected productivity from these stands at that time was equal to "normal yield" tables developed from natural stands around the region. Rotation lengths at that time were planned to be 120 to 140 years. The production expected was approximately 20% to 25% less than what is predicted in the LMP.

In the 1960's artificial regeneration became the standard. Douglas-fir was used almost exclusively, even on sites within the higher elevation Pacific silver fir and mountain hemlock series. Regeneration success on the lower elevation sites was generally high with this method while the higher elevation sites had poorer success. The poor results of the high elevation sites can still be seen today. These plantations are gradually becoming stocked with naturally-regenerated and planted hemlock, true fir and lodgepole pine.

During the 1970's and into the 80's, more intensive silvicultural treatments were utilized to increase timber productivity. The intensive treatments first applied in the 1970's were precommercial thinning and vegetation release treatments with herbicides. In the mid 1980's applications of urea fertilizer began. In the late 1980's and early 1990's, high quality/high cost planting stock became a method used to outcompete brush and to increase survival rates. At this same time, genetic tree improvement programs became popular because of the expected growth increases. All this was done to increase timber growth. New computer growth models were developed based on application of these silvicultural treatments. In general, production levels using intensive management techniques showed about a 30% growth increase over the "normal yields" that were expected in the 1950's.

In the Upper Clackamas watershed, all of these techniques are currently being used except for conifer release with herbicides. In addition, approximately 2,170 acres of commercial thinning has been planned for harvest, and pruning is being used on some sites to increase the quality of the future wood fiber. The use of pruning to improve wood quality is a major change since all of the other intensive treatments have been used to increase wood quantity.

Within the Upper Clackamas watershed, some 10 to 30 year old plantations have been manipulated for objectives other than enhancing wood productivity. These treatments utilized combinations of precommercial thinning, manual brush cutting, fertilization and pruning to increase big game forage, produce two layer stand structures and create old-growth conditions in a shorter period of time. In these areas productivity of wood fiber was actually reduced to meet the other management objectives.

Disturbances - Fire, Wind, Insects and Disease

Fire, wind, insects, and disease have greatly influenced the development of Pacific Northwest forests.

Human activity and fire suppression within the Upper Clackamas watershed has altered the natural fire regime. Fire suppression has resulted in increases in accumulated fuels and has increased the susceptibility of some stands to insect and disease damage. This in turn has increased the chances of fire occurrence. Currently, small smoldering fires caused by recreationists occur regularly within riparian areas.

Long term Forest Service employees (Kyser and Rohling, personal communication, 1994) have provided insight into prevailing conditions for windthrow in the Upper Clackamas watershed. Windthrow has increased with the area that has been harvested for timber, especially becoming apparent since the 1960's. Before timber harvesting, windthrow was more common as scattered individual trees blowing down or small patches of timber going down in areas of disease pockets or wet soils.

Episodes of windthrow in the Upper Clackamas appear to occur on a regular basis approximately every five years. Noticeable windthrow events in recent history, have occurred in 1978-1980, 1984, and 1989-90. These recurring wind events have had the most effect on edge areas of clearcuts and shelterwood harvest units. Also, trees with a high, height-to-diameter ratio and trees in wet soils are more prone to being blown down. Higher elevation stands appear to be more susceptible to windthrow than mid-slope or lowland sites. At the north end of the watershed, the Rhododendron Ridge and the east-west ridge ending at Oak Grove Butte appear to consistently experience more windthrow in recent years. Damaging winds in the Upper Clackamas watershed usually come from either the southwest or the east. Clearcut edges and shelterwood units with a south-southwest aspect offer the most consistent windthrow. Periodically, east winds can be very destructive for small areas at higher elevation. Destructive east winds usually occur during December - January, when very cold high pressure systems are hanging over eastern Oregon. Almost all major wind events occur in fall, winter or early spring.

Regarding windthrow it is helpful to look at the Cyclone Salvage Environmental Assessment that was completed for 200 harvest units of timber that blew down in the 1989-90 wind storms in the Upper Clackamas watershed. Of the 200 units, which came to 802 acres, 18% or 144 acres of the windthrow occurred in areas that are now Riparian Reserves designated by the ROD. Of the 144 acres of riparian windthrow, 76% of this was found in the extreme southwest end of the watershed in Berry and Cub subwatersheds. South-southwest exposures of timber stand edge made up 59% of all windthrow salvage units. East exposures of stand edges only comprised 5% of the windthrow.

Insects, diseases and windthrow have a complex relationship. Most disturbance centers have two of these three factors present, if not all, and are known as a "pest complex". Trees with root diseases are more susceptible to windthrow. Douglas fir trees blown down by the wind are more susceptible to being invaded by bark beetles. These bark beetles can then hatch and fly to stands or trees weakened by other factors, such as root disease or drought. These relationships are understood but occurrence of these events is not very predictable due to the chaos within the ecosystem. What is known and can be predicted with a relative degree of accuracy is that harvesting has increased the incidence of windthrow in the watershed and bark beetle populations have expanded periodically with the amount of windthrow. A general rule of thumb is that for every three windthrown trees left in the woods, one live tree would become infested with bark beetles and die.

There are three insect species that have significantly affected the disturbance regimes within the forested areas of the Upper Clackamas watershed. The Douglas-fir bark beetle has affected approximately 2,000 acres in the last four years. The mountain pine beetle has been active within the lodgepole pine stands in the southeast portion of the watershed. There have been no recorded epidemics in this area but the stand density and size make an epidemic likely. The spruce budworm was active in some stands in the late 1980's and early 1990's. Their disturbance effect has been most noticeable in the overstocked stands in the higher elevations.

The tree disease which has had the most significant effect in this drainage is *Phellinus wierii*. This disease causes what is known as laminated root rot in Douglas-fir. Older trees with this disease tend to blow down very easily in a windstorm, creating small openings within forest stands. Young trees within plantations that become infected with *Phellinus*, will slowly die and spread the disease to adjacent trees.

The PULSE project produced a map (titled Insects, Disease, and Windthrow) which can be referred to for high risk windthrow areas and current activity centers of spruce budworm. The majority of areas recently affected by Douglas-fir bark beetle have been identified and can be found within the Beetlemania Environmental Assessment analysis file.

Wildlife

Vegetative landscape patterns, stand conditions and the network of aquatic habitats intermingle to support a diverse fauna. Sustaining wildlife populations is a key objective of forest management. In particular, late seral associates and aquatic species have been identified for special management strategies, culminating in the design of the LSR and Riparian Reserve network across the Pacific Northwest region today.

Past Conditions

Information about wildlife populations previous to the 1940s is sketchy, but can be at least partially inferred from vegetation patterns and historical records. Late and mid seral associated species were probably more abundant while early seral associates - including deer and elk - were rarer and likely concentrated in a few large patches in the landscape. Wolves, condor, and other large carnivores such as wolverine and lynx probably inhabited the watershed; bears were likely concentrated along the river bottom where fish were more abundant. Snags and coarse woody debris were plentiful in the landscape except where eliminated by extremely hot fires or repeated burns.

Current Habitat Condition / Diversity

The Forest-wide biodiversity assessment completed as part of the PULSE project in early 1994 predicted that 215 vertebrate species are expected to inhabit the Upper Clackamas watershed. The assessment, based on the Species Community and Conservation Assessment (SCCA) methodology, accounts for the influences that seral stage association, home range size and patch configuration (landscape pattern) are thought to exercise on the distribution of animals in the landscape. SCCA data does not include the portion of the watershed on Warm Springs Reservation.

Under the SCCA, certain criteria were used to classify wildlife species into guilds (Table 3-8). Seventeen terrestrial guilds and fourteen aquatic guilds were designated at the Forest level. One special habitat guild is also designated, which covers species reliant on special and unique habitats such as cliffs, bridges, and wetlands. A description of the SCCA methodology (Mellen et al., 1994) is available in the analysis file.

Terrestrial and Riparian Habitats

Amount of Habitat

Table 3-9 shows the total amount of habitat available for each guild within the watershed, as well as a subjective assessment of the connectivity of the available habitat. Maps of habitat for each guild and a list of species within each guild are available within the analysis file. Habitat is most abundant for generalist species of any home range size (TLGG, TMGG and TSGG guilds). By definition, generalist species can use all terrestrial seral stages and are not restricted by landscape pattern. Some generalist species in these guilds include coyote, black-headed grosbeak, pacific tree frog, and deer mouse. The next most common terrestrial guild is TLC (Terrestrial Large Contrast)

Table 3-8. Criteria used to group species by life history into guilds.

TERRESTRIAL: Terrestrial habitat users (may use riparian or special habitats as well but do not require them).

Home Range

- SMALL: Home ranges < 60 acres
- MEDIUM: Home ranges 60-1000 acres
- LARGE: Home ranges > 1000 acres

Patch type

- PATCH: Species requiring one homogenous patch (one structural stage) during life cycle (or breeding period for migrants).
- MOSAIC: Species capable of aggregating patches of like structual stages that are dispersed in a mosaic pattern across the landscape.
- CONTRAST: Species requiring juxtaposition of two dissimilar structural stages.
- GENERAL: Species that can use terrestrial habitat in any landscape pattern.

Stage

- EARLY: Early structural stage required.
- LATE: Late structural stage required.
- GENERAL: Can use any structural stage.
- EARLY-MID: Early or mid structural stage required.
- MID-LATE: Mid or late structural stage required.
- N/A: Not applicable.

RIPARIAN: Species that require aquatic or riparian habitats for breeding and/or feeding.

Water body

- LAKE: Aquatic/riparian obligate using only lakes
- LAKE/RIVER: Aquatic/riparian obligate using lakes or rivers or streams
- RIVER: Aquatic/riparian obligate using only rivers or streams.

Aquatic association

- A: Species use only the aquatic portion of the habitat
- AR: Species use both the aquatic and the riparian (edge or shoreline) portion of the habitat.

SPECIAL: Species requiring special and unique habitats such as caves, cliffs, bridges, buildings and wetlands for breeding and/or feeding

Table 3-9. Amount of habitat available for terrestrial and aquatic wildlife guilds.

Guild Category	Guild	Total Acres	Percent of Watershed	Connectivity	Home Range Size	Patch Type	Type of Water Body	Aquatic Association	Seral Stage
Terrestrial Guilds	TLME	5699	6%	Very Low	Large	Mosaic			Early
	TSME	11515	12%	Moderate	Small	Mosaic			Early
	TMME	14095	15%	Low	Medium	Mosaic			Early
	TSPE	18965	20%	Low	Small	Patch			Early
	TSC	19154	20%	Moderate	Small	Contrast			N/A
	TMC	24273	26%	Moderate	Medium	Contrast			N/A
	TMML	28380	30%	Moderate	Medium	Mosaic			Late
	TLML	38845	41%	Moderate/High	Large	Mosaic			Late
	TSPL	40537	43%	Moderate/High	Small	Patch			Late
	TLC	43927	46%	High	Large	Contrast			N/A
	TSGEM	50229	53%	Moderate	Small	General			Early-Mid
	TSGML	71183	75%	High	Small	General			Mid-Late
	TLGG	94814	100%	Very High	Large	General			General
	TMGG	94814	100%	Very High	Medium	General			General
	TSGG	94814	100%	Very High	Small	General			General
Aquatic Guilds	LKRVARE	0	0%				Lake/River	AR	Early
	LAKERE	64	0%				Lake	R	Early
	LAKEARE	81	0%				Lake	AR	Early
	LAKEA	215	0%				Lake	A	N/A
	LKRVRE	2274	2%				Lake/River	R	Early
	RIVA	10255	11%				River	A	N/A
	RIVARML	10255	11%				River	AR	Mid-Late
	LKRVARML	10287	11%				Lake/River	AR	Mid-Late
	LKRVA	12250	13%				Lake/River	A	N/A
	LKRVARG	12573	13%				Lake/River	AR	General

which includes species like elk and great horned owl which require early and late seral stages in close proximity.

Aquatic and riparian habitats are generally less abundant on the landscape than terrestrial habitats. The most scarce kind of aquatic habitat is for LKRVARE species (Lakes and Rivers, Aquatic and Riparian, Early seral on shore). Species in this guild include mallard and cinnamon teal.

From a Forest-wide perspective, the Upper Clackamas watershed provides a significant quantity of habitat for the following guilds: TLML (Terrestrial Large home range, Mosaic Late seral; includes spotted owl, pine marten and wolverine) and TLC (Terrestrial Large home range, Contrast species; includes elk).

Range of Natural Variability / Effect of Current Vegetation Patterns

The current arrangement of late, mid, and early seral patches on the landscape is considerably altered from the arrangement thought to be typical in the past (see Vegetation section). One result is that the distribution of habitat for terrestrial guilds is probably well outside the range of natural variability. In particular, patch, mosaic and contrast guilds have altered quantities and arrangements. Patch guilds contain species that require minimum contiguous acreages of habitat in their preferred seral stages. As patch size has decreased, so has the amount of habitat available for medium or large sized patch species. Increasing the number of patches and decreasing their size (as has occurred) also affects dispersal for patch species, especially those with small home ranges. Species with small home ranges that require patches would be expected to persist within even small patches - until the patch size falls below about 20 acres. Most of the patch species in the watershed do fall within the small home range type.

Mosaic guilds (including TLML, TMML and TMME) are sensitive to landscape fragmentation. Although species in these guilds can aggregate fragmented patches within their home ranges, patches that are too isolated are not likely to be used. Thus isolated patches cannot be expected to contribute to population maintenance of mosaic species. Map 3-5 illustrates the current situation for TLML guild species within the watershed. Patches coded 1-4 are all contributing to effective habitat for TLML species (with code 1 signifying the highest quality habitat in terms of patch size and connectedness, code 4 signifying the least). Patches coded 5 and 6 comprise late seral habitat but are too isolated to provide primary habitat. These patches do function as dispersal habitat, however. As Map 3-5 displays, significant blocks of high quality habitat are available within the watershed. The largest blocks are centered on the LSR but excellent habitat also exists to the East, West, and Southwest.

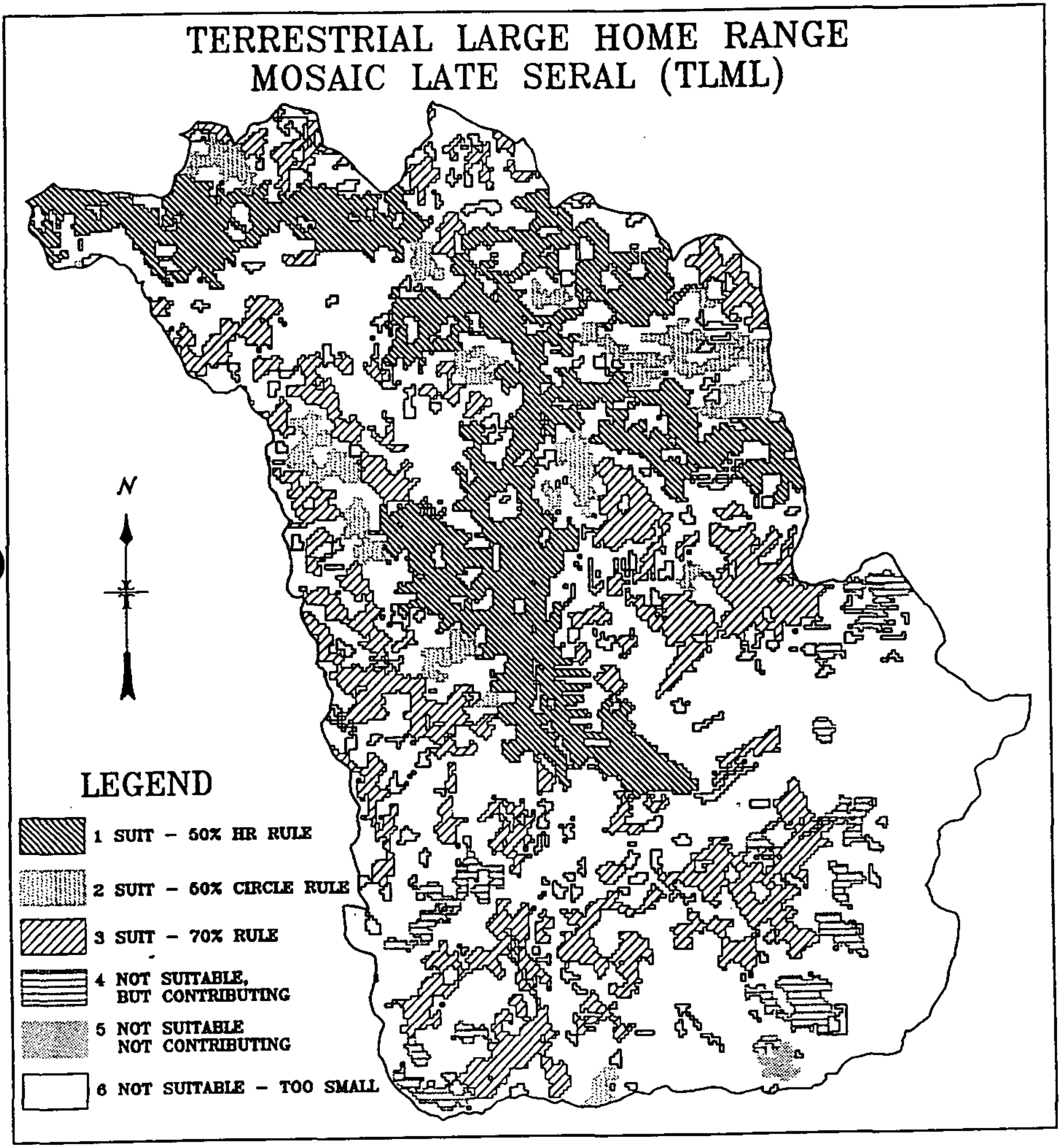
Contrast species respond favorably to fragmentation (but only where late seral meets early seral).

Special and Unique Habitats

Special and unique habitats including caves, rock, talus, cliffs, bridges, buildings, and wetlands are available within the watershed. Some special and unique habitats are shown on Map 3-6. The amount of acreage in special habitats is displayed in Table 3-10. The analysis file contains a list of species associated with or dependent on one or more special habitats. Certain special habitats such as wetlands are notable for providing "focal points" of diversity in the landscape - habitat provided for both a greater array and more unusual species than are found in the surrounding landscape. Detailed records of wildlife presence (from biologists' observations from 1982 to present) at wetlands, lakes and ponds within the watershed are available within the analysis file.

Other special and unique habitats identified by Brown (1985) include snags and coarse woody debris. The analysis file contains a list of species associated with snags , their seral association and role as cavity excavators. Snag density and condition is available from surveys completed in 1987 in unmanaged stands (late seral and naturally regenerated mid seral stands) and from 1992 surveys in managed stands (plantations and clearcuts). Figures 3-8 and 3-9 illustrate the distribution of large and medium-sized snags in unmanaged and managed stands, respectively. Large snags (critical to the survival and successful reproduction of the pileated woodpecker, spotted owl, and northern goshawk, among other species) are most abundant within unmanaged large conifer stands (late seral). From the figures it can also be seen that snags are generally more plentiful in the large conifer stand type than in other unmanaged stands or in plantations. Notable, however, is the high density of medium-sized snags in the unlogged small saw category (mid seral stands generally > 8" diameter at breast height). This is to be expected as small saw stands undergo self-thinning (via a variety of ecological mechanisms) as they grow toward the late seral stage. Snags are practically non-existent

Map 3-5. Terrestrial Large Home Range Mosaic Late Seral (TLML) Species Guild Habitat.



Map 3-6. Special and Unique Habitats.

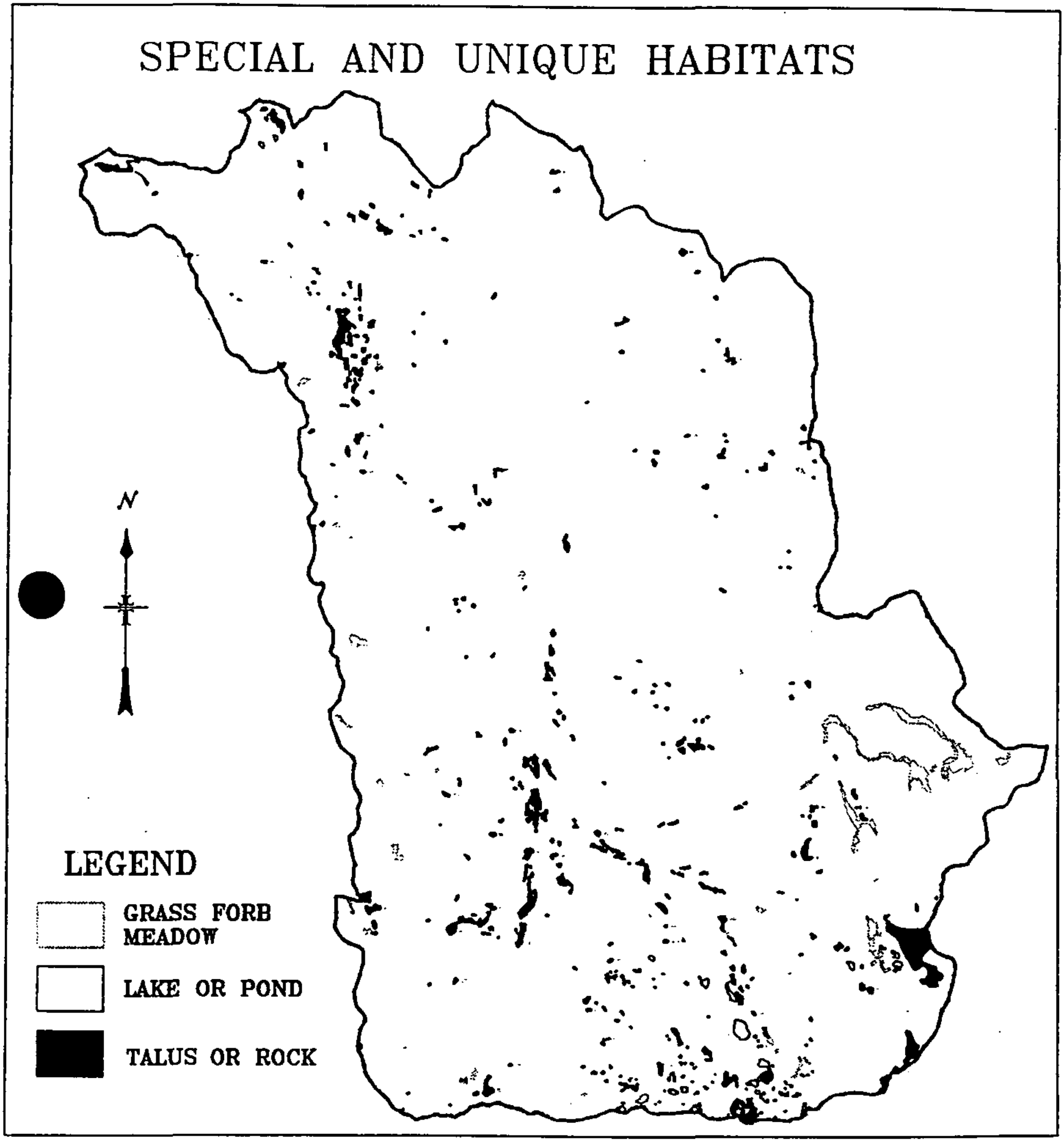


Table 3-10. Special habitat availability.

Type of Special Habitat	Total Acres
Bridges	4
Springs	77
Talus	1243
Buildings	10
Rock	598
Cliffs and Rock	23
Grass Forb Wetland	576
Shrub Wetland	158
Shrub	35
Shrub Wetland	18
Dry Meadow	0
Lava	0
Waterfalls	0

in the older managed plantations (size classes small saw and sapling pole) and are available in the early seral stands at an average rate of about 2 per acre.

The LMP and the ROD each tie snag retention levels to a certain percentage of the theoretical population potential (carrying capacity) of cavity nesting birds in the landscape. Minimum levels across the landscape are set at 40% by the ROD and LMP while the LMP sets a minimum level of 60% through time to be retained in new harvest units. Data from the surveys show that snag levels in unlogged late seral habitat exceed this minimum and in fact exceed the numbers typically stated necessary to attain 100% of potential population. However, these snags do not benefit some early seral associated cavity nesters since they will not use snags in closed canopy stands. According to the model put forward by Neitro et. al. (1985) with two snags per acre, the average existing biological potential in early seral habitats is slightly below the 60% level. As these clearcuts age into the mid seral stage, biological potential is likely to fall below 60% since windstorms often cause snag loss during the early and mid seral stages (Cline, 1980 and local observations). Tree topping can mitigate the rate of fall somewhat, but also accelerates the rate of decay. The loss of snags due to wind illustrates the need for adequate green tree retention in harvest units and intelligent location of these areas to minimize potential wind damage. Plantations in the mid seral stage are currently at zero biological potential for snags.

Coarse woody debris is important for denning areas, invertebrate prey sources for insectivorous birds and salamanders, and habitat for voles, shrews, and various fungi which are utilized by the northern flying squirrel and other small mammals. Coarse woody debris density and condition is available from the surveys conducted in 1987 and 1992 that were described above. Figures 3-10 and 3-11 illustrate the distribution of coarse woody debris in the unmanaged and managed stands, respectively. Coarse woody debris availability corresponds well with the snag availability discussed above - namely, logs are most abundant (between 15-20 hard logs per acre) in the unmanaged large conifer and small saw categories and least abundant in the managed stands (between 5-6 hard logs per acre). ROD standards for regeneration units in the Matrix (retention of 240 lineal feet per acre, 20" minimum diameter) is equivalent to 15 pieces per acre - closely corresponding to levels that are currently available in large conifer stands but quite a bit higher than the amounts typically found today in regeneration units.

Figure 3-8. Hard snag density in unmanaged stands; large and medium size class.

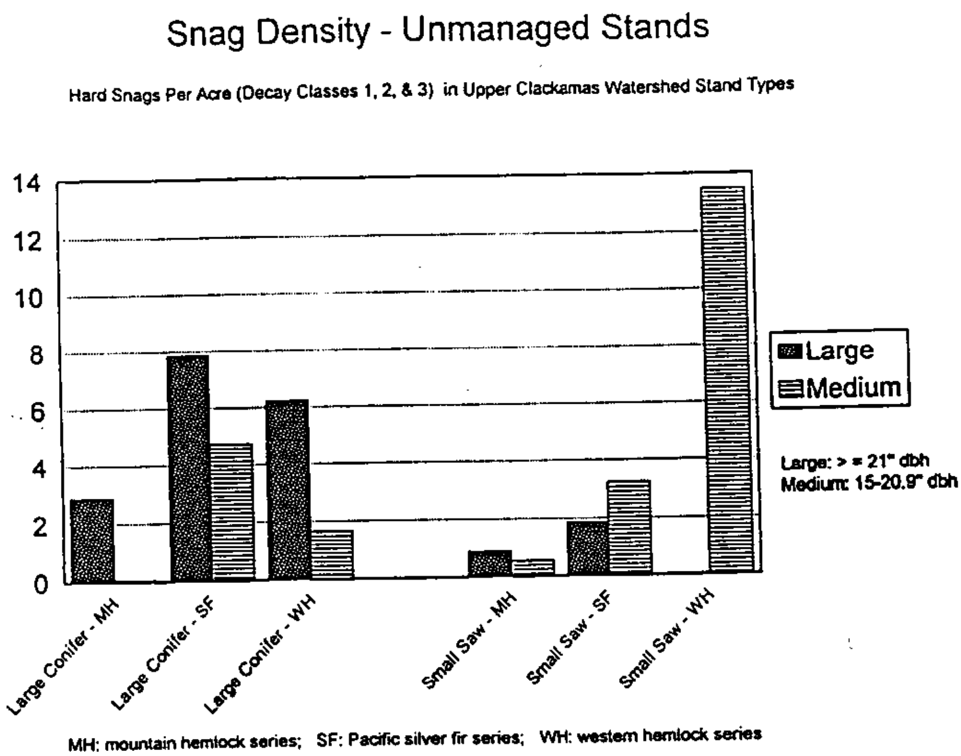


Figure 3-9. Hard snag density in managed stands (plantations); large and medium size classes.

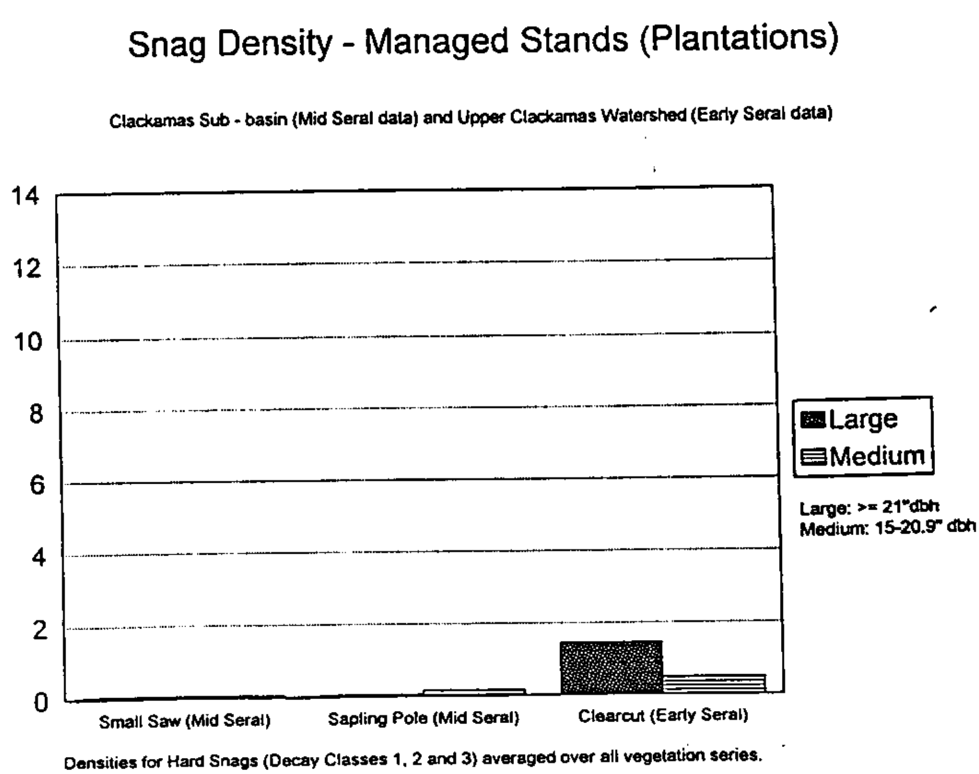


Figure 3-10. Coarse woody debris density in unmanaged stands.

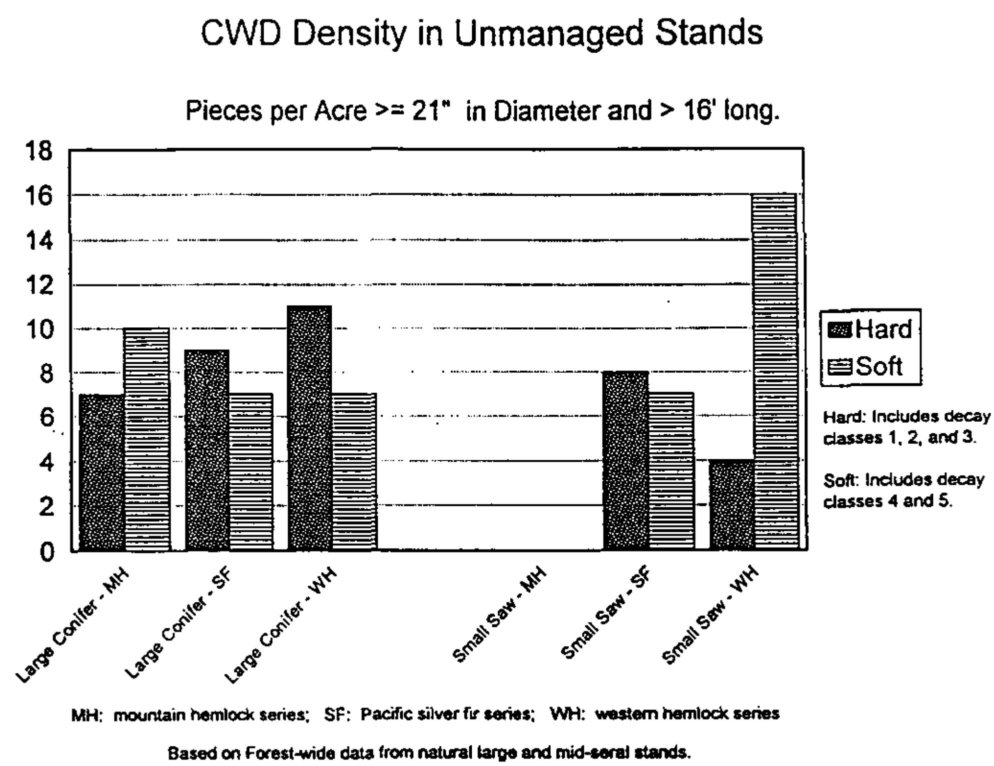
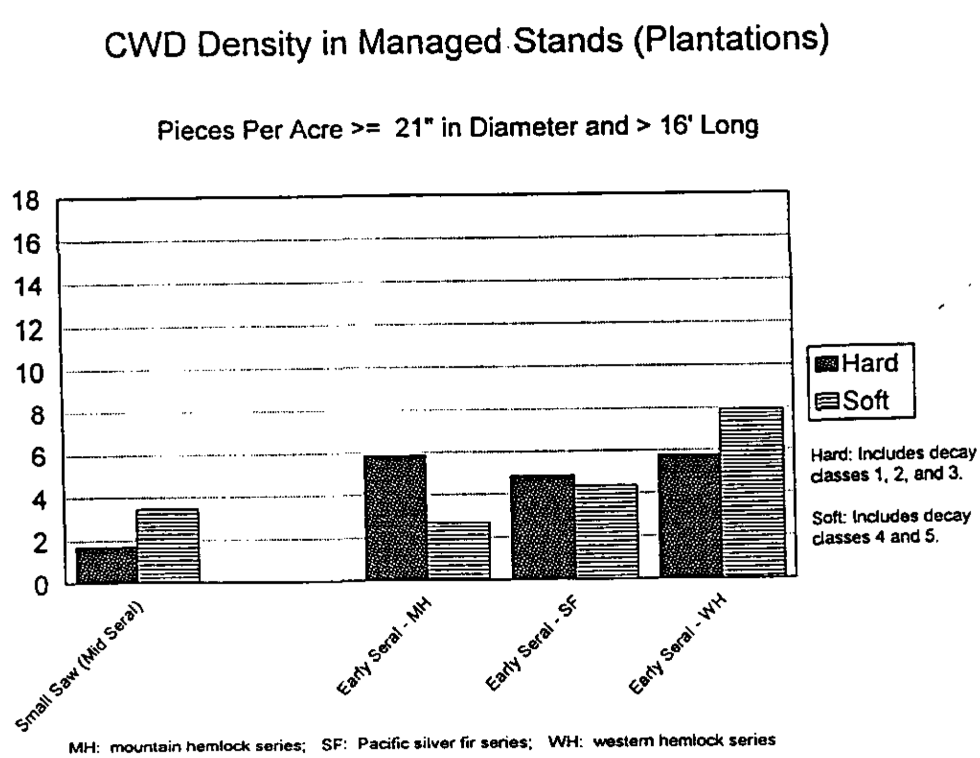


Figure 3-11. Coarse woody debris density in managed stands (plantations).



Threatened, Endangered, and Sensitive Species

One endangered species (peregrine falcon) and two threatened species (bald eagle and spotted owl) occupy the watershed . Six other species that are classified as sensitive by the Regional Forester (based upon state listings of these species as threatened or endangered) are also known or suspected to be present within the watershed (Forest Service Manual 2670). These sensitive species are: harlequin duck, sandhill crane, Cope's salamander, Townsend's big eared bat, California wolverine, and red-legged frog. The species at risk have some commonalities - several are associated with aquatic systems or rare habitats (caves, cliffs, wet meadows, abandoned structures). The others are large, wide-ranging predators with at least some sensitivity to human or landscape disturbance.

Northern Spotted Owl

Spotted owls are dependent on all of the attributes of a late-successional forest, including large diameter trees, a multi-layered canopy, the presence of large snags and large coarse woody debris in various decay stages.

Survey efforts completed since 1990 determined that 41 pairs and 5 resident singles have territories in the Upper Clackamas watershed. Five of the pairs have more than one known nest tree - thus a total of 52 activity centers are identified. Twenty-three of the activity centers are currently located inside the large Clackamas River LSR - most situated at the wider southern end. Seventeen of the others are outside of the mapped LSR, but have 100 acres of unmapped LSR surrounding the activity center. Twelve activity centers (eleven of these are pair centers) have no designated habitat protection because they were found for the first time in the summer of 1994 after the reserves around the known spotted owl activity centers were established, or because better information about the territories from 1994 surveys warranted moving the designated activity center from its previous location. Moving mapped activity centers occurred when, for example, a pair was recorded from a day roost formerly, but this year surveys found the same pair in a different (but nearby) location with young. Some of the unmapped LSRs do not currently have activity centers due to this movement. The ROD states that unmapped LSRs are not to be moved.

Most of the owl territories are overlapped with 3 to 4 other owl territories at a radius of 1.2 miles from the activity center. Overlap is slightly higher within the LSR and the West and South subwatershed groups, suggesting that owls are more "packed" into the available habitat here, which may be a function of habitat connectivity and quality.

Thirteen activity centers are currently below take thresholds as established by the U.S. Fish and Wildlife Service. Eight of these are in the Matrix. Three additional areas do not have complete data; analysis at the 1.2 mile radius level includes a large proportion of habitat outside the watershed on the Warm Springs Reservation, and the owl habitat availability in these areas has not been assessed. The take thresholds are based on analysis of pair territorial persistence and reproductive success. Empirical data shows that reproduction and survival are compromised if the available nesting, roosting and foraging habitat comprises less than 70 acres in a radius 0.25 miles around the activity center, 500 acres within a 0.7 mile radius and 1,182 acres within a 1.2 mile radius around the activity center.

Reproductive histories of certain owl pairs are known for 4 to 5 consecutive years. However, data on the breeding success of other known pairs is more sparse (not all identified activity centers are surveyed in every breeding season). Hence, an analysis of reproductive success by activity center would be incomplete at this time and was not assessed for this document.

Suitable spotted owl habitat has been divided into two categories for analysis purposes. Nesting roosting and foraging habitat (NRF) for the owl includes habitat that is in a condition to support survival and breeding of owls. Within the watershed owls are known to use mid seral stands with a medium - high component of residual large trees, snags and coarse woody debris. Thus NRF habitat is more inclusive than late seral habitat. Dispersal habitat is habitat that supports roosting, foraging and dispersal, but may lack the necessary attributes to support successful breeding. Based on the information used in the Interagency Scientific Committee report (Thomas et al., 1990), dispersal habitat is defined here as forested habitat with an average tree size of at least 11 inches and with at least 40% canopy closure. Spotted owl habitat is distributed across the landscape as described in Table 3-11 which shows that both NRF habitat and dispersal habitat are more abundant within the mapped and unmapped LSRs than in the Riparian Reserves and Matrix.

Table 3-11. Owl habitat by allocation.

Land Allocation	Acres of NRF* Habitat	Percent of Allocation	Acres of Dispersal Habitat	Percent of Allocation
Late-Successional Reserves	19,707	61	21,897	68
Riparian Reserves Outside of LSR	6,043	53	6,497	57
Unmapped LSR (Owl 100's)	1,904	89	1,970	92
Matrix	23,630	46	26,569	48

*NRF = Nesting, roosting, and foraging

Policy

Forest policy has been to minimize take of spotted owls. Thus harvest units have been delineated away from owls that are below or near the thresholds discussed above. Forest policy has changed with the ROD, but an acceptable rate of take within each watershed has not yet been defined.

Critical Habitat Units (CHUs) still exist as mapped in 1991. According to biologists at the US Fish and Wildlife Service (USFWS), in all likelihood the ROD will be adopted as the Final Recovery Plan for the northern spotted owl; the LSRs and reserves around known owl activity centers will comprise the new CHU. Until that time, however, USFWS requires that the Forest Service analyze impacts to existing delineations of the CHUs in project plans likely to affect the spotted owl. There are about 48,300 acres of CHU in the watershed. Of that, about 25,000 acres is nesting, roosting, and foraging habitat (52%), and about 26,900 acres is dispersal habitat (56%).

Bald Eagle

Bald eagles are occasionally sighted on the Clackamas River and in the Olallie area. No nests or communal winter roosts are known within the watershed. Nests are known from Detroit Lake and Marion Lake, in the Willamette National Forest.

Aerial and foot surveys and an assessment of the habitat condition for bald eagles were completed in 1993 by Richard Frenzel, Ph D, within the entire Clackamas River corridor, the Olallie area, and the Collawash River corridor. No pairs or signs of eagle nesting activity were recorded.

Frenzel concluded that habitat conditions through most of the upper Clackamas River corridor were marginal to poor for bald eagle occupancy, due mainly to limited prey density and prey availability. In these areas there are few to no opportunities for enhancement, since the limiting factors are inherent to the topography and physical features of the upper river (narrow strip of open water and low flows) and represent significant obstacles to successful eagle foraging.

A few areas (Big Bottom, Olallie) were deemed fair. Frenzel felt that the Big Bottom area could potentially be improved by increasing resident fish densities. The lakes in the Olallie Scenic Area are generally frozen over well into the nesting season and thus do not represent a stable food source for breeding eagles. In addition, the Olallie area lacks a good supply of large trees adequate to support a nest.

Bald eagle populations in Oregon are increasing - known nests numbered 150 in 1980 and 210 in 1993.

Peregrine Falcons

Forty cliff sites in the Clackamas subbasin thought to have some potential for peregrine nesting were surveyed aerially and/or from the ground by Avian Field Research in 1993. Survey results revealed two eyries (nest sites), one of which produced fledgling young. Each of these sites were located just outside the boundary of the Upper Clackamas watershed and the birds undoubtedly foraged within the watershed. Not until that survey had there been a documented successful eyrie within the Forest boundary, although hacking (release of young) has taken place since 1986.

Although no eyries were located within the watershed, several sites were classified as having high and medium potential for peregrine nesting. High potential sites include Mt. Lowe and Granite Peaks.

Sensitive Species

Over the last several years, surveys have been carried out sporadically for the wolverine, harlequin duck, sandhill crane, Townsend's big-eared bat, Cope's salamander and the red-legged frog. The ROD addresses viability of these species. Habitat needs for these species are available from the scientific literature and are not reiterated here. Results of survey and habitat assessments from local data is presented briefly here:

(1) Townsend's big-eared bat winter hibernacula sites have been located in the neighboring watershed in mine tunnels, while summer roost sites (for males) included buildings and bridges within the watershed. No maternity colonies have been located.

(2) Sandhill crane pairs are known to occupy some of the large wet meadows within the watershed during the breeding season. Although successful reproduction has not been documented from these sites, the species did fledge young from a site on the Bear Springs Ranger District in 1992. Potential exists for successful breeding in several of the meadows within the Upper Clackamas - specifically Olallie Meadow, Lemiti Meadow, Cornpatch Meadow, Rhododendron Meadow, and Cachebox Meadow.

(3) Surveys completed over the last several years by volunteers and stream survey crews have revealed that red-legged frogs are fairly abundant from slow stretches of streams, ponds, and wet meadows within the lower elevational bands of the watershed.

(4) Tracking and baited camera stations have been used to survey for wolverine over the last several years but no wolverine have been sighted within the watershed for at least a decade. Wolverine have been recently confirmed from several locations to the north and one was killed crossing Interstate 84 in 1991.

(5) Harlequin ducks have been infrequently sighted within the watershed and no nest sites are known. Data from a cooperative USFS/Oregon State University/Oregon Department of Fish and Wildlife (ODFW) study carried out in the McKenzie, Molalla, and Santiam River drainages revealed that harlequins may be expected to use streams ranging in width from 2-60 m. with an average width of 23 meters. The stream with the highest density of broods had much bedrock in the channel, an open-canopied riparian zone, relatively warm water and extremely high human use during the spring and summer. The authors speculated that the harlequin density may be positively associated with high densities of caddis fly larvae and snails.

(6) Cope's salamanders are difficult to distinguish from Pacific Giant Salamanders. Many sightings have been turned in but most remain unconfirmed. Their habitat, cold mountain streams and rivers with a cobbly substrate and many small pools, is fairly wide-spread within the drainage.

Other Species of Concern

Pine Marten and Pileated Woodpecker

Sighting data reveals that the pileated woodpecker is uncommon but fairly well distributed in late seral stands throughout the watershed. Pine martens are mainly documented in the Olallie area (including the southern reaches of the LSR). Snowmobile tracking and remote camera stations have been employed to survey for pine martens in the last several winters, but none have been found outside of the Olallie area.

Species of Concern under the ROD

In Appendix J-2 of the Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl (FSEIS) (USDA 1994b), special concerns were expressed about the viability of many species associated with riparian and late seral conditions. Locally, the Upper Clackamas watershed may provide habitat for some of these species, including the vertebrates Cascade torrent salamander, Cope's salamander, tailed frog, Van Dyke's salamander, Oregon slender salamander, black-backed woodpecker, common merganser, fringed myotis, hoary bat, long-eared myotis, long-legged myotis, silver-haired bat, fisher, marten and red tree vole. Local data on the distribution of these species is scarce, but verified sightings within the watershed or district have been recently recorded for tailed frog, black-backed woodpecker, common merganser, fringed myotis, long-eared myotis, long-legged myotis, silver-haired bat, fisher and marten. Several of these species were selected for the Survey and Manage provision under the ROD, which applies to all land allocations.

LSR Role in Habitat Conservation for Late Seral Associates

A glance at the map of LSRs throughout the range of the northern spotted owl (USDA 1994a) quickly reveals that the Clackamas River LSR is different. Rather than being round and fat (as most of the rest on Forest Service lands are) or checkerboard shaped (as many of the Bureau of Land Management LSRs are), this LSR is long and narrow and appears placed mainly as a connection between the Roaring River LSR and the Breitenbush / Mt. Jefferson LSR.

The Clackamas River LSR has a very high ratio of perimeter to area, probably one of the highest ratios for LSRs in the region. This characteristic results in a situation where species territory centers inside the LSR are potentially affected by changes outside the LSR. Timber harvest activities in the Matrix have a good chance of affecting habitat directly available to LSR species, particularly those with large home ranges like the spotted owl

The LSR is also distinguished by the presence of well-used road running through its center and a powerline corridor bisecting it in two places. The effects of roads on late seral inhabitants is not well understood since roads bring people and the cumulative effect can have complex results. In general, birds and flying mammals are expected to be less affected by roads than animals that do not fly. The effect of the powerline is unknown, but is probably less of a barrier than the road.

As discussed in the vegetation section, a large amount of the LSR is situated within the mountain hemlock vegetation series. Forested stands in the mountain hemlock zone often achieve late seral status but not always. Some of the areas in the LSR within this zone are thought to be unlikely to achieve late seral status, particularly those areas south of the powerline that signifies the boundary of Olallie Lake Scenic Area. Interestingly, this area is one of the only areas where pine martens have been consistently sighted in the watershed.

Evaluation of LSR Effectiveness

The FSEIS (USDA 1994a) referenced the Interagency Scientific Committee report model which showed that owl "clusters" of 15 - 30 owls (numbers varied depending on the assumptions for juvenile dispersal) could be expected to be "self-sustaining" or unlikely to disappear due to random demographic and environmental events. This finding led to the original impetus to draw HCAs (and later, LSRs in such a way that they encompass potential territories for 15 to 30 pairs of owls. Theoretically, take could occur within the Matrix without significantly affecting owl population dynamics if two conditions are met: (1) a cluster of 15 to 30 reproductively successful pairs owls is maintained in an interconnected part of the landscape; and (2) dispersal habitat leading to other significant sources of owls (e.g. other productive LSRs) is maintained over time.

A fully functioning LSR can be evaluated on several criteria. The above is one suggested measure; using the higher estimate of 30 owls per cluster would provide opportunities to incorporate new information in the future. It is also appropriate to evaluate the biological status of other late seral associates inhabiting the LSR. Currently, that kind of information is sparse. Another measure is the percentage of LSR in late seral habitat. Currently the LSR is comprised of 48% late seral, 35% mid seral and 17% early seral. Intuitively, a fully functioning LSR should be largely late seral. A range between 90 to 100% would be desirable, however this amount may not be attainable since a large portion of the mid seral is not capable of growing to late seral.

Dispersal

Distribution (connectivity) of habitats has been recognized as an important consideration in habitat management (Lehmkuhl and Ruggiero, 1991; Thomas et al. 1993). Dispersal habitat management has the primary goal of ensuring safe passage for animals between breeding territories, thus maintaining genetic flow and correspondingly, a healthy, resilient population. In particular, dispersal of late seral associated organisms emerged as a key biodiversity issue as regional forest landscapes became visibly fragmented.

Under the ROD, Riparian Reserves which include upland habitat are envisioned as the primary mechanism to assure dispersal of late seral associates between LSRs. Dispersal pathways for early and mid seral associates were not addressed by the ROD.

Dispersal needs for most late seral organisms are not well documented. Dispersal habitat has been roughly defined for the spotted owl as habitat in an 11-40 condition. It is not known whether other late seral associates (including vertebrates and invertebrates, vascular and non-vascular plants and fungi) have more restrictive needs or less. Until more is known on this topic it seems safe to assume that late seral associates require late seral habitat for effective dispersal to neighboring LSRs.

Within the Upper Clackamas watershed, Riparian Reserves radiate out in most directions from the LSR (Map 1-3). Adjacent LSRs are located to the south, west, and north (Map 3-7), hence the most important dispersal pathways are in these directions.

The Riparian Reserves reach their highest density as a percentage of the subwatersheds in the Northwest and South groups; the Mainstem and West groups have a moderate density and the East and Southeast Groups the lowest density. Thus potential dispersal habitat under the current land management strategy is most abundant to the Northwest and South. Dispersal habitat radiating south is partially provided for by the LSR, which is quite broad at the southern end (though the high elevation areas at the extreme southern end may represent dispersal barriers to some late seral species).

The Riparian Reserves in each subwatershed group are comprised of from 10 to 64% late seral habitat with an average of 48% overall (see Table 3-6). The Matrix also currently includes late seral habitat. Presumably, dispersal by late seral associates is currently strongly influenced by the presence of late seral patches in the Matrix. Under the above assumption, the Riparian Reserves are currently providing 48% late seral dispersal habitat.

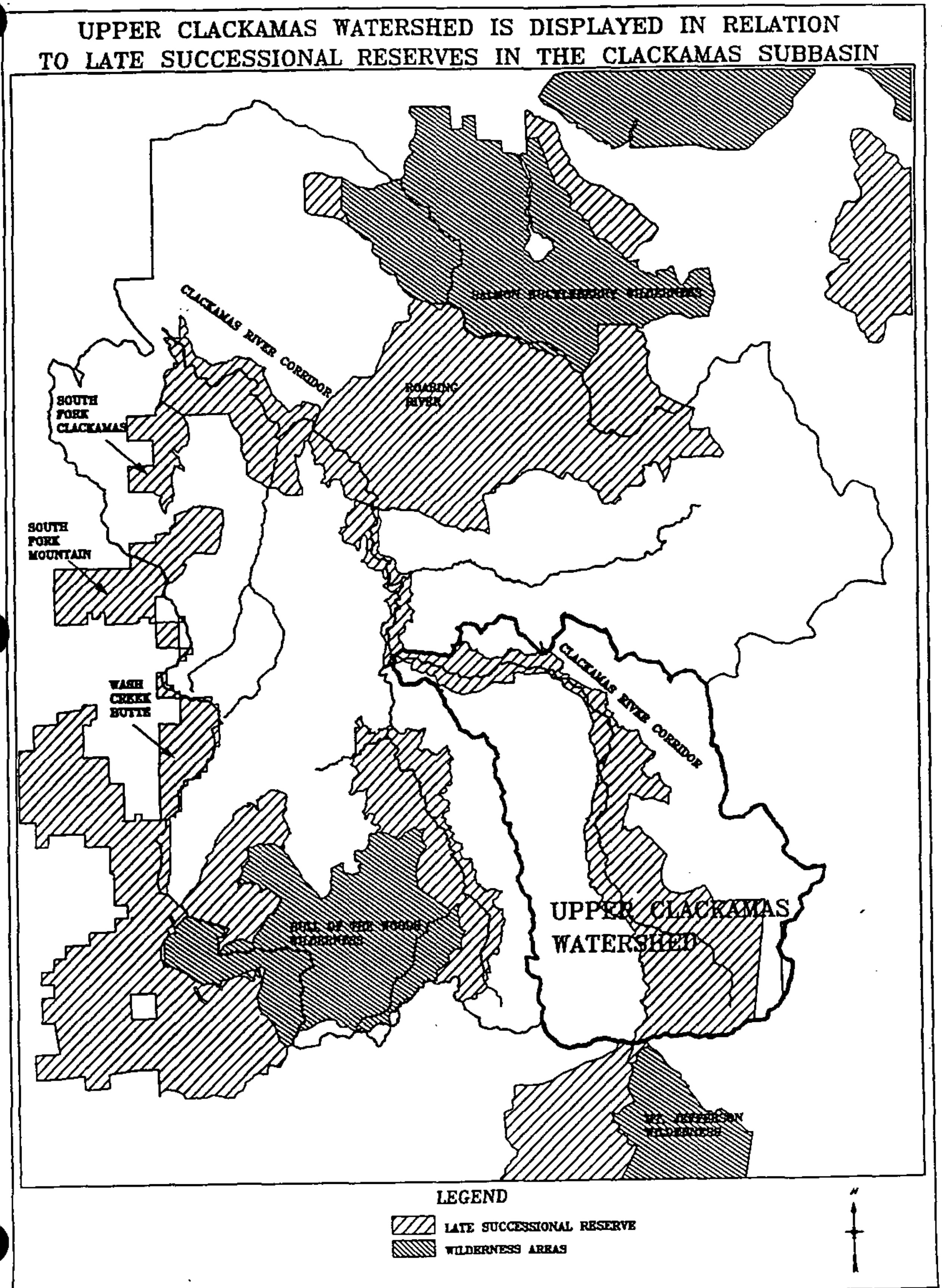
Role of Pine Marten / Pileated Woodpecker Management Areas

Within the watershed, the existing pine marten and pileated woodpecker habitat areas under the LMP (B5 allocation) were evaluated with respect to the connectivity-based thinking described above. In particular, the amount of late seral habitat and the value of that habitat with respect to connectivity and size of patch were evaluated for each area. The method used was to evaluate the amount and type of TLML (Terrestrial Large home range, Late seral) habitat within each B5 area, using the coding system developed for mosaic habitats described above (pine marten and pileated woodpecker are both considered part of the TLML guild).

Thirteen B5 areas are located within the watershed outside the bounds of the existing LSR. Several of these include expanses of Riparian Reserves. Of the thirteen areas, the following four were deemed notable for the amount of connected late seral habitat that they incorporate. TLML habitat Type 1 is considered superior to Type 2 and so on.

MR Name	Location Relative to LSR	Incorporation of TLML Habitat
3141W	North	Core on 2 and 3
3261M	East	Core on 2. Also encompasses some 6.
3021M	West	Encompasses 2 and 6.
3251M	West	Encompasses 1

Map 3-7. Late-Successional Reserves in the Clackamas Subbasin.



The other nine B5 areas in the watershed are not located in areas of superior TLML habitat. These nine B5 areas are not located within the best areas to conserve for the purposes of conserving existing patterns of connected late seral landscape in the Matrix while the LSRs and Riparian Reserves recover. These four B5 areas could contribute to that objective, again, either as formal allocations or as informal delineations.

As a whole, the B5 areas are not placed in such a way that they promote connectivity of important late-seral areas in the Matrix. Other areas, specifically, TLML habitat (areas coded 1, 2, and 3) and interior habitat blocks are superior.

Economically Important Species

Deer and Elk

Deer and elk range throughout the Upper Clackamas watershed. Lower lying areas adjacent to the Clackamas River Corridor and extending up Pinhead Creek drainage comprise winter range in normal years (approximately 11,700 acres or about 12% of the watershed). In unusually warm years, Cub and Berry Creek areas are also used by wintering elk. Some of the elk herds on the southern edge of the watershed move further south for the winter (into the Willamette National Forest), while those on the eastern edge of the watershed move into Warm Springs Reservation.

Telemetry information gained through a five-year cooperative elk study with the Confederated Tribes of the Warm Springs and ODFW (Feidler, 1992) yielded valuable information about habitat uses, home range sizes, herd sizes, calving areas, and other attributes related to elk. The study showed that elk were located within 100 meters of a riparian area 70% of the time. In addition, the elk preferred old-growth and early seral stages to mid seral. Areas that had been enhanced with nutritive grasses, forbs and or shrubs were used far out of proportion to their availability. Additional studies along the Cascade Crest (Calvin, et. al., 1991) have validated much of the information in the first study as well as showing that adult and calf elk mortality outside of the hunting season is relatively high in the Sisi/Lemiti/Olallie area. The cause of the mortality is unknown.

Deer have not been studied intensively within the watershed, but are generally considered to be wider ranging, more tolerant of human disturbance, and less dependent on riparian areas and forage seeded units.

Normally no more than a dozen bull elk are killed during the hunting season every year. Most are taken from the Lemiti or Hawk Mountain area. Deer are harvested in a variety of locations. Hunter success has declined somewhat over the years and ODFW has begun to implement a lottery system for the taking of does (rather than the one week antlerless season available in the past) partly in response to the perception of diminished deer populations.

Available thermal cover, especially optimal cover (thermal cover with forage interspersed in small openings) may be more important to overwintering deer and elk than large forage openings - especially in cold hard winters. Minimum levels of optimal and thermal cover are set under the

LMP. Area analysis (see Table 3-12) was conducted by fixed analysis areas (known collectively as Range X) established several years ago. The analysis areas differ slightly from the watershed boundaries and were designed to analyze habitat components within the two ecological classifications deemed most important to deer and elk - winter and summer range. The analysis shows that most areas are well within the standard. Range X areas Lemiti, Fish Lake and Northeast Sisi areas are currently under the prescribed levels, while Granite, Pot and Graham Pass areas are all nearing the minimum limit. Interestingly, the shortage of optimal and thermal cover in the Lemiti and Northeast Sisi areas does not appear to preclude use by elk; currently some of the largest elk herds are located in this area. One reason may be that these areas are relatively isolated and still roaded more lightly than many other areas of the district (see Table 3-13). These areas may represent "security areas" for elk despite the low proportion of optimal and thermal cover. "Effective" thermal cover may be less critical to deer and elk in summering areas than in wintering areas, since foraging times in open areas more do not coincide with deer and elk would be expected to avoid summer extreme hot temperatures by their when foraging at night.

Other Game Animals

Grouse, quail, and band-tailed pigeons are hunted occasionally on the watershed. Turkey were released in 1991 and are still occasionally sighted in the watershed. Habitat conditions for gamebirds is currently good, although mountain quail are not as numerous on the district as in the past. These species require seeds and fruits as well as adequate cover near the ground.

Cougar and bear are also hunted. Bear appear to be most numerous in the Olallie area while cougar are reported more from the Rhododendron Ridge area than elsewhere.

Table 3-12. Optimal and thermal cover by big game fixed analysis areas (Range X).

Range X Area	Location	Acres Within Upper Clackamas	Acres of Optimal Cover	Percent Optimal	Minimum Optimal %	Acres of Combined Optimal & Thermal	Percent Combined Cover	Minimum Comb. %
Key Winter Range 6	Big Bottom	4599	2731	59%	25	2829	62%	50
Key Winter Range 8	Sluice	785	302	39%	25	483	61%	50
Summer Range 10	Last	6658	3224	48%	20	3488	52%	30
Summer Range 11	Pinhead	4302	1674	39%	20	1766	41%	30
Summer Range 12	West Pin	3395	1058	31%	20	1498	44%	30
Summer Range 13	NE Sisi	3012	253	8%	20	384	13%	30
Summer Range 14	SW Sisi	3260	1565	48%	20	1784	55%	30
Summer Range 15	Squirrel	6098	2279	37%	20	3540	58%	30
Summer Range 16	Fish Lake	6132	777	13%	20	2278	37%	30
Summer Range 19	Granite	3616	934	26%	20	1838	51%	30
Summer Range 20	June	6444	1838	29%	20	3019	47%	30
Summer Range 21	Lowe	3723	1562	42%	20	1950	52%	30
Summer Range 22	Fawn	3331	1199	36%	20	1417	43%	30
Summer Range 23	Hunter	3137	1405	45%	20	1548	49%	30
Summer Range 24	Berry	6508	3102	48%	20	3466	53%	30
Summer Range 25	Cub	6446	2174	34%	20	2277	35%	30
Summer Range 6	Kink	2118	900	42%	20	1098	52%	30
Summer Range 8	Pot	4505	1478	33%	20	1670	37%	30
Summer Range B11 - 1	Sheep Springs	925	430	47%	20	467	50%	30
Summer Range B11 - 2	Lemiti	3752	442	12%	20	846	23%	30
Summer Range B11 - 3	Graham Pass	4582	935	20%	20	1423	31%	30
Winter Range 5	Mid Clackamas	3640	2424	67%	20	2691	74%	40
Winter Range 7	Upper Clackamas	2643	2146	81%	20	2162	82%	40

Table 3-13. Road density for big game by fixed analysis areas (Range X).

Range X Area	Area Name	Acres Within Upper Clackamas	Total Road Miles	Existing Road Mi./Sq. Mi.	Open Road Mi./Sq. Mi.	Target Road Mi./Sq. Mi.
Key Winter Range 6	Big Bottom	4599	30.0	4.2	2.0	1.5
Key Winter Range 8	Sluice	785	5.3	4.3	2.6	1.5
Summer Range 10	Last	6658	44.5	4.3	2.0	2.5
Summer Range 11	Pinhead	4302	30.4	4.5	2.8	2.5
Summer Range 12	West Pin	3395	18.8	3.5	1.1	2.5
Summer Range 13	NE Sisi	3012	2.6	0.6	0.3	2.5
Summer Range 14	SW Sisi	3260	11.7	2.3	1.7	2.5
Summer Range 15	Squirrel	6098	30.1	3.2	2.6	2.5
Summer Range 16	Fish Lake	6132	10.3	1.1	1.1	2.5
Summer Range 19	Granite	3616	20.9	3.7	2.5	2.5
Summer Range 20	June	6444	33.3	3.3	2.3	2.5
Summer Range 21	Lowe	3723	20.8	3.6	2.4	2.5
Summer Range 22	Fawn	3331	17.5	3.4	1.7	2.5
Summer Range 23	Hunter	3137	23.4	4.8	2.9	2.5
Summer Range 24	Berry	6508	34.0	3.3	2.1	2.5
Summer Range 25	Cub	6446	36.6	3.6	2.7	2.5
Summer Range 6	Kink	2118	12.3	3.7	1.4	2.5
Summer Range 8	Pot	4505	34.5	4.9	2.4	2.5
Summer Range B11 - 1	Sheep Springs	925	3.3	2.3	0.8	1.5
Summer Range B11 - 2	Lemiti	3752	11.7	2.0	1.5	1.5
Summer Range B11 - 3	Graham Pass	4582	18.9	2.6	1.6	1.5
Winter Range 5	Mid Clackamas	3640	16.5	2.9	2.5	2.0
Winter Range 7	Upper Clackamas	2643	16.5	4.0	2.2	2.0

Hillslope Processes

Range of Natural Conditions

Four primary factors affect soil productivity, soil erosion, sediment production, and sediment delivery to streams in the Upper Clackamas watershed: geology, landforms, landslides, and soils.

Geology

The character of the Upper Clackamas watershed is strongly influenced by geology. The Clackamas River flows through parts of the two physiographic provinces that comprise the Oregon Cascades; the older Western Cascade and the younger High Cascade physiographic provinces. The Western Cascade province consists chiefly of dark colored andesitic lava flows, light colored pyroclastic flows, and related intrusions and deposits. These rocks dip slightly eastward, have undergone widespread low-grade metamorphism and local hydrothermal alteration, and have been deeply dissected by stream and glacial erosion. The younger rocks of the High Cascade province form a plateau capping the Cascade Range. These rocks are slightly altered, dark-colored basaltic and andesitic lava flows. The high plateau has been only slightly dissected by stream and glacial erosion. The watershed is transected by numerous southeast-northwest trending faults which disrupt and complicate the geology.

Volcanics

The rocks of the Western Cascade province developed approximately 20 million to 5 million years ago. The two oldest formations in the watershed are exposed in the extreme northwest portion of the drainage along the steep north and south facing slopes of the Clackamas River from Big Bottom to the confluence of the Collawash and Clackamas rivers. The oldest formation, the andesites of Nohorn Creek (Tn), is found in the lower 3.5 miles of the watershed between elevations of 1,450 and 2,400 feet, and consist of andesitic lava flows with minor interbeds of less resistant materials. The lower hillslopes adjacent to Austin Hot Springs are an example of this formation. The beds of Bull Creek Formation (Tbc) is exposed within the lower 7.5 miles of the watershed between elevations of 2,000 and 3,200 feet and is characterized by weak pyroclastic deposits with interbeds of more resistant andesitic flows. The middle reach of Switch Creek flows through this formation. The Rhododendron Formation (Tr), positioned above the beds of Bull Creek, is generally found at various locations on both sides of the Clackamas River between elevations of 2,400 and 4,800 feet from Austin Hot Springs south toward Hawk Mountain and southeast toward the area north of Sisi Butte. Like the beds of Bull Creek, it consists of weak pyroclastic deposits interbedded with thinner flows of resistant lava. It is thought to be derived from volcanoes west of the Clackamas River. Granite Peaks is probably the eroded core of one such volcano.

Rocks of the High Cascade Province developed approximately 5 million to 12,000 years ago. Older basalt and basaltic andesite flows (QTb) cap the ridge positions on the north and west slopes of the watershed, including Burnt Granite, Hawk Mountain and Bald Butte along Rhododendron Ridge, and Oak Grove Butte and Peavine Mountain in the north. The light grey basaltic lava flows of the

Basalts of Minto Mountain (QTbm) form Sisi, Olallie, West Pinhead and South Pinhead Buttes, volcanoes located in the southeastern third of the watershed.

Localized areas of intrusive rocks (QTi,Tipa,Tiha) are found primarily in the western portion of the watershed, and include those features forming the summit of Mt. Lowe and the rib of resistant rock protruding at the top of Sisi Butte.

Glacial Deposits

During the most recent glacial advance, small alpine glaciers formed in upper Granite Creek, the drainage west of Granite Creek, in the Clackamas River above the Road 4650 bridge at river mile (RM) 65, and in the upper reaches of all drainages that enter the Clackamas River above this point, with the most extensive coverage on the eastern slopes of the watershed (Qyt). Glaciation has smoothed valley sides and widened valley floors in these subwatersheds. Material from earlier and more extensive glacial episodes has been mapped in Kansas Creek and on the flats east of Oak Grove Butte(Qot).

Surface Deposits

Landslides and earthflows (Qls) determine the character of the watershed from about three miles upstream of Austin Hot Springs (RM 65) to the confluence of the Collawash and the Clackamas Rivers. Earthflows are large masses of deep soil and bedrock material moving slowly downslope above or within a shear zone. They result from alteration and weakening of the Western Cascade rocks, as well as alpine glaciation, which eroded lower valley slopes and then melted away, removing lateral support from the oversteepened slopes. The headwall scarps of the earthflows are located where the resistant andesite flow rocks overlie the incompetent pyroclastics of the Rhododendron and beds of Bull Creek formations. Portions of these earthflows are active, and slopes in this area are often plagued by stability problems. For example, material from the earthflow in the upper reaches of Switch Creek drainage created a debris flow which blocked the Clackamas River and Road 46 for a short time in December 1975.

The LMP has identified 231 acres of low risk, 1,063 acres of moderate risk, and 458 acres of high risk earthflows in four areas of the northwest section of the watershed. The risk definitions are based on geomorphology and probability of failure, with consideration given to downslope consequences if failure were to occur. Specific management standards and guidelines identified for each earthflow risk category address the percent of acreage on the earthflow with vegetation able to evapotranspire water equivalent to that of an old-growth stand. Switch, Austin, and the moderate risk portions of Granite and Two Rivers earthflows currently do not meet LMP standards for hydrologic recovery. These earthflows will not be in a "recovered" condition for 12 to 29 years. Small, high risk areas of the Granite and Two Rivers earthflows currently meet the LMP recovery standards. It is not certain, however, that upon achieving this state of hydrologic recovery a give earthflow will in fact be stable. Table 3-14 displays the current recovery status for these earthflows.

Table 3-14. Earthflow recovery status.

Earthflow	Acres	Forest Plan: Rating	Forest Plan: Recovery Standard	Current Condition: % Recovered	Current Condition: Years to Recovery
Switch	299	High	>=90%	85%	22
Two Rivers A	64			58%	24
Two Rivers B	69			99%	0
Granite A	27			100%	0
Two Rivers C	675	Moderate	>=75%	55%	16
Austin A	174			52%	12
Granite B	189			63%	29
Austin B	231	Low		63%	

Talus materials (Qta), characterized by large slopes of unvegetated and unsorted boulders, are mapped on the western slopes of Burnt Granite and Peavine Mountain and along slopes adjacent to portions of Cub and Berry Creeks. Smaller talus slopes are found throughout the watershed.

Alluvium (Qal), characterized by deep, sorted to unsorted deposits of clay to boulder size materials deposited by streams, is found on the valley floor of the Clackamas River from RM 62.5 to RM 77 and on the valley floor of the lower 2 miles of Cub Creek. The Big Bottom area of the Clackamas River, with its gentle slopes and braided channels, has been formed in alluvial materials created in part from the Clackamas River reworking older glacial outwash deposits.

Areas of Geologic Interest

The high lake density in the Olallie area is probably due to a combination of volcanism and Pleistocene glaciation. Recent lava flows built up a high elevation plateau with subdued relief. About 20,000 years ago an ice cap developed that was centered in the Olallie area but also spilled down into the Upper Clackamas River valley. Differential ice scouring accentuated slight depressions on the recent lava flow surfaces. Some glacial till accumulated in the depressions and sealed up the bottoms, and when the ice melted, lakes formed. In some areas pre-Pleistocene cinder cones were easily removed by the ice to create depressions which later became lakes, though it is not known if any of the lakes in the Olallie area formed in this particular way.

The porous lava flow surfaces which were not sealed by till allow water to infiltrate down to an older impermeable layer and then resurface downslope as springs. Water emerges from both Last and Peavine Springs with considerable force, and these and others may be artesian springs.

An area of rock that has undergone intense alteration occurs just downstream from Big Bottom on the north side of the river. This alteration is probably related to the nearby Austin Hot Springs. In the Cascade Range most of the hot springs occur near the contact of the Western Cascade Province and the High Cascade Province. The younger High Cascade rocks provide the heat and the altered and fractured Western Cascade rocks provide the openings to the surface. At Austin Hot Springs about 250 gallons/minute of 73.5°C water issue from several openings along a 300 foot stretch of the river.

Landforms

The Upper Clackamas watershed has been delineated into broad scale landform units that reflect geologic type, slope gradient, surface drainage and terrain features. These landform units were defined to elicit meaningful differences in landslide occurrence. Landform location and distribution is presented in Map 3-8. Table 3-15 displays the characteristics for landform units in the Upper Clackamas River.

Natural rates of sediment production and delivery

Table 3-16 provides a qualitative rating for sediment delivery for all landform types in the Upper Clackamas watershed. The highest rates of sediment delivery are associated with the landforms that are steeply sloping and consist of weak or resistant rock types. These landforms occupy 11% of the Upper Clackamas watershed and are found primarily in the Northwest and West Group subwatersheds. A medium sediment delivery rating was given to quarternary landslide deposits, glaciated valley side slopes, and alluvial valley bottoms and terraces. These landforms occupy approximately 23% of the watershed, and are distributed throughout its northern and western portions. A low sediment delivery rating was given to the remaining landforms (68% of the watershed), most of which have gentle to moderate slopes. Talus receives a low rating despite its steep slopes, because it is incapable of producing appreciable amounts of sediment.

Landslides

The occurrence of landslides in the Upper Clackamas watershed is strongly associated with steepness of slope and the presence of weak, pyroclastic rock formations (landform type WRSS). This combination occurs almost exclusively in the northwestern portion of the watershed. Accordingly, this is where landslides have occurred and will continue to occur. A majority of landslides that have been mapped in this area, however, are inactive. They represent relics of a past climate and were initiated during periods of glacial retreat that left valley walls oversteepened, saturated, and unconfined. Since these conditions persisted for hundreds or perhaps thousands of years, large-magnitude earthquakes are believed to have played a role in triggering these large-scale landslides. These dormant landslides can be reactivated under the right circumstances. A recent example, Austin Slide, located west of Switch Creek, was reactivated after the toe was eroded away during the 1964 flood. It continues to deform internally despite efforts to stabilize it with a large rock shear key.

One reason for the instability associated with landform type WRSS is the presence of pyroclastic bedrock, either beds of Bull Creek or the Rhododendron Formation. These formations tend to be deeply weathered and contain large amounts of clay. However, lava flow interbeds may also be present and, where they are, the formation tends to be more stable. This is the case near the central portion of the watershed in the vicinity of Kansas Creek, Lowe Creek, and Wall Quarry. Here, the Rhododendron Formation reportedly contains an unusually high concentration of lava flows and therefore lacks the instability with which it is normally associated.

Map 3-8. Landform Units.

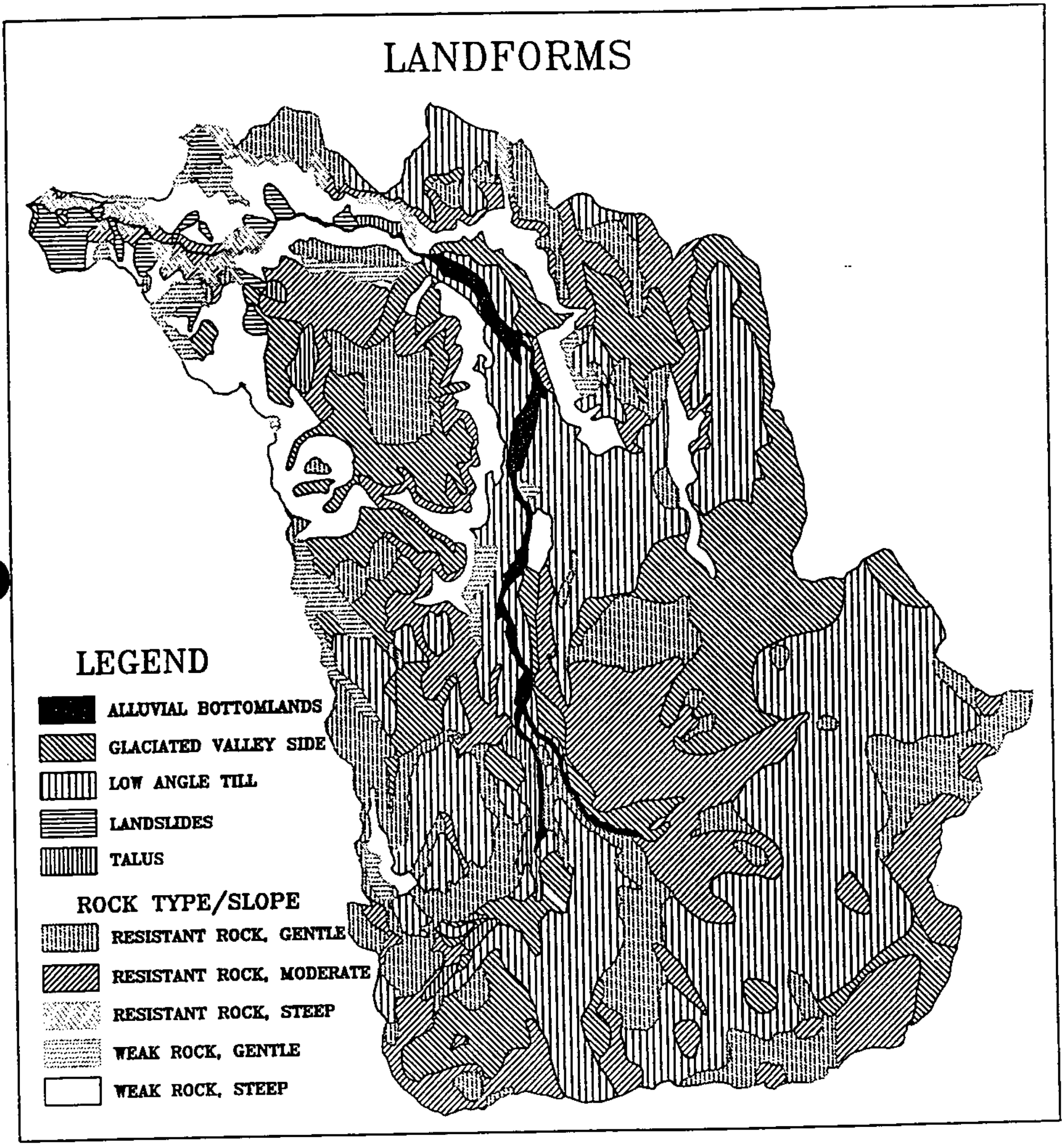


Table 3-15. Characteristics and processes associated with landform units.

Landform Unit	Geologic Type	Physical Characteristics	Slope Forming Process	Sediment Delivery Mechanisms
Resistant Rock - Steep Sides Slopes (RRSS)	Andesites of Nohorn, Basalts and basaltic andesites, Basalts of Minto Mt., intrusives	Slopes from 60% to vertical cliffs, channels steep and straight, shallow soils	Regional uplift, fluvial & glacial erosion, debris flows, debris slides, soil creep and erosion	Debris slides, debris flows, soil erosion, soil creep
Resistant Rock - Moderate Slopes (RRMS)	Andesites of Nohorn, Basalts and basaltic andesites, Basalts of Minto Mt., intrusives	Slopes 30-60%, soils tend to be shallow	Regional uplift, fluvial & glacial erosion, debris flows, debris slides, soil creep and erosion	Debris slides, debris flows, soil erosion, soil creep
Resistant Rock - Gentle Slopes (RRGS)	Andesites of Nohorn, Basalts and basaltic andesites, Basalts of Minto Mt., intrusives	Slopes <30%	Regional uplift, fluvial & glacial erosion and erosion	Debris slides, debris flows, soil erosion, soil creep
Weak Rock - Steep Side Slopes (WRSS)	Rhododendron and beds of Bull Creek formatation	Slopes > 50%, steeper slopes tend to be deeply dissected by streams	Regional uplift, fluvial & glacial erosion, debris flows, debris slides, soil creep, earthflows, slumps and erosion	Slumps, debris slides, debris flows, soil erosion, soil creep
Weak Rock - Gentle Side Slopes (WRGS)	Rhododendron and beds of Bull Creek formation	Slopes <30%	Regional uplift, fluvial & glacial erosion, debris flows, debris slides, soil creep, earthflows, slumps and erosion	Slumps, debris slides, debris flows, soil erosion, soil creep
Quarternary Landslides Deposits (QLD)	Ancient landslides deposits	Large ancient earthflows and debris slides, slopes from 0 to 30 percent	Quarternary landsliding, slumps, earthflows, debris slides, soil creep and soil erosion within the landslide mass	Direct delivery to stream systems, soil creep and erosion
Glaciated Valley Side Slopes (GVSS)	Unsorted and compacted deposits of detritus ranging in size from sand to boulder	Glacially smoothed slopes. Slightly to moderarely dissected slopes from 30 to 50 %.	Glaciation, debris flows, debris slides, soil creep and soil erosion	Debris slides, debris flows,stream bank failures, soil erosion, soil creep
Low Angle Till (LAT)	Unsorted and compacted deposits of detritus ranging in size from sand to boulder	Smooth valley floor and side slopes, reduced dissection by streams, slopes 0 to 30%.	Glaciation, debris flows, debris slides, soil creep and soil erosion	Debris slides, debris flows,streambank failures, soil erosion, soil creep
Alluvial Valley Bottoms & Terraces (AVBT)	Boulder to silt sized material	Level flood deposits along Clackamas R. and Cub Creek.	Glacial outwash, flooding, streambank failures, soil erosion	Surface erosion and stream bank failures
Talus (T)	Unsorted deposits of angular bolders freq. overlie resistant rock units	Steep, rock mantled slopes, usually positioned along upper valley walls 40-70%.	Debris slides, frost heave, soil creep, soil colluvial processes	Debris slides

Table 3-16. Relative sediment delivery and landslide potential ratings by landform unit.

Landform Type	Watershed Acreage	Percent of Watershed	Sediment Delivery	Landslide Potential
Resistant Rock - Steep Sides Slopes (RRSS)	1,009	1%	High	Medium
Resistant Rock - Moderate Slopes (RRMS)	18,086	18%	Low	Low
Resistant Rock - Gentle Slopes (RRGS)	15,445	15%	Low	Low
Weak Rock - Steep Side Slopes (WRSS)	9,956	10%	High	High
Weak Rock - Gentle Side Slopes (WRGS)	2,340	2%	Low	Low
Quarternary Landslides Deposits (QLD)	1,495	2%	Medium	Medium
Glaciated Valley Side Slopes (GVSS)	18,588	19%	Medium	Medium
Low Angle Till (LAT)	30,828	31%	Low	Low
Alluvial Valley Bottoms & Terraces (AVBT)	1,147	1%	Medium	Low
Talus (T)	1,486	1%	Low	Medium
Total	**100,380**	**100%**		

Where resistant rock occurs on steep slopes (landform type RRSS), the landslide risks are somewhat different. Shallow soils and deeply incised stream valleys tend to favor debris slides and debris flows, respectively. On lower gradient slopes, which clearly dominate the watershed, these types of failures are uncommon, regardless of the geologic formation in question. Thus, a majority of the watershed is quite stable and the risk of landsliding is low.

A qualitative rating for landslide potential for all landform types in the Upper Clackamas watershed is provided above in Table 3-16. The highest landslide potential is associated with the landform type that is steeply sloping and consists of weak rock types (10% of the watershed). A medium landslide potential rating was given to steeply sloping resistant rock types, large landslides, glaciated valley side slopes, and talus slopes (24% of the watershed).

Soils

Soils in the Upper Clackamas watershed have formed from pyroclastic, andesitic, and glacial parent materials.

Soils derived from weathered pyroclastic materials are deep, fine textured, poorly drained, nutrient rich, have high water holding capacities, and tend to grow site class 1, 2, and 3 trees. Slopes are gentle to steep. Erosion hazards are moderate to severe and compaction hazards are moderate to high.

Soils developed on moderately steep to steep residual and colluvial sideslopes of glacial and andesitic materials generally have surface and subsoil textures of silt loams to very gravelly loams. Soil depth is generally less than 60 inches. These soils are generally stable, surface erosion potentials are moderate to very severe, and subsoil erosion potential is low to high. Productivity is moderate to low, as is regeneration potential.

Soils formed on the gentle, smooth upland slopes are generally derived from glacial till. These soils are shallow to deep, well drained, and have textures ranging from silt loams to sandy loams. These soils are generally quite stable, have moderate to high profile rock content, slight to moderately erosive surface soils, moderately erosive subsoils, and a low to moderate compaction hazard. Timber productivity is low to moderate. Regeneration may be a problem in some areas due to high elevations and cool temperatures.

Interpretations of surface erosion hazard for soils in the Upper Clackamas watershed are displayed in Table 3-17. Thirty-five percent or more of the basin has a severe or moderate erosion hazard.

Table 3-17. Surface soil erosion potential by subwatershed.

Subwatershed	Surface Erosion Potential (Acres)				
	Very Slight	Slight	Moderate	Severe	Very Severe
Austin Segment	430	2428	1981	3595	1527
Granite	185	195	1144	272	41
Northwest Group Totals	614	2623	3126	3868	1567
Cabin	9	1209	3001		
Dyke	28	1615	613		
Last	77	5010	1745		
Pinhead	24	5469	1433	558	
Pot		1959	322		
East Group Totals	138	15262	7115	558	
Fawn	41	1729	621		
Hunter	138	2530	1420		
Lowe	60	1847	2192	4	12
Rho	70	2871	1145		
West Group Totals	359	8977	5379	4	12
Berry	297	3854	1193		54
Cub	609	7380	1076		
Squirrel	66	2781	839		
South Group Totals	971	14016	3108		54
Lemiti	309	5086	1146		
Olallie	38	800	259		
S. Fk. Lemiti	101	1277	210		
Southeast Group Totals	449	7163	1615		
Big Botttom Segment	171	4970	3470	297	23
Headwaters Segment	993	5281	2656	800	162
Mainstem Group Totals	1165	10251	6125	1097	185
Totals	3696	58291	26467	5527	1819

Two types of natural disturbances were identified as affecting sediment production and delivery and soil productivity in the Upper Clackamas watershed. Fire, which varies with intensity, frequency, and location on the landscape can cause loss of organic matter and nutrients, but also facilitates nutrient cycling. Fire can also accelerate erosion and can affect soil organisms. High intensity precipitation events can be a natural source of surface soil disturbance.

Soil Processes

The soil processes affecting sediment production and delivery to streams under natural conditions are primarily a function of ground cover, precipitation, fire, and wind events. The natural rates of erosion and sedimentation are unknown.

The processes affecting soil productivity within the watershed are tied to soil parent material, organic matter input, and nutrient cycling.

Management Activities Affecting Natural Processes

Sediment Production and Delivery to Streams

Landslides

Mass wasting is a dominant process affecting the aquatic ecosystems in the northwest portion of the Upper Clackamas watershed. A limited landslide inventory was conducted using aerial photographs of this portion of the watershed. The remainder of the watershed was not inventoried for landslides due to time constraints and the expectation that mass wasting is only a minor process there. Project files and past mapping were also utilized during the inventory. Small failures which occur under a mature tree canopy are probably under represented in the inventory because they are not necessarily visible on aerial photos.

Fifty-three landslides were identified during the inventory. Of these, 23 are considered ancient and therefore have no associated land-use activity. Nonetheless, most appear to have delivered sediment to the Clackamas River or one of its tributaries when they first occurred. Table 3-18 displays the number of recent or active mass wasting events for managed sites (roaded and harvested areas) and unmanaged sites (mature forest and non-forest, e.g. exposed bedrock). Powerline roads are shown separately. They are not well-constructed compared to Forest roads, and may be more likely to produce landslides.

Table 3-18. Landslide occurrence by land use.

Land Use		Landslide Type								
		Debris Flow	Debris Slide	Earthflow	Slump	Creep	Rock fall	Surface Erosion	Streambank failures	Totals
Managed	Clearcut Units	7	1	1						9
	Roads-USFS		4							4
	Roads-Powerline		3		1					4
Natural	Mature Forest	1	3	3	2				4	13
	Non-Forest									0
Totals		8	11	4	3	0	0	0	4	30

A greater number of landslides were identified in managed than in unmanaged stands. Analysis revealed little difference in numbers of road and harvest initiated mass wasting events. There was a difference however, in the dominant type of mass wasting associated with the two disturbances. Many more debris slides than debris flows are associated with roads. Most debris flows are associated with clearcuts.

Roads

Roads create disturbances on the landscape that are not replicated by natural factors operating in forest ecosystems. The impact roads have depends on road construction techniques, topographic characteristics, the underlying geologic material, and the subsurface flow of water. In general, roads cause steep slopes to be less stable, contribute sediment to stream systems from road surface and cutslope surfaces, and interrupt the surface and subsurface flow of water to stream channels, affecting baseflow and peakflow characteristics of a watershed.

Aerial photo inventory data displayed in Table 3-18 indicate that debris slides are associated predominantly with road construction. Road related landslides occur most frequently within landform units of resistant rock, steep slopes and weak rock, steep slopes. There is a higher incidence of debris sliding on the landform unit with weak rock compared to the resistant rock unit, though both of these landform units have a high sediment delivery rating.

Miles of road by landform unit for the different subwatersheds in the Upper Clackamas watershed are exhibited in Table 3-19. Using the miles of road located within the landform types that have a high relative sediment delivery rating for landslides, (WRSS and RRSS) as an indicator of possible sediment delivery from road related mass wasting, Hunter, Lowe, Last, Rhododendron, Granite, and the Austin and Big Bottom Segment subwatersheds are seen to merit the greatest degree of concern for road-related mass movements delivering sediment to streams.

Roads are capable of delivering large amounts of sediment to streams over extended periods of time from unvegetated cutslopes and running surfaces. Impacts to water quality occur when sediment is delivered directly to the stream system at road crossings via ditch-line runoff. Roads that are located in close proximity to streams can also deliver sediment to stream channels from culvert out flow. Typically, sediment is delivered more efficiently at stream crossings via ditchline flow compared to delivery from culvert outflow occurring on vegetated slopes.

A table was used to describe the relative capability of a road segment to deliver sediment to stream channels. The table combined cutslope erosion risk and road surface characteristics for roads at stream crossings and road segments within 200 feet of streams. A description of the process and assumptions in developing the table are presented in the analysis file. Miles of roads by relative sediment delivery capability class is presented in Table 3-20. Road segments greater than 200 feet from creeks are not thought to deliver appreciable amounts of sediment to stream channels, so are not displayed in this table.

Table 3-19. Road miles by landform type by subwatersheds.

Subwatershed	Landform Unit										Total Miles	Miles Per Sq. Mi.
	RRSS	RRMS	RRGS	WRSS	WRGS	GVSS	LAT	QLD	AVBB	TAL		
Austin Segment	2.2	6.9	8.0	14.3	11.2	0.8	3.0	8.6	0.3	0.0	55.3	3.5
Granite	0.0	0.2	0.0	2.9	0.2	0.2	2.2	2.2	0.0	0.5	8.4	2.9
Northwest Group Totals	2.2	7.1	8.0	17.2	11.4	1.0	5.2	10.8	0.3	0.5	63.7	3.4
Cabin	0.0	4.0	3.1	0.4	0.0	2.2	2.5	0.0	0.1	0.8	13.1	3.9
Dyke	0.0	0.0	0.4	1.4	0.0	5.8	5.1	0.0	0.0	0.0	12.7	3.6
Last	0.0	5.6	2.5	2.6	0.0	13.1	23.0	0.0	0.0	0.0	46.8	4.1
Pinhead	0.0	0.2	4.8	1.3	0.6	15.8	17.0	0.0	0.2	0.0	39.9	3.4
Pot	0.7	2.5	3.3	0.7	0.0	1.4	8.4	0.0	0.0	0.0	17.0	4.8
East Group Totals	0.7	12.3	14.1	6.4	0.6	38.3	56.0	0.0	0.3	0.8	129.5	3.9
Fawn	0.0	3.0	1.4	0.0	2.3	3.9	4.1	0.0	0.0	0.0	14.7	3.9
Hunter	0.0	1.2	9.0	3.4	0.5	2.6	7.9	0.0	0.0	0.0	24.6	3.8
Lowe	0.0	0.7	1.0	8.8	0.5	11.1	1.4	0.0	0.1	0.0	23.6	3.7
Rho	0.0	1.6	2.8	2.2	3.2	6.6	2.9	0.0	0.1	0.0	19.4	3.0
West Group Totals	0.0	6.5	14.2	14.4	6.5	24.2	16.3	0.0	0.2	0.0	82.3	3.6
Berry	0.0	4.0	10.4	0.0	0.0	7.3	5.4	0.0	0.0	0.7	27.8	3.3
Cub	0.0	3.5	8.7	0.0	0.0	7.2	21.9	0.0	0.0	0.1	41.4	2.9
Squirrel	0.0	3.6	1.5	0.0	0.0	0.2	5.8	0.0	0.0	0.0	11.1	1.8
South Group Totals	0.0	11.1	20.6	0.0	0.0	14.7	33.1	0.0	0.0	0.8	80.3	2.8
Lemiti	0.0	5.3	5.6	0.0	0.0	3.4	14.3	0.0	0.0	0.0	28.6	1.9
Otallie	0.0	0.5	0.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	3.7	0.9
S. Fk. Lemiti	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	6.0	1.7
Southeast Group Totals	0.0	5.8	5.6	0.0	0.0	3.4	23.5	0.0	0.0	0.0	38.3	1.7
Big Bottom Segment	0.0	6.3	8.5	12.4	0.7	11.9	15.8	0.0	0.9	0.0	56.5	4.0
Headwaters Segment	0.0	13.7	4.7	0.4	0.0	5.1	19.0	0.0	0.3	0.0	43.2	2.6
Mainstem Group Totals	0.0	20.0	13.2	12.8	0.7	17.0	34.8	0.0	1.2	0.0	99.7	3.3
Totals	2.9	62.8	75.7	50.8	19.2	98.6	168.9	10.8	2.0	2.1	493.8	3.2

Approximately 67 miles of road in the Upper Clackamas watershed are capable of delivering some level of sediment to streams. There are approximately 489 miles of roads in the watershed.

Table 3-21 displays the characteristics of roads within 200 feet of streams by subwatersheds. There are approximately 377 crossings of streams by roads in the Upper Clackamas watershed. Twenty percent of the stream crossings in the watershed have a high sediment delivery rating. Due to the high erosion susceptibility of soils derived from pyroclastic material, Granite and Austin Segment subwatersheds have the greatest concentrations of high sediment delivery capability stream crossings. Factoring in drainage size, Berry and Squirrel have similarly high concentrations.

The amount of sediment produced by roads is greater for native surfaced roads than aggregate surface roads. Approximately 10% of the total stream crossings in the watershed have a native running surface. Subwatersheds with the greatest miles of native surface roads are Last, Cub, and Austin Segment. Pot, South Fork Lemiti, Last, Dyke and Cabin subwatersheds have the highest densities of native surface road. Pot and Squirrel subwatersheds the highest densities of native surface road stream crossings.

Approximately 59 miles of road with the potential to deliver sediment to streams from culvert out flow are located within 200 feet of streams. Highest mileages of these types of roads occur in the

Austin Segment, Big Bottom Segment, Headwaters Segment, Last, Berry and Cub subwatersheds. Austin Segment, Cabin and Berry subwatersheds have the highest densities of roads within 200 feet [of s]treams.

Table 3-20. Miles of road by sediment delivery capability by subwatersheds.

Subwatershed	Sediment Delivery Capability: High	Mod	Low	Total Miles of Roads in Sediment Delivery Zone	Total Miles of All Roads
Austin Segment	3.6	6.6	3.8	14.0	55.3
Granite	0.2	1.0	0.1	1.3	8.4
Northwest Group Totals	3.8	7.6	3.9	15.3	63.7
Cabin	0.2	2.2	0.2	2.6	13.1
Dyke	0.0	0.1	0.0	0.1	12.7
Last	0.5	1.2	2.6	4.3	46.8
Pinhead	0.1	1.5	1.4	3.0	39.9
Pot	0.7	1.0	0.2	1.9	17.0
East Group Totals	1.5	6.0	4.4	11.9	129.5
Fawn	0.0	1.6	0.4	2.0	14.7
Hunter	0.8	1.5	0.7	3.0	24.6
Lowe	0.6	1.7	0.7	3.0	23.6
Rho	0.2	0.8	0.2	1.2	19.4
West Group Totals	1.6	5.6	2.0	9.2	82.3
Berry	0.8	5.1	1.2	7.1	27.8
Cub	0.7	2.8	1.6	5.1	41.4
Squirrel	1.0	0.5	0.1	1.6	11.1
South Group Totals	2.5	8.4	2.9	13.8	80.3
Lemiti	0.6	0.2	0.4	1.2	28.6
Olallie	0.3	0.1	0.0	0.4	3.7
S. Fk. Lemiti	0.6	0.0	0.0	0.6	6.0
Southeast Group Totals	1.5	0.3	0.4	2.2	38.3
Big Bottom Segment	0.8	4.0	4.0	8.8	56.5
Headwaters Segment	0.8	2.5	2.4	5.7	43.2
Mainstem Group Totals	1.6	6.5	6.4	14.5	99.7
Totals	12.5	34.4	20.0	66.9	493.8

Table 3-21. Characteristics of roads within 200 feet of streams by subwatersheds.

			Road Miles			Road/Stream Crossings		
Subwatershed	Acres	Road Density Miles Per Sq. Mile	High Landslide Risk Landforms	High Sediment Delivery Hazard	Native Road Surface	Total	w/High Sediment Delivery Hazard	w/Native Surface Road
Austin Segment	10123	3.6	14.3	3.6	8.1	64	16	5
Granite	1878	2.2	2.9	0.2	0.7	12	2	1
Northwest Group Totals	12000	3.3	14.3	3.6	8.1	76	18	6
Cabin	2144	3.9	0.4	0.2	2.7	9	1	1
Dyke	2258	3.6	1.4	0.0	3.2	1		
Last	7355	4.1	2.6	0.5	10.5	13	4	4
Pinhead	7486	3.4	1.3	0.1	4.9	13	1	1
Pot	2281	4.8	0.7	0.7	5.8	11	4	4
East Group Totals	21523	3.9	6.4	1.5	27.1	47	10	10
Fawn	2391	4.1			1.6	10		
Hunter	4151	3.8	3.4	0.8	1.6	19	3	
Lowe	4120	3.6	8.8	0.6	1.8	18	1	1
Rho	4086	3.0	2.2	0.2	1.5	7	2	
West Group Totals	14747	3.6	14.4	1.6	6.5	54	6	1
Berry	5430	3.3		0.8	2.5	59	6	2
Cub	9074	2.9		0.7	9.0	36	5	2
Squirrel	3863	1.8		1.0	3.1	10	7	5
South Group Totals	18367	2.8		2.5	14.6	105	18	9
Lemiti	9422	1.9		0.6	8.0	6	3	1
Olallie	2675	0.9		0.3	1.4	3	1	1
S.F. Lemiti	2271	1.7		0.6	4.0	1	1	
Southeast Group Totals	14368	1.7		1.5	13.4	10	5	2
Big Bottom Segment	8931	4.2	12.4	0.8	2.8	54	5	1
Headwaters Segment	10443	2.6	0.4	0.8	7.0	31	3	9
Mainstem Group Totals	19375	3.3	12.8	1.6	9.8	85	8	10
Totals	100380	3.2	47.9	12.3	79.5	377	65	38

Harvest Areas

Harvest areas located adjacent to streams can be a source of sediment to stream channels. As vegetation within harvest units becomes re-established, sediment production and transport diminish.

Delivery of sediment was estimated by categorizing harvest units that are adjacent to stream channels into disturbance types identified by harvest and fuel treatment history; low for cable or skyline harvested units, moderate for tractor or rubber tired skidder harvested units, and high for tractor or rubber tired skidder harvested and machine piled fuel treated units. Disturbance type and surface soil erosion hazards were combined into a table. A description of the process and assumptions in developing the table can be found in the analysis file. Acres of 0 to 5 year old stands near streams are displayed below in Table 3-22 according to disturbance class and surface erosion potential. A table for older stands harvested near streams is located in the analysis file.

Table 3-22. Disturbance and erosion potential of 0-5 year old stands near streams.

Acres of 0-5 Year Old Stands Near Streams With Disturbance Class and Surface Erosion Potential

Subwatershed	Disturbance Category	Surface Erosion Potential: Very Slight	Slight	Moderate	Severe	Very Severe
Austin Segment	High		32.2			
	Mod		28.7	37.8	0.2	68.2
	Low		23.9	6.9	11.6	34.7
Dyke	Mod		2.3	0.8		
	Low	0.1	1.2	0.8		
Fawn	High		1.7	0.5		
	Mod		6.7	0.4		
	Low		0.8	4.2		
Hunter	High		0.3	0.7		
	Mod		3.2			
	Low		2.8	1.5		
Lowe	Mod		6.1	1.7		2.1
	Low		4.8	3.4		1.1
Rho	Mod	0.6	39.1	9.4		
	Low		1.5	7.1		
Berry	High		10.1	1.7		
	Mod		5.2	3.2		
	Low		5.0	4.7		2.4
Cub	High		10.2	0.1		
	Mod		15.2	0.0		
	Low		2.4	0.1		
Big Bottom Segment	Mod		1.9	4.6	3.0	
	Low		2.6	9.3		
Headwaters Segment	Mod			2.0	2.2	
	Low				0.0	

Timber has been harvested from about 3,500 acres located within 200 feet of stream channels, 435 of these acres being harvested in the last 5 years. Historically, the greatest number of acres harvested near streams have occurred in Austin Segment, Big Bottom Segment, Cub, and Berry subwatersheds. Highest acreages of harvest near streams in the last 5 years have occurred in the Austin Segment subwatershed on moderate to very severe erosion hazard lands. Currently some of these acres have the potential to deliver sediment to stream channels.

Harvest on the Switch Earthflow is believed to have initiated the Switch Creek Slide in 1975. [illegible],000 cubic yards of mud and debris closed Road 46 and blocked the Clackamas River for a short time.

Dispersed Recreation Sites

Most dispersed recreation sites are located near water, and have a potential to deliver sediment directly to stream channels. Four of the 26 sites identified during the Upper Clackamas River Corridor Dispersed Sites Environmental Assessment deliver sediment directly into Cub Creek, Last Creek and the Clackamas River.

Trails

Erosion is currently not a problem with the trail system in the watershed. The Rhododendron Creek trail is very steep, but is maintained and lightly used. If use increases or maintenance is reduced, erosion problems may develop. The Rhododendron Ridge trail and trails in the Olallie area produce little sediment as they are on flat terrain and are not adjacent to water. The proposed Urban Link trail, if well designed and constructed, should pose little risk of erosion.

Soil Productivity

Within the Upper Clackamas watershed. Changes in soil productivity due to management-related disturbances are primarily the result of reductions in total soil porosity and site organic matter.

Compaction and Soil Resiliency

Two factors were examined to determine significant detrimental soil quality conditions: soil resiliency, and compaction caused by disturbances from timber harvest and associated activities, roads, and other uses. Extent of growth loss depends on how growth-limiting the macropore reductions are. Soil resiliency, or the ability for a soil to recover from disturbance, is influenced in this watershed by soil parent material, elevation, aspect, slope, and soil rock content. Soils with greater resiliency have higher silt and clay contents, accumulate more organic material, weather faster, and display more horizination than less resilient soils. Soils with lower resiliencies will recover at a slower rate from disturbances such as compaction or removal of soil organic material.

Timber Harvest

Acres of harvest activity were calculated for three categories of logging systems based on level of disturbance. These acres were then multiplied by a percent activity area compacted factor developed from ground monitoring results to attain total compacted acres. This is displayed in Table 3-23. Harvest type was then combined with relative soil resiliency ratings as displayed in Table 3-24. A detailed breakdown by subwatershed can be found in the analysis file.

Table 3-23. Acres of compaction by disturbance rating.

Compacted Acres by Disturbance Rating				
Harvest Method	Disturbance Rating	Total Acres	% Activity Area Compacted	Total Acres Compacted
Tractor & Machine Pile	High	9,727	17%	2,140
Tractor Only	Moderate	13,270	9%	1,327
Cable, Skyline	Low	6,763	2%	135
Totals		29,760		3,602

Table 3-24. Acres of harvest type by soil resiliency rating.

Harvested Acres by Disturbance and Soil Resiliency Ratings						
Harvest Method	Disturbance Rating	Soil Resiliency Rating			Total Acres	% of Harvested Acres
		Low	Moderate	High		
Tractor and Machine Pile	High	7,988	1,691	48	9,727	33%
Tractor only	Moderate	9,060	3,645	565	13,270	44%
Cable, Skyline	Low	4,205	2,157	401	6,763	23%
Total Acres Resiliency		21,253	7,493	1,014	29,760	100%
Resiliency Acres by %		72%	25%	3%		

As shown in Table 3-23, approximately 3,600 acres have been compacted by non-road timber harvest activities within the watershed. Subwatersheds with the greatest number of acres in a compacted condition are Pinhead, Last, Cub, and the Austin and Big Bottom Segments. Table 3-24 shows that 72% of timber harvest has occurred in areas of low soil resiliency. Of those acres, 20% were harvested using logging methods that result in low soil disturbance and 80% were harvested using logging methods that result in moderate or high soil disturbance.

Roads

A long term reduction of soil productivity is realized on road surfaces and on road cut and fillslopes. Acreage in a detrimental soil condition was calculated by multiplying road length by average width for each surface type. Approximately 2,000 acres in the watershed are occupied by roads and road clearings. Austin and Big Bottom Segments and Last subwatershed have the greatest total miles of road. Subwatersheds with the highest road densities are Pot, Big Bottom Segment, Last, Fawn, and Cabin.

Other Management Activities

Vehicle and foot traffic from recreational activities has created soil compaction on an estimated 45 acres of ground. Four developed campgrounds and over 60 miles of hiking trails have been established in the watershed. Numerous dispersed camping sites are located within the Upper Clackamas River corridor, including a large site on private ground at Austin Hot Springs. Outside the corridor, dispersed sites are found primarily on old landing sites, at ends of roads, and adjacent to creeks. Administrative sites such as rock pits, stockpile sites, and a landslide buttressing area at the base of Austin slide have taken approximately 12 acres of land out of production.

Soil Erosion

Soil loss decreases the amount of soil water available to plants by changing the available rooting depth and water holding characteristics. Loss of soil removes nutrients available to plants, and removes soil organisms which help in nutrient uptake by plants. Loss of the organic surface encourages drying and crusting-over of the soil surface. As infiltration is reduced, additional erosion occurs.

Erosion and mass wasting play a larger role in reducing soil productivity levels in the northwest section of the watershed where pyroclastic materials are prevalent and erosion hazards are high. Elsewhere in the watershed, productivity losses due to erosion are more localized.

Fisheries

Throughout this discussion, the term "RM" (river mile) is used to describe locations along the Clackamas River. Map 3-9 displays the Clackamas River above North Fork Reservoir and the locations of river miles in five mile increments.

Fish Stocks

Two species of Pacific salmon, one anadromous trout, and three species of resident trout historically used the rivers and streams within the Clackamas River subbasin, and the upper watershed, for spawning, rearing, and migration. Table 3-25 displays fish species, stocks, and their status. Native anadromous fish included spring chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), and steelhead trout (*Oncorhynchus mykiss*). Native resident salmonids included cutthroat trout (*Oncorhynchus clarki*), rainbow trout (*Oncorhynchus mykiss*), bull trout (*Salvelinus confluentus*), and mountain whitefish (*Prosopium williamsoni*). Sculpin (*Cottus sp.*) are the only other native fish that occur in the streams and river in the watershed. Introduced fish species such as brook trout (*Salvelinus fontinalus*), brown trout (*Salmo trutta*), and kokanee salmon (*Oncorhynchus nerka*) along with different stocks and races of the native fish have been introduced since the turn of the century. These introduced stocks and races include Willamette strain spring chinook salmon, early run coho salmon, Big Creek and Eagle Creek strains of winter steelhead,

Map 3-9. River Miles.

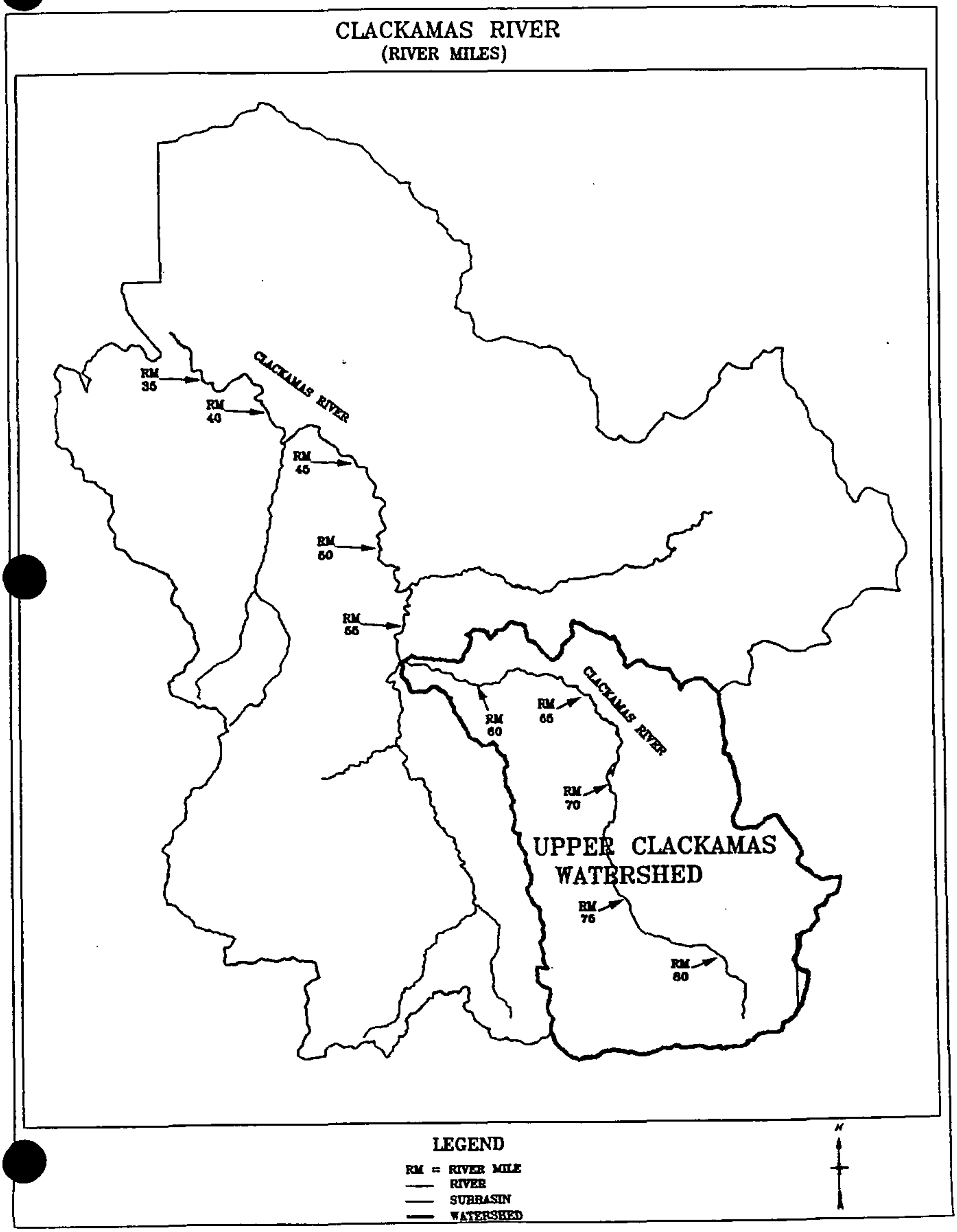


Table 3-25. Fish species and stocks that inhabit the Clackamas River and their status.

Common Name	Scientific Name	Stock Origin[4]	Status
spring chinook salmon[5]	Oncoryhnchus tshawytscha	W/H	Increasing
coho salmon	O. kisutch		
-early run		H	Stable
-late run		W	Declining
winter steelhead[6]	O. mykiss	H	Stable
		W	Declining
summer steelhead	O. mykiss	H	Stable
cutthroat trout	O. clarki	W	Stable
rainbow trout	O. mykiss	H/W	Stable
bull trout	Salvelinus confluentus	W	Unknown Extinct(?)
brook trout	S. fontinalis	H	Unknown
mountain whitefish	Prosopium williamsoni	W	Stable
sculpin	Cottus sp.	W	Stable

[4] W=wild, native stock; H=hatchery supported or hatchery origin.

[5] Most of the spring chinook salmon in the Clackamas River are either Willamette stock hatchery fish or the genetics of the native stock have been greatly changed by interactions with the Willamette stock.

[6] Two stocks of winter steelhead live in the Clackamas River. The run entering from December through February is a hatchery origin stock. The run that enters the river from late-March through May is an native wild run.

Skamania/Foster origin summer steelhead, and different races of cutthroat and rainbow trout (ODFW 1992).

The indigenous late run coho salmon distinguishes the Clackamas River from other rivers and streams in the Pacific Northwest. The anadromous fishery resource of the Clackamas River has national, regional and local significance. The Endangered Species Committee of the American Fisheries Society cited the native runs of coho salmon and the winter steelhead in the Clackamas River as requiring special management consideration because of low or declining numbers (Nehlson et al., 1991). This list included 214 stocks in California, Idaho, Oregon, and Washington (Nehlson et al., 1991). On a national scale, anadromous fish are classified as an "outstandingly remarkable value" under the Clackamas National Wild and Scenic River Management Plan. Agencies such as the Forest Service and ODFW, along with Portland General Electric (PGE), consider the Clackamas River late-run coho salmon a stock of special concern. In 1990, the Forest Service placed the late-run on the Forest Service, Region 6, sensitive species list (Forest Service Manual 2670). ODFW classifies this stock as "critical" under their management guidelines (Oregon Administrative Rules 635-100-140).

The Clackamas River subbasin has played a major role in commercial fish production based on information dating back to the late 1800's. The Clackamas River was considered one of the largest producers of spring chinook salmon in the Pacific Northwest (ODFW 1992). As many as an estimated 12,000 spring chinook were harvested in 1893. In addition to the direct harvest of fish, spring chinook salmon were collected at upriver stations for eggs to supply hatcheries in the lower Clackamas River and near Tag Creek at river mile (RM) 54.5. This latter hatchery was built by the Columbia River Packers Association. Native Americans from the Warm Springs and Klamath tribes came to the hatchery to take the hatchery spawned salmon.

Today, the Clackamas River supports what many fishery biologists believe to be the remnant native run of lower Columbia River coho salmon. The late-run coho salmon in the Clackamas subbasin has received considerable attention in recent years because of its potential as the remnant lower Columbia River wild coho run. In 1990 and 1993, interest groups filed petitions with the National Marine Fisheries Service (NMFS) for them to review the status of the coho salmon pursuant to the Endangered Species Act. NMFS determined that the petitions had merit and subsequently conducted the status reviews. NMFS has not issued a decision on the most recent status review. In 1991, NMFS determined that there were no wild coho salmon remaining in the lower Columbia River due to the large hatchery production and potential interbreeding (Federal Register 56: 29553-29554).

The Clackamas River salmon and steelhead runs benefit commercial and recreational anglers in the Pacific northwest and local areas and provide an increasing number of visitor viewing opportunities for the local Portland metropolitan area. The Clackamas subbasin has one of the largest trout fisheries in Oregon (ODFW 1992). The Clackamas River Subbasin Fish Management Plan states that there are an estimated one-quarter million angler days of effort trout fishing in the Clackamas subbasin (ODFW 1992). The amount attributed to the Clackamas River, tributaries and lakes in the watershed was not estimated.

In general, escapement of anadromous fish to the Clackamas River subbasin upstream of North Fork Dam have declined. Some such as the late-run coho salmon are at critically low levels. The numbers of anadromous fish returning to the upper Clackamas River subbasin declined due to similar factors affecting anadromous fish throughout the Pacific Northwest. Overfishing, hydroelectric development, habitat loss and degradation, hatchery practices and poor ocean rearing conditions are the most likely factors affecting the fish. Migration barriers (hydro, fish collecting for hatcheries, and commercial harvest) and addition of hatchery stocks severely altered the current composition and life histories of the endemic stocks. Each of these factors contributed to the decline of all the stocks in the Upper Clackamas watershed to some degree. The relative degree of the effect is stock specific and depends on the life history characteristics of the stock as well as desired human values (i.e. commercial vs. recreational harvest allocations).

Starting in 1992, a group of fishery biologists from various agencies and entities with legal responsibility for managing Clackamas River fish stocks started meeting to define stock specific problems and develop an action plan to restore the fish runs. This group of biologists developed an action plan in 1993 that lists priorities for managing and restoring Clackamas River salmonids. The following examples illustrate how some of these problems have directly contributed to the decline of the indigenous fish stocks.

In general, the effects of fish harvest, hatchery fish management, and hydroelectric facilities and operation have had a larger effect on the escapement of anadromous fish than habitat. It is difficult to partition and isolate the effects of each factor on returns of anadromous fish because there is considerable interaction of the factors, some of which may be synergistic. For example, high commercial fishing harvest rates could reduce the number of returning adults. These returning fish could be delayed as they pass through the hydroelectric dams downstream. The delay could cause the fish to spawn in less than optimal habitat or environmental conditions. The result is that there would be fewer fish that spawn in less than optimal conditions; thus, yielding fewer smolts per spawning pair. The net result is a decrease in the productive capacity of the affected stock.

Harvest

Overfishing has been particularly harmful to the endemic late-run coho salmon. ODFW manages Columbia river coho salmon to capitalize on hatchery surpluses (ODFW 1982). Management strategies targeting hatchery fish in fisheries containing both hatchery and wild stocks tend to overharvest wild stocks. This results in the decline or possible extinction of the wild stocks. Commercial fishing harvest rates in the Ocean and in the Columbia River on Clackamas River late-run coho salmon have been as high as 80% in recent years (Cramer et. al, 1991). Only 18%, 12%, and 14% of adults to returned to spawn from 1967 through 1969, respectively (Cramer et. al, 1991). This is significantly below ODFW's estimate of a 31% escapement level necessary for a sustainable harvest of wild coho salmon (Cramer et al., 1991).

Hydroelectric Development

Portland General Electric (PGE) operates five dams in the Clackamas River subbasin. River Mill, Faraday, and North Fork dams occur on the mainstem Clackamas River between RM 23 and RM 31. Harriet and Timothy dams occur on the Oak Grove Fork of the Clackamas River. All anadromous fish moving out of and returning to the upper Clackamas River and its tributaries must pass through the three mainstem dams.

There was no fish passage above Faraday Dam from 1917 to 1939 due to an inoperable fish ladder. River Mill, Faraday, and North Fork dams continue to affect fish passage in two ways. First, the fish must ascend the ladders at the dams. There could be some delay of fish trying to locate the entrance to the ladders. The fish could also be delayed once in the ladders if they tire trying to ascend them. The ladder from Faraday Dam to North Fork Dam is 1.7 miles long. The magnitude or degree of delay on upstream migrating fish is uncertain at this time. Second, downstream migrating smolts could be killed or injured by the turbines. This would occur if the fish do not find the entrance to the bypass facility at North Fork Dam.

Studies have shown that the North Fork screen and diversion facility is effective at attracting and passing coho salmon and steelhead trout smolts because they typically migrate downstream near the surface of the water. On the other hand, the screen might not be as effective at diverting chinook salmon smolts from the turbines because chinook tend to migrate at greater depths. Smolt counts at North Fork Dam support this statement. Spring chinook salmon have consistently had the highest adult escapement, yet the number of downstream migrating juvenile chinook salmon counted in the diversion facility at North Fork Dam has been the lowest. Two possible explanations are that there is very low juvenile spring chinook salmon survival upriver or most of the fish do not use the bypass system at North Fork Dam. Other studies on outmigrating spring chinook show the latter to be the case. Therefore, the existing information supported by other studies could lead to the conclusion that most of the juvenile spring chinook migrate through the hydroelectric system via the turbines or are spilled over the dams during high flow events. Conclusions drawn from the anecdotal evidence are only speculation at this time until further studies determine the effect of the dams on downstream migrating salmon or determine the upriver survival of juvenile spring chinook salmon.

Habitat Degradation

Habitat loss and degradation has also contributed to the decline in anadromous fish returning to the Clackamas River. Timber harvest on over 29,000 acres and constructing about 490 miles of road in the watershed has affected riparian and aquatic habitat conditions and fish production. For example, the Forest Service realigned and straightened the mainstem Clackamas River between RM 57 and RM 65 in the 1950's to facilitate construction of Forest Road 46 in the floodplain. The realigned channel is about 20% shorter than the natural channel. Road 46 prevents the Clackamas River from meandering. Rivers increase their channel length and create meanders to dissipate energy. If prevented from meandering, rivers dissipate energy by scouring the channel. In the past, engineers and biologists recommended removal of large organic debris to reduce the risk to structures from floods and improve fish passage. Large quantities of coarse woody debris (CWD) was sold in salvage timber sales and removed from streams for milling. Some of these salvage sales were linked to protection of structures such as roads and bridges.

The effects of timber harvest on existing and potential CWD levels in streams throughout the watershed are described in the Riparian Vegetation discussion earlier in this appendix. The greatest effects are in the East, West and South Groups. One would expect CWD levels in streams to reflect the effects of the timber harvest within riparian areas.

Road building for access to the Upper Clackamas watershed has probably had the most extensive effect on fish habitat and distribution. Roads modify natural hillslope networks, accelerate the erosion process, and possibly lead to changes in streamflow patterns and substrate composition, the configuration of channel banks and beds, and the stability of slopes located adjacent to streams (USDA, 1994a). The effects of roads can have substantial biological consequences that affect virtually all components of stream ecosystems. Some culverts, if placed without considering fish passage criteria, block fish access to historical spawning and rearing areas and can isolate populations by blocking the interchange of genetic material. Main access roads were frequently constructed in the floodplains of streams due to the more gentle gradient. Thus, road construction had the potential to remove considerable quantities of riparian vegetation. In addition, unpaved roads constructed primarily for accessing timber are probably the primary source of sediment to streams and the mainstem Clackamas River.

There are approximately 490 miles of road within the 103,000 acre watershed. This equates to a little over 3 miles of road per square mile. Of these 490 miles, 70 miles are covered with asphalt while the rest, 420 miles, are either aggregate or natural surface. These latter categories along with the unvegetated cut banks adjacent to roads would be the primary sources of sediment in the watershed. There are approximately 377 points where roads cross streams.

A number of the culverts block fish passage. Some of the culverts block upstream passage of anadromous fish returning to their natal streams. For example, the most downstream culverts on Rhododendron and Lowe Creeks block or impede anadromous fish passage (USDA 1985). Forest Service fishery biologists identified an additional 17 culverts that block or impede fish passage during surveys conducted in 1984 (USDA 1985).

Hatchery Practices

Catchable rainbow trout, summer steelhead and plants of subyearling trout in the lakes support the largest recreational fisheries in the watershed in terms of angling effort. Hatchery production supports these fisheries. The management of hatchery fish within the Clackamas River subbasin, as in the Pacific Northwest, directly affects anadromous and resident fish stocks of the upper Clackamas River subbasin. Commercial fish harvest strategies designed to capitalize on hatchery stocks has contributed to a shift in the time of return for late-run coho salmon to the upper Clackamas River subbasin. The peak spawning periods and return time of spring chinook salmon and winter steelhead trout have shifted towards the spawning period and return time of hatchery fish in the lower Clackamas River subbasin. This indicates possible interbreeding of the native fish with the hatchery fish. Planting catchable trout and the resulting high angling effort in the area near where the fish were released can negatively affect wild trout populations.

Other Aquatic Dependent Resources

In addition to the anadromous and resident fish, the upper Clackamas River and its tributaries support a diverse flora and fauna of aquatic and riparian dependent species. For example, the mainstem Clackamas River in the area known as "Big Bottom" (RM 65 to 72.8) contains an estimated one-third to one-half of the known population of *Corydallis aquae-gelidae*. The river, streams, wetlands and lakes throughout the watershed support numerous species of amphibians. Many of these, such as the red-legged frog (*Rana aurora*), are considered much reduced in distribution throughout their range. There appears to be large numbers of red-legged frogs in the Clackamas River floodplain within the watershed.

Stock Management

The Northwest Power Planning Council and ODFW prepared fishery management plans for Clackamas River fish stocks (NPPC 1990; ODFW 1992). The two plans propose generally the same management strategies and goals for anadromous fish in the Clackamas River subbasin. Essentially, the Clackamas River upstream of North Fork Dam is managed primarily for natural production. ODFW no longer releases hatchery fish to the upper Clackamas River because it is being managed for natural production. The only exceptions are summer steelhead, catchable rainbow trout, and subyearly fish stocked into the lakes.

Spring Chinook Salmon

Prior to 1899, the Clackamas River was considered one of the best producing spring chinook systems in the Pacific Northwest (ODFW 1992). Since that time, the number of wild spring chinook returning to the upper Clackamas River has dramatically declined. Historical records estimate that commercial fishermen harvested about 12,000 and 8,000 spring chinook salmon in 1893 and 1894, respectively. The historical records also show that the Clackamas River spring chinook run had been reduced by the 1890's compared to levels before 1876 (ODFW 1992). One can logically assume that the historical run size exceeded 12,000 adults. There are no estimates as to how many of these adults used the upper Clackamas River subbasin for spawning and rearing.

The number of spring chinook salmon that return to spawn upstream of North Fork Dam has increased and remained relatively stable the last 15 years (Table 3-26). This coincides with the time frame for returns of hatchery produced spring chinook to Clackamas Hatchery. The Integrated System Plan and the Clackamas River Subbasin Plan define the escapement goal for spring chinook salmon at 2,900 fish upstream of North Fork Dam (Table 3-26) (NPPC 1990; ODFW 1992). Spring chinook salmon escapement during the 1980's and 1990's averaged very close to this number (Table 3-26). In the 1990's, escapement consistently exceed the goal.

Table 3-26. Decadal fish counts and escapement goals

Species	1960's Average	1970's Average	1980's Average	1990's Average	ODFW Plan Goals
Winter Steelhead	1,590	2,010	1,554	1,406	3,000
Late Run Coho Salmon	1,275	797	1,408	1,011	3,000
Spring Chinook Salmon	450	530	2,614	3,335	2,900

Few, if any, native spring chinook salmon exist within the subbasin and factors other than the quantity and quality of habitat regulate the population size. The Clackamas Subbasin Work Group cited stock identification, hatchery effects, commercial and recreational fish harvest, dam effects, and the potential loss of the productive capability of the population as priority information needs for spring chinook salmon. Stock identification, hatchery effects, fish harvest and dam effects probably influence the numbers of spring chinook salmon more than habitat condition. The habitat issue relates more to the distribution of spring chinook salmon relative to available spawning and rearing habitat. For this analysis, the salient factor is the potential loss of the productive capability of the population. Few fish spawn and rear in the highest quality habitat remaining in the upper subbasin in Big Bottom which reduces the productive capability of the population.

Spring chinook salmon typically spawn in mainstem Clackamas River, Oak Grove Fork, Roaring River, and Collawash Rivers throughout the subbasin upstream of North Fork Dam. The majority of spring chinook salmon spawn in the Clackamas subbasin, upstream of the hydroelectric dams. Most of the spring chinook salmon that spawn in the upper subbasin spawn downstream of the watershed. The largest quantity of suitable spring chinook salmon spawning and rearing habitat occurs in Big Bottom but only a small proportion of the population spawns there. Thus, the largest amount of suitable riverine habitat and possibly the most diverse and highest quality habitat is underutilized.

As discussed previously, the current run of spring chinook salmon in the subbasin upstream of North Fork Dam is more representative of the hatchery Willamette strain spring chinook rather than the historical run. This premise is based on a shift in the spawning time and a large increase in escapement over the dams at the same time the first fish returned to Clackamas Hatchery. Today, most of the spring chinook salmon spawn in late-September through early-October. Historical records show that a July through early September spawning population of chinook salmon occurred in the upper Clackamas around the turn of the century. Today, recent spawning surveys show that chinook salmon initiate spawning activity in mid-September with the peak spawning period in the last week of September and first week of October. This is almost a two month shift in time from the earlier spawning spring chinook around the turn of the century. The current spawning period coincides with the typical spawning period of the Willamette strain spring chinook produced at Clackamas Hatchery.

The number of spring chinook salmon returning to the subbasin upstream of North Fork Dam has increased in the last decade probably in response to hatchery releases from Clackamas Hatchery located near RM 23. Before the first returns of spring chinook salmon to the Clackamas Hatchery, the number of spring chinook passing over North Fork Dam averaged 530 fish (1970 - 1979). These were probably remnant wild stock fish.

Since 1980, the number has dramatically increased to over 2,500 fish per year. In 1991, a record of over 4,000 fish passed over the dam. This large jump at the same time the hatchery stock returned in large numbers to the hatchery indicates that most of the fish passing over the dam were hatchery stock. This ratio of wild:hatchery fish (estimated at 1:4 based on the 1979 hatchery return time to the average annual escapement over North Fork Dam) leads to interbreeding and depletion of the wild gene pool. Genetic analyses of other salmon populations show that when hatchery salmon comprise 20% or more of the spawning population with frequent interaction, 28 to 87% of the total population will be comprised of hatchery origin salmon within three generations (Hutchings 1991). In this instance, hatchery origin salmon could constitute about 80% of the spawning population (long term average of 530/ 2,500 fish escapement following the first returns of fish to Clackamas Hatchery). This ratio is only speculation based on historical averages and is not based on genetic or tagging information. Given the 14 year period, which equates to four or five generations, of the disproportionate ratio of hatchery to wild fish, it is highly unlikely that any native spring chinook salmon exist in the subbasin. This is true unless the wild fish spawned at different locations than the hatchery fish. It is unlikely that the fish were spatially segregated given the relatively even distribution of spawning fish throughout the river. Thus, one can conclude that the genetic makeup of spring chinook salmon in the Clackamas River is primarily that of Willamette strain brood stock and not of the native spring chinook salmon.

Coho Salmon

Two runs of coho salmon occur in the Clackamas River. These are an early-run that originated from non-native hatchery stock released in the subbasin upstream of North Fork Dam and the native late-run. The early-run fish migrate in the fall and typically spawn in October and November. Late-run coho salmon migrate from November through February and spawn from January through and March.

The Integrated System Plan and the Clackamas Subbasin Plan define the escapement goal for native coho salmon passing over North Fork Dam at 3,000 fish (NPPC 1990; ODFW 1992). Returns of early-run coho salmon has remained relatively constant the last few years. The number of early-run coho salmon passing over North Fork Dam averaged around 800 fish in the last 15 years (Table 3-26).

Returns of late-run coho salmon to the Clackamas subbasin upstream of North Fork Dam have declined in recent years and are considerably below the estimated historical run size. The average number of fish returning to the subbasin upstream of North Fork Dam has remained relatively stable the last 30 years (Table 3-26). The "average" trend can mask true trends. Coho salmon typically live three years which makes it easy determine trends of given brood years. A brood year is the year that the fish returned to spawn. For example, the progeny of the 1990 brood year would return in 1993. Three distinct brood years occur in the watershed. The 1993 brood year is in serious danger of becoming extinct because only 50 adults passed over North Fork Dam. The number of returning adults of the 1993 brood year has declined by about 95% in just two generations. About 824, 410, and 50 adults passed over North Fork Dam in 1987, 1990, and 1993, respectively. The recent precipitous decline along with an analysis of trends indicate a very low probability of the 1993 brood year surviving for 100 years.

The factors affecting the late-run coho salmon are similar to those affecting spring chinook salmon. Commercial fish harvest, habitat condition, and ocean rearing conditions have a greater influence on the distribution and abundance of late-run coho salmon than the other factors. Commercial harvest has affected the time of return of spawning late-run coho salmon (Cramer and Cramer 1994). The shift in return time has resulted in a restricted spawning distribution, later emergence of fry, a shortened growing season, and changes in juvenile migration (Cramer and Cramer 1994). This, in turn, corresponds to an approximate 50% decrease in the productivity of Clackamas River late-run coho salmon (Cramer and Cramer 1994).

The restricted spawning distribution affects the productivity of coho salmon similar to the spring chinook salmon. A large percentage of the adult coho now spawn in the mainstem river just upstream of North Fork reservoir around RM 33. This area does not contain the slower water spawning and rearing areas typically preferred by adult and juvenile coho salmon (Meehan and Bjornn 1991; Groot and Margolis 1991). As with the spring chinook salmon, the largest quantity and potentially best suitable coho salmon spawning and rearing habitat occurs in the watershed, mainly in Big Bottom. Few late-run coho salmon return to this area to spawn (Cramer and Merritt 1991).

Coho salmon use a diversity of habitat types but typically prefer areas with low water velocities such as low gradient streams, side channels, and at the margins of the mainstem river (Meehan and Bjornn 1991; Groot and Margolis 1991). Large woody debris frequently acts as the roughness element creating the protected low velocity areas found at the margins of the river. Outside of the Big Bottom area, natural and created side channels typically have the highest concentrations of juvenile coho salmon along the mainstem Clackamas River (USDA, unpublished). Low velocity habitat types are the most limited in amount and distribution within the watershed and within the Clackamas subbasin upstream of North Fork Dam. Coho salmon typically reside in fresh water for one year prior to migrating to the Pacific Ocean. Therefore, the mainstem and tributaries contain coho salmon at all times. Peak downstream migration of coho salmon occurs in May and June.

Habitat degradation due to road construction and log removal from the mainstem and tributaries has also contributed to the decline in coho salmon. Realignment of Forest Road 46 between RM 57 and RM 65 and the placement of culverts that blocked fish passage has eliminated large amounts of coho salmon habitat. The removal of large log jams following the 1964 flood event and during subsequent salvage timber sales further eliminated or degraded existing and potential coho salmon habitat in the watershed. There were at least two timber sales in the Big Bottom area to remove wood from the large log jams following the 1964 flood (Kyser, personal communication, 1994).

Winter Steelhead

Three stocks of winter steelhead occur in the Clackamas River (ODFW 1992). These include Eagle and Big Creek hatchery stocks and the native stock. The first introductions of hatchery winter steelhead occurred in 1965.

The Clackamas Subbasin Plan outlines an escapement goal for native winter steelhead of 3,000 fish (ODFW 1992). The 3,000 fish escapement goal is an "interim" goal designed to reverse the decline in escapement (ODFW 1992). ODFW estimates that between 4,300 and 13,000 adults are needed to seed available habitat in the subbasin above North Fork Dam (ODFW 1992).

In the last 30 years, the number of returning adult winter steelhead has decreased by about 50%. Current run size averages around 1,400 fish (Table 3-26). In 1990, the number of winter steelhead passing over North Fork Dam in April and May barely exceeded 300 fish. In 1992 the Oregon Fish and Wildlife Commission adopted a catch and release angling regulation for all non-clipped wild steelhead. Since that time, over 1,000 native winter steelhead passed over North Fork Dam in April and May.

The Clackamas Subbasin Work Group cited hatchery effects via competition among juveniles and interbreeding, harvest of juvenile steelhead in the trout fishery, and habitat degradation as the principle factors affecting native steelhead production. Habitat degradation includes decrease in habitat conditions due to removal of instream structure and creation of migration barriers through road construction.

Similar to the spring chinook salmon, there is evidence that the native winter steelhead have been affected by hatchery practices. Prior to the introduction of hatchery steelhead in 1965, 95% of the winter steelhead passed over the dam in April and May. The percent of all steelhead adults passing over North Fork Dam in the spring has declined since 1965. For example, 75% of fish returned in May from 1960 to 1965. This has subsequently declined to about 55% during 1985 to 1987. The increased proportion of fish returning from November through March coincides with the return time of the introduced stocks. Therefore, there appears to be a greater decline in wild fish than that indicated by the overall average number of native winter steelhead passing over North Fork Dam. Fishery biologists are also concerned about the possible competing of juvenile summer steelhead and winter steelhead.

Winter steelhead have a wider distribution than either spring chinook or coho salmon in the watershed. Steelhead tend to migrate farther upstream in the mainstem and in the tributaries than the salmon. Therefore, they are widely distributed throughout the Clackamas River and in a variety of habitat types. Preliminary results of a radio tagging effort of 20 adult winter steelhead and spawning surveys confirm that these fish go farther upstream than coho or spring chinook salmon. It also showed that the native fish tend to use the mainstem for spawning. This could be due to their large size. The tagged fish typically exceeded 30 inches in length which is comparable to the average spring chinook salmon.

Juvenile steelhead trout typically prefer faster water areas than coho or spring chinook salmon (Groot and Margolis 1991; Meehan 1991). In addition, the production of juvenile steelhead greater than one year old is closely associated with the quantity and quality of larger pools. Riffles and boulder cascade areas (i.e. faster water areas) are the predominant habitat feature of the mainstem and tributaries within the watershed.

Summer Steelhead

Summer steelhead in the Clackamas River originated from Skamania/Foster origin hatchery stock (ODFW 1992). ODFW first released summer steelhead in the upper Clackamas River in 1968. ODFW annually releases about 160,000 summer steelhead smolts in the subbasin upstream of North Fork Dam (ODFW 1992). Summer steelhead escapement over North Fork Dam averaged about 5,700 fish during the 80's (Table 3-26). The 1994 count over North Fork Dam was around 2,500 fish.

ODFW manages summer steelhead as a harvestable stock. The management objectives for summer steelhead are to plant hatchery smolts, to promote harvest of the returning adults and to minimize competition and possible interbreeding between the summer steelhead and native steelhead (ODFW 1992). The means to achieve the objective is to minimize competition among summer steelhead and native stocks of anadromous and resident salmonids via angler harvest (ODFW 1992). Information exists that summer steelhead successfully spawn in the subbasin. A number of summer steelhead return each year without noticeable fin clips. ODFW clips the adipose fins of all hatchery produced summer steelhead. Thus, non-clipped steelhead indicate natural production. The amount of naturally produced summer steelhead is unknown.

Resident Trout

Native cutthroat and rainbow trout and hatchery origin rainbow and brook trout live in the main stem and tributaries. They also live in intermittent streams at the headwaters of creeks. Little information exists on the life history of resident coastal cutthroat and rainbow trout in the Clackamas River.

Resident trout in the watershed tend to occur farther upstream in the headwaters than in other parts of the subbasin. One of the reasons is that the watershed has a more gentle topography allowing access and springs provide good flow and temperature conditions throughout the year. The general distribution patterns of resident trout were established during a resident fish distribution study conducted in 1994 along with local knowledge. For example, coastal cutthroat trout can frequently be traced to the origin of a creek at its spring source in the upper Clackamas whereas they are frequently blocked from large stream segments in the Collawash watershed due to topography. Cutthroat trout tend to be more concentrated from Big Bottom upstream and in the tributaries. Coincidentally, the distribution of cutthroat trout coincides with the area that ODFW manages for wild trout. Few cutthroat trout have been observed during snorkeling and electrofishing sampling efforts in areas where ODFW plants catchable rainbow trout.

ODFW manages over two-thirds of the mainstem and all of the tributaries for wild trout (ODFW 1992). ODFW annually stocks about 80,000 catchable rainbow trout in the mainstem Clackamas River from Big Bottom at the Forest Road 4650 bridge (RM 65) on downstream. Most of the fish are released near campgrounds or dispersed sites.

In 1991, the Oregon Fish and Wildlife Commission adopted special wild trout regulations for the Big Bottom area. The area between Forest Road 4650 at RM 65 on up to Forest Road 4670 at RM 70 is a catch and release wild trout area. ODFW discontinued releasing hatchery rainbow trout in this special regulation wild trout area in order to comply with the regulations.

Bull trout were found throughout the Clackamas River in the past. In 1878, David Starr Jordan, one of the premier ichthyologists, reported that Mr. Livingston Stone caught Dolly Varden (since reclassified as bull trout) in the Clackamas River. He also used a drawing from a Clackamas River specimen in one of his publications. The last known record of a bull trout in the Clackamas River was in the early 70's. Fish biologists intensively surveyed habitat having the highest potential of containing bull trout in the Clackamas subbasin in 1990 and 1991. They did not find any bull trout (Kamikawa and Eberl 1992). Based on these surveys and the lack of angler information suggesting the presence of bull trout since the 1970's, it is reasonable to conclude that bull trout do not currently exist in the subbasin upstream of North Fork Dam (Kamikawa and Eberl 1992).

The Forest Service, Region 6, classify the bull trout as a sensitive species (FSM 2670). It is classified as such due to its recent decline in abundance and distribution throughout the Forests in Oregon and Washington. ODFW classifies the bull trout as "critical" on the State's sensitive species list (OAR 635-100-140). A "critical" classification denotes a species for which listing as threatened or endangered is pending; or those for which listing as threatened or endangered may be appropriate. In 1994, the U.S. Fish and Wildlife determined that sufficient information existed to warrant protection for bull trout under the Endangered Species Act but listing was precluded at this time (Federal Register 59: 30254-30255).

Brook trout were found in the river upstream of RM 79. They probably came from fish planted in lakes that drain into the Clackamas River.

Habitat Conditions

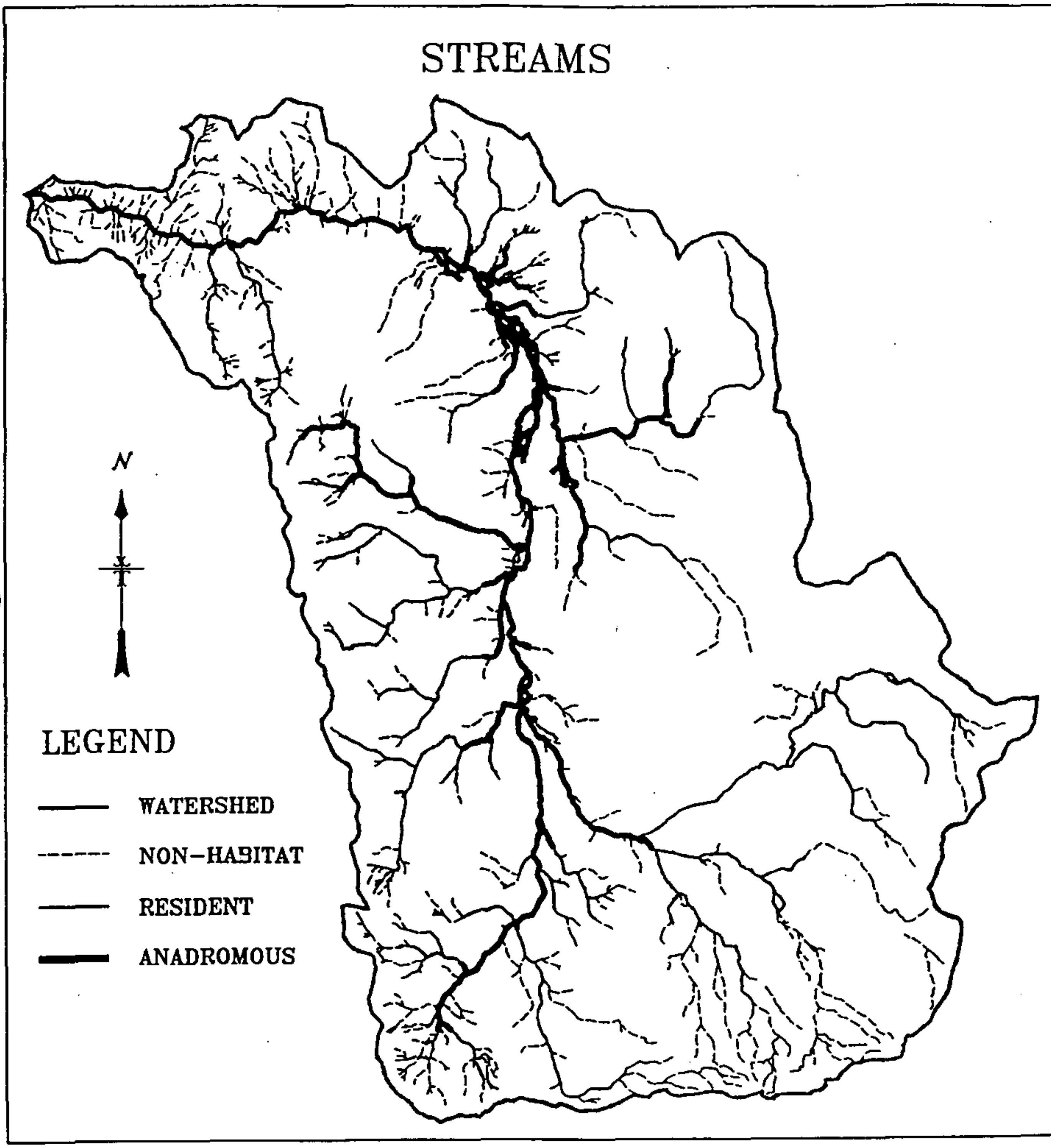
The Clackamas River initiates west of the Cascade crest north of Mt. Jefferson. The river flows through a variety of valley forms and ecotypes as it flows along the 25 mile journey from the headwater springs near RM 81.4 to the confluence with the Collawash River at RM 57. The river within the watershed is a fifth order river (Strahler 1957).

Approximately 320 miles of streams flow through the watershed. Of this quantity, anadromous fish have access to about 65 miles of the mainstem and tributaries while resident trout occur within an additional 75 miles in the tributaries. Thus, fish use at least 140 miles or about 45% of the mainstem and tributaries in the watershed (Table 3-27). Map 3-10 displays the stream network in the watershed classified by fish use (anadromous, resident, or no fish presence).

Table 3-27. Stream length, density and fish distribution by subwatersheds and natural groups.

Subwatershed	Acres	Stream Miles			Total Stream Miles	Stream Miles Per Sq. Mile
		Anadromous	Resident	Non-Fish		
Austin Segment	10123	8.1	3.8	38.8	50.6	3.2
Granite	1878	0.1	2.5	5.4	8.0	2.7
Northwest Group Totals	12000	8.2	6.2	44.2	58.6	3.1
Cabin	2144	1.0	3.0	1.4	5.3	1.6
Dyke	2258	0.0	0.0	1.6	1.6	0.4
Last	7355	4.1	5.6	3.8	13.5	1.2
Pinhead	7486	4.7	1.9	6.3	12.9	1.1
Pot	2281	0.4	3.9	2.9	7.3	2.0
East Group Totals	21523	10.2	14.4	16.0	40.6	1.2
Fawn	2391	1.2	3.2	2.9	7.3	1.9
Hunter	4151	1.6	6.3	5.5	13.5	2.1
Lowe	4120	6.4	2.2	6.0	14.6	2.3
Rho	4086	0.7	7.7	4.2	12.6	2.0
West Group Totals	14747	9.9	19.4	18.6	48.0	2.1
Berry	5430	3.0	4.8	20.3	28.0	3.3
Cub	9074	4.8	7.3	17.4	29.5	2.1
Squirrel	3863	0.0	3.5	15.7	19.2	3.2
South Group Totals	18367	7.7	15.7	53.4	76.7	2.7
Lemiti	9422	0.0	10.6	6.1	16.6	1.1
Olallie	2675	0.0	0.9	4.9	5.8	1.4
S. Fk. Lemiti	2271	0.0	3.0	1.9	4.9	1.4
Southeast Group Totals	14368	0.0	14.5	12.9	27.3	1.2
Big Bottom Segment	8931	19.3	2.4	19.1	40.7	2.9
Headwaters Segment	10443	8.2	3.8	17.3	29.3	1.8
Mainstem Group Totals	19375	27.5	6.2	36.3	70.0	2.3
Totals	100380	63.4	76.4	181.4	321.1	2.0

Map 3-10. Stream Network and Fish Distribution.



The physical processes that affected aquatic and riparian habitat conditions were different historically than at present. A number of assumptions were developed to determine historical conditions. These include: 1) flow events exceeding a 100 year recurrence interval were probably the dominant floodplain forming event; 2) debris flows tended to be isolated in the narrow corridors along creeks and were infrequent; 3) landslides were limited to small parts of the watershed, were relatively small in size, and probably accounted for less than 10% of the landscape; 4) aquatic disturbance regimes were different upstream and downstream of Big Bottom; and 5) there were fewer species of fish and bull trout were the top fish predator.

Lakes

Over 130 lakes and ponds having a combined surface area over 220 acres occur within the watershed. Map 3-6 in the Wildlife section displays some of the larger lakes and ponds. The majority of the lakes have surfaces areas less than one acre. Most of the many lakes in the Olallie area result from volcanism and Pleistocene glaciation (Chapter 3 - Geologic Processes). This is also the case for most of the higher altitude lakes above 3,000 feet. Some lakes, such as Fish and Gifford Lakes in the Olallie Lakes area, may have been formed by landslides. Many of the small ponds below 3,000 feet are sag or slump ponds that are formed behind rotational blocks in moving earth flows. Tag Creek Pond at the north end of the watershed is a good example. Some ponds may also be the result of beaver activity. Beavers may build and maintain dams that create large, long lasting ponds in marshy, low gradient valleys. The majority of the lakes occur in the south end of the watershed above the 4,000 foot elevation mean sea level. The lakes and ponds in the watershed vary from shallow, seasonal ponds covering around 0.1 acres that dry out during the summer, to large, deep, permanent lakes such as Fish Lake, which is 24 acres and 67 feet deep.

Most of the lakes in the watershed are glacial, pothole lakes that lack permanent inlet or outlet streams. Most of the lakes are bordered by mature or old-growth forest cover. Portions of lake shorelines are sometimes wetland meadow or talus rock slopes. Many of the lakes surveyed to date are oligotrophic lakes. Oligotrophic lakes tend to be nutrient poor, have high water clarity, and abundant dissolved oxygen. This is especially true of the deeper lakes. Some of the shallower lakes can be classified as either mesotrophic or eutrophic. Eutrophic lakes are the most advanced in nutrient and trophic levels and mesotrophic lakes are intermediate between oligotrophic and eutrophic lakes. Switch Creek Pond (1 acre) is an example of a fish bearing, sag pond in earth flow terrain. This pond, at the north end of the watershed, has a permanent inlet stream and some limited capability for natural fish reproduction in the inlet. Switch Creek Pond is very shallow, with a large area of emergent aquatic vegetation and higher nutrient levels; thus, it is considered mesotrophic.

Lakes within the watershed have different characteristics, depending upon their morphology, location within the watershed, or other factors. Fish Lake is a very deep and large lake in the south end at 67 feet deep and 24 acres surface area. Fish Lake stratifies with a thermocline at between 20 to 23 feet. Lake temperatures range from 16.5°C at the surface to 4.2°C at the bottom. The dissolved oxygen levels drop off sharply below 40 feet. Dissolved oxygen levels actually peak at the 20 foot depth in Fish Lake. In contrast, Olallie Lake is a relatively deep lake at 46 feet with a large surface area of [illegible]0 acres in the adjoining watershed. Dissolved oxygen remained saturated throughout the Olallie Lake water column. Although not as deep as Fish Lake at 46 feet, Olallie shows no signs of stratification with surface and bottom temperatures ranging from 18.0 to 17.8°C, a less than 2°C difference. Olallie Lake does not stratify or stratification is limited because of the large, open basin with a relatively long axis in line with the prevailing winds. This results in thorough mixing of lake waters from the wind.

Many of the lakes have high water temperatures during dry, sunny summers even at higher elevations. The lakes may show elevated water temperatures through the water column regardless of depth. Shallow lakes typically are uniformly warm. The deeper lakes within the watershed would also be warm from surface to bottom if uniformly mixed by surface winds. Lake water temperatures have commonly exceeded 20-25°C during the hot summers. Many of the lakes in the watershed have low values for alkalinity, conductivity, and especially low pH. This makes the more oligotrophic lakes of the area sensitive to potential acid deposition.

Recreation use modifies and reduces shoreline riparian vegetation and groundcover at the more popular lakes, like Olallie. In some areas, recreation foot traffic near roads, has denuded lake shore banks of almost all ground cover. The more popular backcountry lakes have suffered similar damage but on a smaller scale. Deep cut trails and small localized areas of heavy trampling at lake shore campsites are common for the more visited of the trail accessible lakes. Recreation use and resulting impacts will probably continue into the future and will likely increase at many lakes with increased population growth in Oregon. Other remote lakes could probably tolerate additional use but are less well known or accessible. The Olallie Lakes portion of the watershed area is heavily used recreationally and as a popular sport fishery during the summer months.

ODFW manages the trail accessible and other backcountry lakes as "put and grow" fisheries. Most of the lakes within the watershed are managed in this manner. ODFW releases sub-yearling brook, rainbow and cutthroat trout by aircraft and backpack. Backcountry lakes in recent years have been stocked on a bi-annual basis (stocking varied from <50 fish/acre to >150 fish/acre in past). Most of the lakes do not have natural reproduction of trout and were fishless before introductions of fish began in the 1920's. Lack of year round inlet or outlet streams and spawning gravel prevents natural reproduction in most of the lakes. The backcountry lakes provide a high quality sport fishery in an unroaded, natural forest environment. Many of the lakes support healthy trout populations even in the lakes with water temperatures exceeding 20°C. This temperature can be lethal to trout.

Habitat Composition

The river contains a diversity of channel and valley form characteristics. The tributaries that flow into the mainstem can also be stratified into larger groups based on stream density, gradient, habitat composition, hydrology, coarse woody debris, substrate, and valley form. Map 1-4 displays the subwatersheds by these groupings. Information collected during stream surveys conducted between 1989 and 1994 formed the basis for stratification of subwatersheds into larger groups. Table 3-28 displays the results of these stream surveys.

The mainstem Clackamas River within the watershed consists of three areas based on these characters. The Headwaters Segment includes the mainstem from its origin downstream to Big Bottom at RM 72.8. The Headwaters Segment includes headwater springs at RM 81.4 and the intermittent area of the river upstream of the springs. The area from RM 79 to RM 80.3 lies within this but is distinctly different. The Big Bottom Segment includes from RM 72.8 downstream to

Table 3-28. Stream survey information used to delineate natural groups.

Stream*	No. Peices CWD/mile (>36"x50')*	No. of Pools/Mile*	Dominant Substrate*	Average Channel Gradient(%)*	Average Channel Width(ft)*	Stream Miles Per Sq. Mile**
Austin Seg.	0.1	2.1	Cobble	1	66	
Northwest Group Avg.						3.1
Cabin	9.3	7.3	Cobble	6.7	7.3	
Wolf	38	4	Gravel	7	10	
Pinhead	5.3	16.5	Cobble	4.6	16.8	
Last	26	4.9	Sand	4	12.5	
Camp	54	14	Sand	8	4	
Poop	21	10.6	Sand	7	4	
East Group Avg.	25.6	9.6		6.2	9.1	1.2
Kansas	7.0	4.0	Cobble	15.5	15.0	
Lowe	67.0	20.0	Cobble	7.5	12.0	
Rho	1.0	2.7	Cobble	8.0	8.0	
Tumble	19.0	8.7	Cobble	11.0	7.0	
Fawn	14.0	45.0	Cobble	10.0	10.0	
Hunter	90.0	13.7	Cobble	7.0	12.0	
West Group Avg.	33.0	15.7		9.8	10.7	2.1
Cub	8.0	18.5	Small Bould.	3.0	22.5	
Cub Springs	12.8	41.0	Cobble	6.0	12.0	
Berry	11.0	38.5	Cobble	4.5	18.5	
Squirrel	4.0	16.0	Small Bould	6.0	16.0	
South Group Avg.	9.0	28.5		4.9	17.3	2.7
***						
Southeast Group Avg.						1.2
Hdwtrs Seg.	3.8	12.4	Cobble	4	31	
Mainstem Group Avg.						2.3
Totals	14.3	14		5.2	27	2

* Data was collected during streams surveys '89-'94. Streams not surveyed were not included.
** Data was generated by subwatershed and averaged for each group.
*** No streams were surveyed in this subgroup.

RM 65 and the Austin Segment is the area from RM 65 downstream to RM 57 where the river joins the Collawash River.

In general, the mainstem Clackamas River consists primarily of riffles and cascades interspersed with large pools. Large boulders and cobble are the predominant substrate type. The river flows from a 1 to 3% gradient as it approaches the confluence with the Collawash River up to 5 to 8% gradient just below the headwater spring source near RM 81.4. In almost all areas, the riffles exhibit whitewater as the water passes over the larger boulders. Big Bottom and the river between RM 79 and 80.3 are notable exceptions to the general character of the river.

The mainstem Clackamas River between RM 57 and RM 65 provides a diversity of habitat types. Cascades are the dominant habitat characteristic in this area. Pools are limited in frequency and size in this stretch. Small pockets of spawning gravel occur in the margins and riffles of the mainstem or around large boulders or coarse woody debris. Juvenile spring chinook and coho salmon, juvenile winter steelhead, and resident cutthroat and rainbow trout are frequently observed in this reach. The heaviest concentrations of fish occur in the side channels and near coarse woody debris in the channel.

Mainstem Group

Big Bottom Segment

Big Bottom is an area of extremely diverse fish habitat and hydraulic conditions. The river flows through numerous channels as it meanders through an unconstrained wide, glacial valley. Big Bottom has one of the highest stream densities in the Clackamas subbasin. Mapped stream channels yield an estimate of 2.9 miles of stream per square mile (Table 3-27). Actual stream miles are at least 50% higher based on ground verification of a subsample of Big Bottom with Global Positioning Satellite technology. Therefore, actual stream density probably exceeds 4 miles of stream per square mile. This area of the river contains very dense concentrations of coarse woody debris in the channel. Many large debris jams containing in excess of 20 logs exist in this 8 mile stretch. In this area, the valley frequently exceeds one-half mile in width.

Big Bottom contains some of the most diverse and complex aquatic habitat in the Clackamas River. The interspersion of braided channels and frequent accumulations of coarse woody debris create the habitat complexity. Thus, Big Bottom provides excellent large pools for holding adult anadromous fish, contains large amounts of spawning gravel, and the frequent concentrations of large woody debris in the mainstem and the quantity of side channels provides excellent rearing habitat for resident and anadromous salmonids.

Headwaters Segment

The headwaters segment has a stream density of 1.8 mile/square mile with a total of 29.3 miles of stream. Upstream of RM 81.4 the Clackamas River becomes an intermittent system. Surface flows occur during the spring runoff and during intense rainfall events. These rainfall events typically occur during the fall, winter, and spring.

The river between RM 79 and 80.3 has a very different character than the immediately upstream and downstream areas. In this section the river flows at a 2% gradient and through a wide "U" shaped valley with numerous channels similar to Big Bottom. This latter unconstrained reach does not have the density of logs or debris jams as in Big Bottom. The paucity of logs in this area could be due to the harvesting that occurred in the early 1980's.

Tributaries to the mainstem Clackamas River are grouped into five groups. These groups are: 1) Northwest Group; 2) Southeast Group; 3) South Group; 4) East Group; and 5) West Group.

Northwest Group

Tributaries in the Northwest Group flow through the earthflow landform near the confluence with the Collawash River and include the mainstem and smaller tributaries downstream of Big Bottom. The tributaries tend to have more fines in the substrate, poorly developed pools, and are steep. Riparian Reserves account for about 27% of the area within this group. The streams flow at gradients exceeding 10% and stream adjacent slopes frequently exceed 30%. Northwest Group tributaries and their catchments account for about 12% of the watershed.

Southeast Group

Southeast Group streams have intermittent flow regimes, stream gradients less than 5%, and a stream density of 1.2 miles of stream per square mile (Table 3-27). Southeast Group subwatersheds account for about 14% of the watershed. Coarse woody debris is important for creating and maintaining fish habitat. Riparian Reserves encompass 14% of the Southeast Group (Table 3-6 in Vegetation section).

South Group

The South Group includes the Berry, Cub, and Squirrel Creek subwatersheds. Springs serve as the primary source for perennial flow. Streams in this group have one of the highest stream densities in the watershed. These streams have average stream gradients around 5%, about 28 pools per mile, and a relatively high frequency of coarse woody debris. Coarse woody debris acts as the primary factor for creating, maintaining, and diversifying fish habitat. South Group subwatersheds account for about 18% of the watershed.

Riparian Reserves in the South Group comprise about 26% of the combined subwatershed areas in this Group (Table 3-6). Riparian Reserve acreage reflects stream density and fish distribution. For these tributaries, Riparian Reserves make up a higher proportion of the subwatershed area due to an average stream density that is higher than the watershed average of 2.0 miles per square mile (Table 3-27).

East Group

East Group streams flow over a moderate gradient, have fewer pools per mile, an intermediate concentration of coarse woody debris, and a low stream density (Tables 3-27 and 3-28). East Group streams and their subwatersheds account for about 21% of the watershed. Many of the streams originate from large springs. For example, the spring that serves as the primary perennial water source for Pinhead Creek is estimated to flow at around 30 cubic-feet-per-second (cfs). Coarse woody debris acts as the primary factor for creating, maintaining, and diversifying fish habitat. The low number of pools combined with the low amounts of coarse woody debris indicates that coarse woody debris is limiting the creation of pools. This in turn currently limits fish production in the East Group streams.

Riparian Reserves along East Group streams make up 14% of the combined subwatershed areas in this Group (Table 3-6). Fish distribution more than stream density affects the amount of Riparian Reserves. The East Group subwatersheds have a relatively high percentage of streams that contain fish at 61% but the stream density of 1.2 miles per square mile is considerably less than the watershed average of 2.0 miles per square mile (Table 3-27).

West Group

West Group streams flow over more steep terrain. They originate from large wet meadows, flow at steeper gradients (about 10%), have a higher concentration of pools per mile (about 15), and are less dependent on coarse woody debris for creating, maintaining, and diversifying fish habitat. Wet meadows within the watershed average about 12 acres in size and get as large as 80 acres. Many of these meadows serve as the primary hydrologic sources for these creeks. These streams tend to be more of the step-plunge pool streams. West side tributaries have a higher proportion of boulders in the substrate. Thus, boulders become the dominant roughness element in the channel that facilitates pool formation. Coarse woody debris in the riparian areas along west side streams tends to be larger than in other parts of the watershed. These trees can affect changes in the habitat composition of these streams due to their large size. West Group streams and their catchments account for about 15% of the watershed.

Riparian Reserves along West Group streams make up about 21% of the subwatershed area (Table 3-6). West Group tributaries have a relatively high proportion of streams containing fish and a stream density equal to the watershed average (Table 3-27). Thus, fish distribution affects the amount of area covered by Riparian Reserves more than stream density for west tributary streams.

The effects of dispersed camping along the mainstem Clackamas River have been mitigated by controlling vehicle access and reestablishing vegetation within previously compacted areas. These actions restore much of the function of riparian habitat in the localized area and if done on a watershed wide scale provide cumulative benefits along the mainstem. Conversely, uncontrolled use of dispersed sites would negatively affect riparian function and aquatic habitat in the local area and along the mainstem paralleled by roads.

Administrative Habitat Characteristics

The LMP and Columbia Basin Anadromous Fish Policy and Implementation Guide (PIG) include numeric standards for stream habitat conditions (Table 3-29) (USDA 1990; 1991). These standards include target values for pools and coarse woody debris levels per mile of stream. The Pacific Salmon Work Group of the Forest Service developed the ranges of natural variability for pools and coarse woody debris attributes as part of the PACFISH strategy (USDA 1993d). The standards vary depending upon the size of the stream. These two attributes are important indicators of instream habitat condition. Coarse woody material frequently serves as a catalyst for pool formation and diversification of instream habitat. The loss of pools may also indicate a loss of coarse woody material and thus, a simplification of instream habitat (USDA 1993b). The interaction of the two attributes may be more important than focusing on each attribute independently when assessing instream habitat conditions. Figures 3-12 and 3-13 display the averages and measured range of streams within the groups.

The number of pools in the Clackamas River does not meet the numeric standards (USDA 1993d). All of the surveyed streams within the watershed fall below the target standards for streams of equivalent size (Figures 3-14 and 3-15). Only Berry Creek, a south watershed tributary, has pool frequencies that fall within the numeric standards for streams having similar channel widths (Figure 3-14).

The differences in pool frequencies and densities of coarse woody debris in the tributary streams and mainstem Clackamas River relative to the numeric standards does not necessarily reflect degraded instream habitat conditions. The influence of coarse woody debris to create and maintain pools and diversify habitat is different in each of the stream groups, if not each stream. Further, the criteria used to define a pool is not uniform for each of the streams because the definition of pools changed during subsequent years when biologists surveyed the streams. Thus, there could be more pools in a given stream than indicated in the data.

As discussed above, the relative importance of coarse woody debris size and function in the creation and maintenance of instream habitat varies by each stream group. For example, coarse woody debris

Table 3-29. Numeric habitat standards described in the LMP and PIG.

Stream Habitat Numeric Standards		
Pool Frequencies (pools /mile)		
Average Stream Width (ft.)	**LMP* Desired Future Condition**	**PIG** Desired Future Condition**
< 5	> 151	184
5-10	75-211	96
10-15	50-106	70
15-20	38-70	56
20-25	30-53	47
25-50	15-42	26
50-75	10-21	23
75-100	8-14	18
Large Woody Debris (# pcs./mile)		
Size Class	**LMP Desired Future Condition**	**PIG Desired Future Condition**
(24 - 36" x 50')	85	
(>36" x 50')	21	80

* LMP - Mt. Hood National Forest Plan 1990

** PIG - Pacfish (Policy Implementation Guide 1994)

Figure 3-12. Average and measured range of pools per mile for sampled streams by natural group.

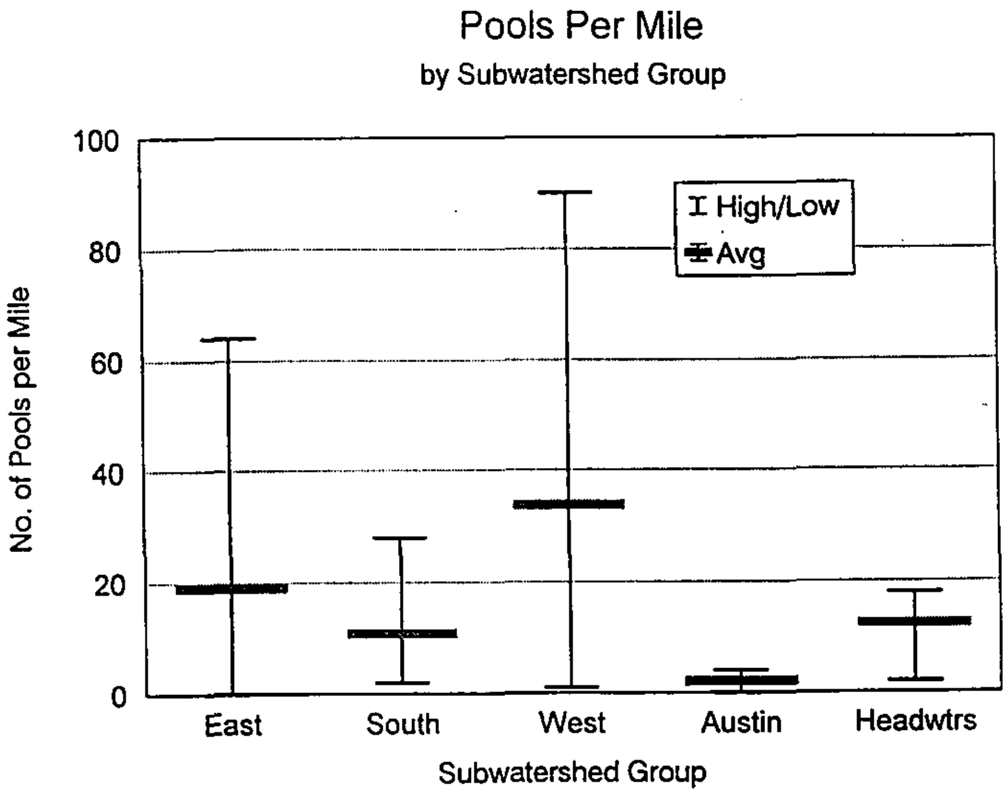


Figure 3-13. Average and measured range of pieces of coarse woody debris (> 36 inches diameter and > 50 feet long).

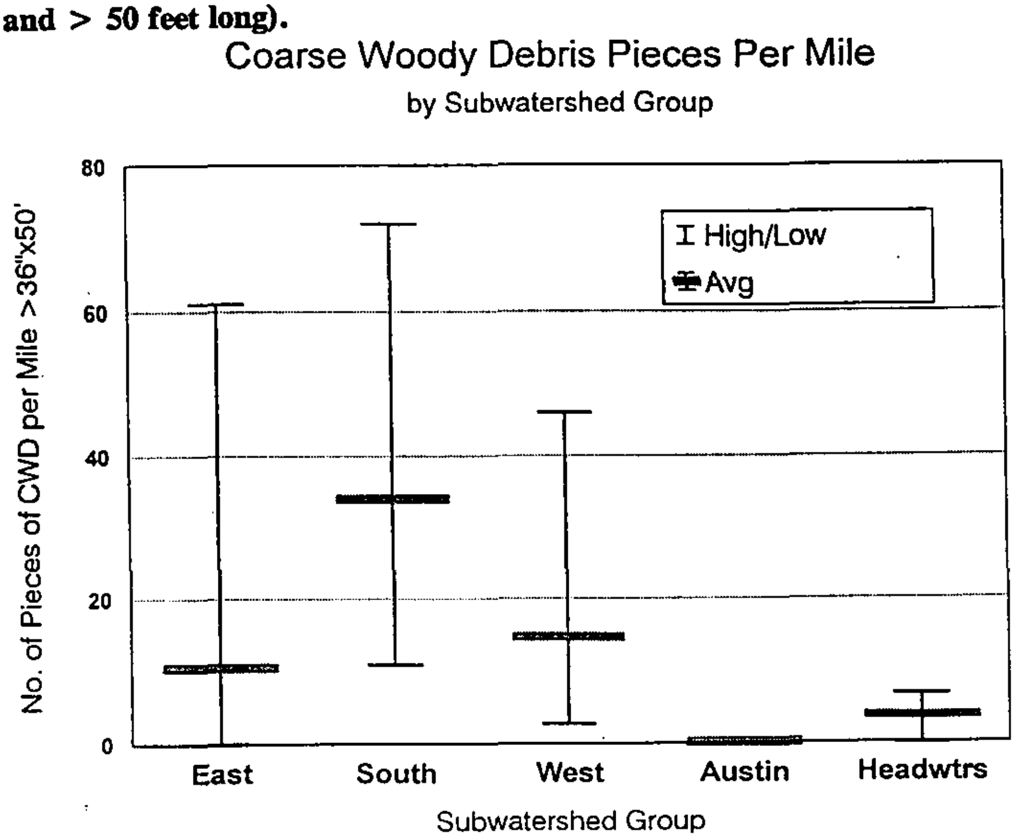


Figure 3-14. Average number of pools per mile for sampled streams by natural group with LMP and PIG numeric standards.

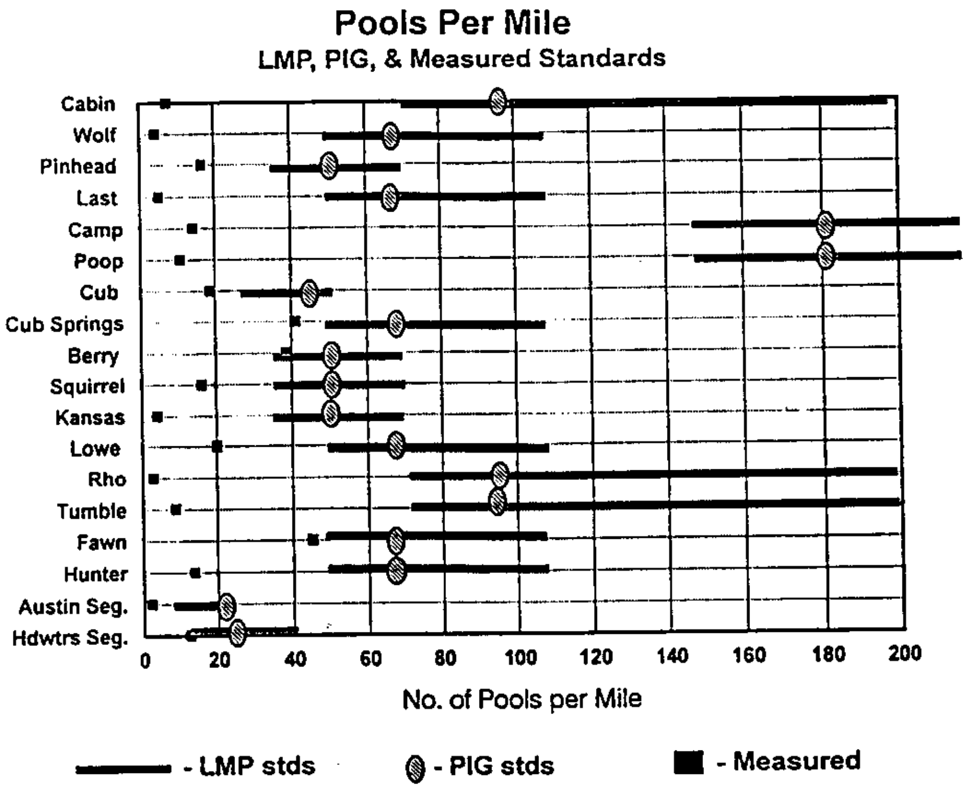
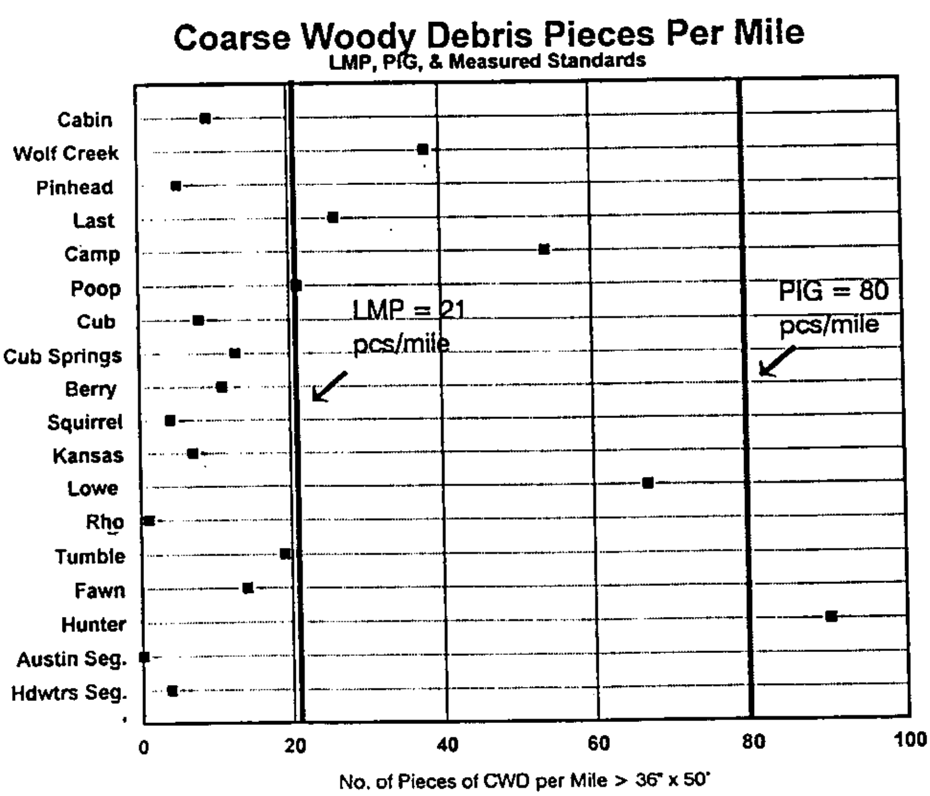


Figure 3-15. Average pieces of coarse woody debris (> 36 inches diameter and > 50 feet long) per mile for sampled streams by natural group with LMP and PIG numeric standards.



is more important in maintaining and creating pools in the lower gradient streams containing cobble and smaller sized substrate. Conversely, steeper gradient streams with boulder substrates are less dependent on coarse woody debris for pool formation and maintenance. Applying this principle, the East, South, Northwest, and Southwest groups depend more on coarse woody debris than the west side tributaries for pool formation and maintenance. This does not discount the influence of coarse woody debris in the west side tributaries. They are important for other purposes such as providing cover for fish or serve as source material for downstream areas. Further, the East and South groups require larger material for the creation and maintenance of pools than the Northwest and Southeast groups because of their larger flow volumes.

Larger material in the East and South Group streams also function to store spawning gravel. Higher flow volumes require larger material to affect the hydraulic conditions that allows for the movement and storing of spawning gravel. The boulders in the west side tributaries serve a similar function. Coarse woody material is more important as a roughness element for regulating the storage and transport of fine sediment in the northwest tributaries than in the other parts of the watershed.

The numeric standards also do not reflect the dispersion and concentration of the coarse woody material. Larger streams require larger material, in more dense clumps to create and maintain pools and diversify the instream habitat. On the other hand, one large piece of wood can affect a greater amount of instream habitat in a smaller stream than a larger one. For example, log jams in the lower segments of Pinhead and Cub Creeks would be necessary to create large pools. Whereas, one large log that meets the numeric standard of greater than 36 inches diameter and at least 50 feet long would cause substantial changes to the habitat in streams such as Wolf and Squirrel Creeks.

Fish Utilization and Production

Approximately 321 miles of perennial and intermittent streams flow through the watershed. Fish use about 48% of this total. Anadromous fish use 63 miles or 20% of the total. Resident fish occupy an additional 76 miles or 24% and also overlap the areas used by anadromous fish.

Steelhead and resident cutthroat trout are the primary inhabitants of the area from RM 72.8 to 79.0. The reason is that the area has an increased gradient and there are frequent cascades and slack water behind large rocks in the channel. Steelhead and resident cutthroat trout are more adapted to the higher velocities and habitat characteristics than the juvenile salmon. The complexity of the habitat changes due to channel braiding near RM 75.

Resident cutthroat trout and brook trout utilize the use the unconstrained area from 79.0 to 81.4. This area is above the steep cascades at RM 77.3 that blocks anadromous fish passage to the upper reaches.

The Forest Service developed smolt habitat capability estimates for the tributaries and mainstem of the Clackamas River within the watershed (Table 3-30). These estimates are based on stream survey information in conjunction with the smolt habitat capability model developed for the PIG (USDA 1991). The estimates developed for the tributaries and the mainstem Clackamas River within the watershed reflect two levels. The 15% level represents the low escapement levels that currently exist

Table 3-30. Smolt habitat capability estimates for spring chinook salmon (Onts), coho salmon (Ontk), and steelhead (Onmykl) for sampled streams and the mainstem.

	Current			Potential		
Stream	Onts	Onki	Onmy1	Onts	Onki	Onmy1
Cabin	96	72	29	2367	959	320
Pinhead	221	166	66	5448	2209	736
Last	97	73	116	2399	973	1287
Poop						
Cub	151	113	135	2714	1505	1495
Cub Springs						
Berry			107			999
Kansas						
Lowe	49	36	130	1200	487	1446
Rho	83	62	25	2048	830	277
Tumble						
Fawn	98	73	29	2416	980	327
Hunter	97	73	59	2392	970	653
Austin Segment	3765	2824	1129	25100	18825	7530
Big Bot Segment	41000	15000	4578	280000	98000	30520
Headwtrs Segment	6715	2722	907	44770	18150	6050
Totals	**52372**	**21214**	**7310**	**370854**	**143888**	**51640**

while the potential smolt habitat capability represents the potential capability given correction of known habitat deficiencies and assumes full seeding of adults.

The output from the model underestimates the existing production of coho salmon and overestimates the existing production of steelhead trout in the watershed. Modeling results estimate that coho salmon and steelhead trout smolt production in the watershed is 21,200 and 7,300, respectively; while the modeled *potential* production of coho salmon and steelhead trout smolts in the watershed is 144,000 and 51,600 smolts, respectively (Table 3-30). In 1994, an estimated 72,000 coho salmon and 3,100 steelhead trout smolts were produced from the watershed above the Austin segment.

The above information allows one to refine the smolt habitat capability models to better reflect existing conditions, allows an analysis of habitat capability by species and by locale in the subbasin, and allows an assessment on relative escapement of adults to a given area. The Forest Service operated three traps during spring, 1994. The traps were operated on Fish Creek near RM 42, the Oak Grove Fork near RM 53 and the mainstem near RM 58. The estimated coho salmon smolt production for these traps was 24,000, 2,000, and 72,000, respectively. The watershed has the highest production capability for coho salmon smolts in the subbasin upstream of North Fork Dam. An estimated 122,000 coho salmon smolts passed over North Fork Dam by the end of June. Thus, the watershed upstream of the Austin segment produced about 60% of the coho smolts produced upstream of North Fork Dam.

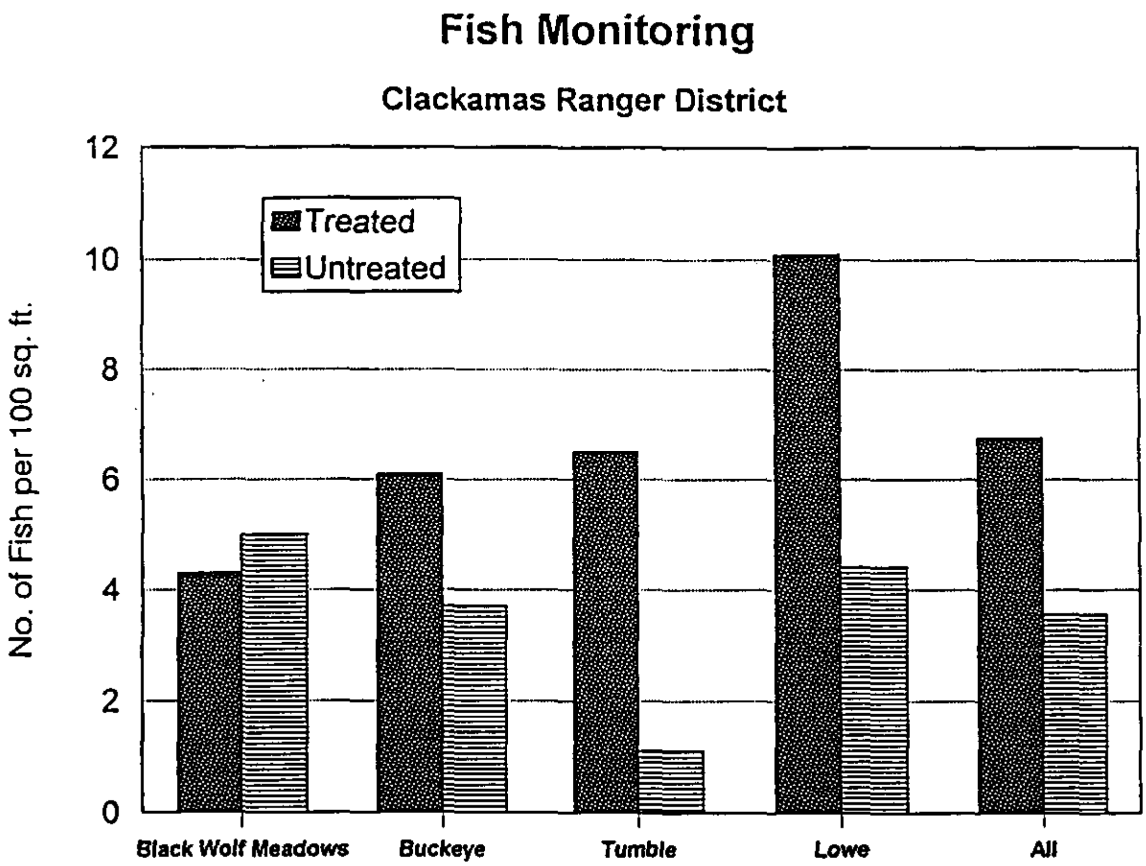
Steelhead trout smolt production was the opposite of coho salmon smolt production. Fish Creek, Oak Grove Fork, and the mainstem Clackamas River above the Austin segment produced an estimated 12,500, 1,000, and 3,100 smolts, respectively. An estimated 63,000 steelhead smolts passed over North Fork Dam by the end of June, 1994. The watershed upstream of the Austin segment produced about 5% of the steelhead smolts produced upstream of North Fork Dam.

The estimated smolt production clearly underestimates current capability. The high coho production supports the contention that Big Bottom has the highest potential for producing coho salmon in the subbasin upstream of North Fork Dam. The high stream density due to frequent channel braiding, preponderance of low velocity areas in the side channels, and frequent concentrations of coarse woody debris throughout the Big Bottom area contribute to the high potential. The information also allows one to assume that high numbers of coho salmon spawned in the Big Bottom area or in the tributaries on the east side of the river. These areas provide the most suitable habitat conditions in the watershed for coho salmon production. The South and West Group tributaries are typically too steep and have water velocities that exceed the preferred velocities for juvenile coho salmon.

The physical factors affecting steelhead production are different than those affecting coho salmon. Juvenile steelhead trout typically prefer faster water than juvenile coho salmon. The production of steelhead smolts is closely related to the quantity and quality of large pools. The mainstem, including Big Bottom, contains a large amount of large pools. The habitat in the East, West, and South tributaries is more suited to produce steelhead than coho salmon due to the higher gradient and higher water velocities. The estimated smolt production is below what one would expect based on the habitat information and estimated capability. This leads one to conclude that escapement rather than habitat affects the existing production. One possible explanation is that adult steelhead are not using the mainstem upstream of Big Bottom and tributaries for spawning. Spawning surveys during spring 1994 support this contention. Most of the native winter steelhead spawned downstream of Big Bottom or in other parts of the subbasin in spring, 1994 based on spawning surveys and radio tagging information. Steelhead trout production in the watershed consists of native winter steelhead, hatchery origin steelhead, and summer steelhead. The 1994 smolt estimate probably includes smolts from all three stocks of steelhead. This further underestimates the production of native winter steelhead from the watershed.

Resident trout production appears to depend on the quantity and quality of pool habitat in the tributaries. Some of the highest concentrations of resident cutthroat trout occur in the slack water behind boulders in the mainstem and in the pools in the smaller tributaries. Pools in Tumble and Lowe Creeks within the watershed created by habitat modification had higher densities of cutthroat trout than natural pools (Figure 3-16). The created pools tended to be larger and deeper than natural pools and frequently had more cover in them. Although there are no estimates on the production of resident trout for the watershed, one could reasonably conclude that the quantity and quality of pool habitat in the tributaries is a significant factor in the production of resident trout.

Figure 3-16. Density of resident trout collected (fish per 100 sq. ft.) in Clackamas River tributaries.



Hydrology

The Upper Clackamas watershed has numerous seeps and springs in addition to the stream network. Many of these seeps and springs feed directly into streams and many appear to be isolated from surface channels. These small springs occur throughout the watershed but some of the more dense concentrations of these springs occur in the South Group. Many of the springs are only visible in small pockets (< 10 feet diameter) and many of the openings occur near the roots of large trees.

From RM 81.4 downstream to the Collawash River at RM 57, the Clackamas River maintains a steady base flow due to the large spring located at RM 81.4 and the large number of spring fed tributaries that contribute to the flow in the watershed.

The hydrograph of the mainstem Clackamas River, just downstream of Big Bottom as gaged at RM 65, (USGS gage 14208000), shows that the river has a more gentle flow pattern than other watersheds downstream (Figure 3-17). The period of record for the gage was 1920 to 1970. The average annual water yield for the 50-year period of record was approximately 345,600 acre feet or about 400,00 acre feet adjusted for the entire watershed. This equates to about 48 inches of runoff year.

Approximately 50 percent of the annual runoff comes in the months of November through March. May (12.6%), April (10.8%), January (10.7%), and December (10.5%) have the largest percent contribution to the annual runoff. Mean monthly flows range from 257 cubic feet per second (cfs) in September to 707 cfs in May. Extreme flows for the period of record range from a low of 184 cfs in September, 1942 to a high of 11,200 cfs in December, 1964. Rainfall or rain on snow events drive peak flows in December and January, while snow melt drives the peak flows during the spring .

Of interest is the shape of the hydrograph, the difference between low flows and high flows, and monthly flow patterns. The hydrograph of the watershed reflects gradual increases in flow during peak rain periods and during snow melt in the spring. This hydrograph shows that there is a strong consistent base flow. The difference between the average monthly minimum low flow and the average monthly minimum high flow is 391 cubic-feet-per second (cfs). In other terms, there is about a 250% increase between low and high flows. This is not a large difference considering the size of the watershed. The relatively low amount of change between low and high average monthly flows is indicative of a spring fed system. Other areas in the drainage have much larger differences between average monthly low flow and average monthly high flow. For example, the same analysis for Fish Creek shows an absolute difference of 331 cfs between average monthly low and high flows but the relative change is about 2700%. This is a difference of over two magnitudes. Rainfall and rain on snow events have a greater effect on the Fish Creek hydrograph than the Upper Clackamas hydrograph in part due to the gradual storage and release characteristics of a spring fed system.

The shape of a hydrograph also illustrates how a watershed responds to changes in climatic conditions. The hydrograph for the Upper Clackamas shows that the drainage network and storage capacity of the watershed is much greater than in Fish Creek, the Collawash River or for the subbasin upstream of North Fork Dam including the Collawash River. In other words, for a given rainfall event, there will be much less flow in the channel of the Upper Clackamas River than in Fish Creek or the Collawash River.

Cubic feet per second per square mile (csm) is a metric to standardize the measurement of hydrology of watersheds. The csm is a measure of how much water is delivered to the channel from the watershed. In essence, it is the response time of flows in the channel to rainfall events. The csm allows one to compare runoff patterns of watersheds. A csm analysis of Fish Creek, the Collawash River and the Upper Clackamas watersheds shows that the Upper Clackamas has a much lower csm for the higher runoff periods and a higher csm for the low water periods than the other two near by watersheds. The highest csm for the Upper Clackamas is 5.2 csm, Fish Creek is 7.4 csm, and the Collawash is 11.3 csm. Conversely, the low csm value for the Upper Clackamas is 1.9 csm, Fish Creek is 0.3 csm, and the Collawash is .8 csm.

The flow-duration curve supports the above analysis showing that springs and the greater storage capacity of the watershed are the primary mechanisms affecting the hydrologic regime of the watershed (Figure 3-18). The slope of the flow-duration curve also is an indication of the characteristics of a watershed (Morisawa 1968). A steeper slope indicates that a drainage has a large amount of direct runoff. The slope of the curve for the watershed is not very steep (Figure 3-18). Again, this indicates that there is considerable amount of storage capacity in the watershed and/or the stream drainage network is not so dense as to capture the moisture, rainfall or snowmelt, and rapidly deliver it to the mainstem.

Figure 3-17. Hydrograph of the Clackamas River at river mile 65.

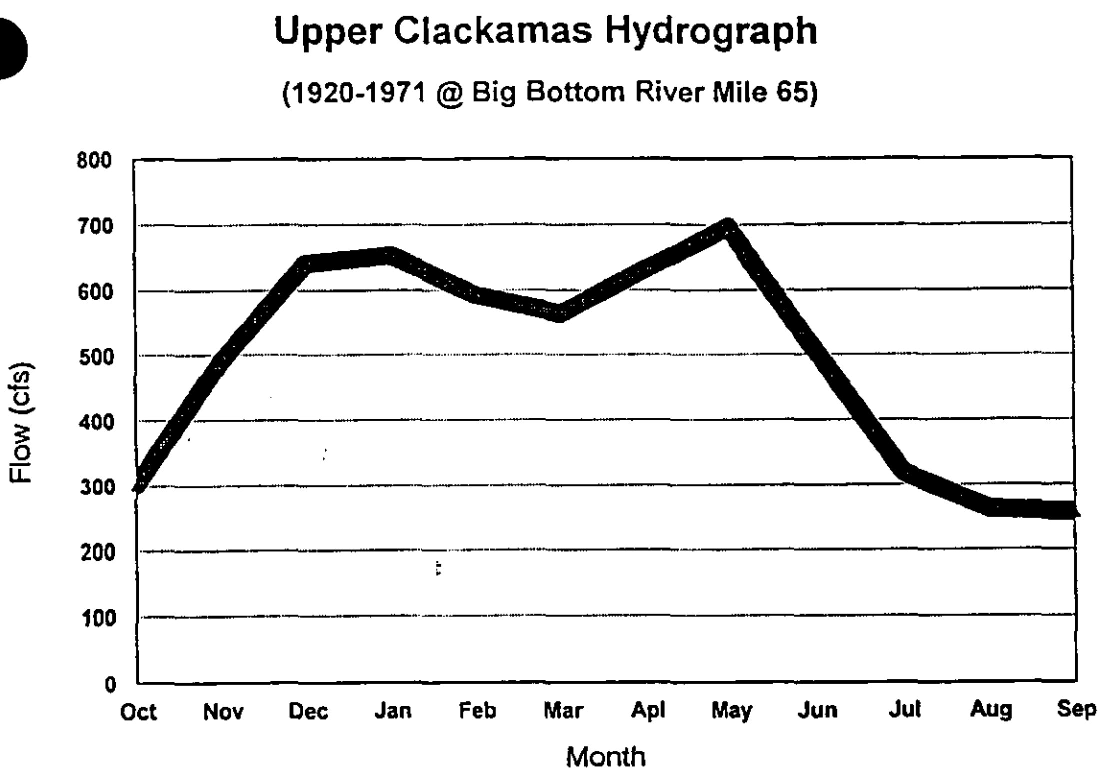
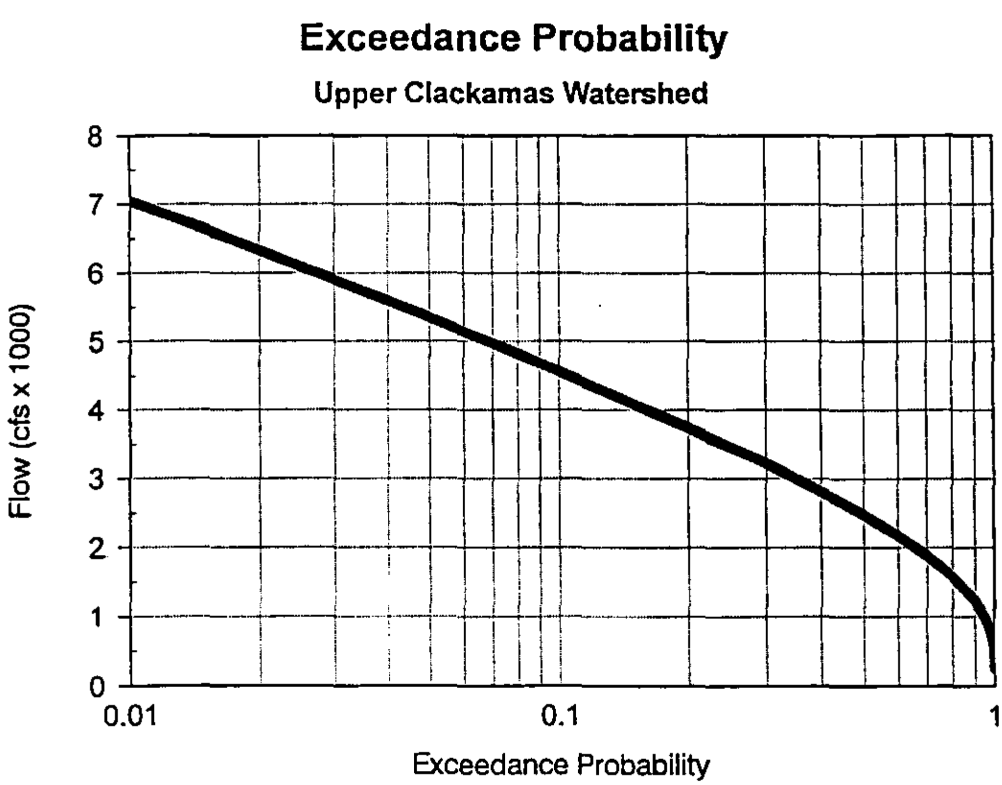


Figure 3-18. Flow duration curve for the Clackamas River at river mile 65.



The Upper Clackamas watershed exhibits daily responses to rainfall or rain on snow events but in a much reduced magnitude than other watersheds in the upper subbasin. The preceeding hydrograph and CSM analysis do not reflect large scale changes in flow patterns due to rainfall or rain on snow events based on mean monthly flows.

Figure 3-18 also shows that a flow of 250 cfs or greater occurs more than 99.99% of the time. The curve also shows that 50% probability that a flow of about 2500 cfs would occur in a given year. The fiftieth percentile flow corresponds to the 2 year recurrence interval flow. In other words, a flow of 2500 cfs would be expected for 2 year flow events. Two year flow events are the most frequent channel forming flow events.

The effects of roads and openings on the hydrology of streams is well documented (USDA, 1994a). Road ditches collect and concentrate the water as well as shorten the transport time from hillslope to stream channel compared to natural processes. The principle effects are to increase the volume and shorten the duration of the amount of overland flow to the stream channels. This results in an increase in the magnitude of peak flows for a given return interval flow event. The stream channels will reflect this change. For example, an increase in peak flows will increase the amount of channel scour at lower return interval flows. The channels will adjust to the change in hydrology. One would expect a greater change in the lower frequency flow events such as the 2 year return interval flow event. The higher magnitude events, such as the 50 and 100 year return interval storms, are more driven by climatic influences than surface runoff.

Three ways to look for effects of roads and openings is to examine the change in the stream network, road density, and for changes in peak flows through time. For the Upper Clackamas watershed, there has been a 9% increase in the stream network due to roads (Figure 3-19). The largest increase in stream network occurred in the South Group, with the largest increase in the Berry Creek subwatershed (Table 3-7 in Vegetation section). Although there is an absolute increase in the stream drainage network, the hydrologic analysis did not reveal changes in peak flows. The amount of roads within the watershed ranges from 1.6 to 4.8 miles per square mile in the subwatersheds and averages 3.1 miles per square mile in the watershed. Many of the stream channels in the watershed do not exhibit the effects of increases in peak flows. For example, many of the streams have moss dominated rocks and logs within the water column. At least within the last five years, there has not been a flow event that resulted in the scouring of the mosses in many of the streams within the watershed. Although there is no evidence in the change in peak flows through the hydrologic analysis, one would expect a "true" increase in peak flows for the lower return interval storm events due to the increase in road density and expansion of the stream network due to roads. We currently do not have the capability to determine the absolute change with existing information.

The LMP requires that the Forest Service manage the Upper Clackamas watershed so that not more than 35% of the watershed is in a hydrologically disturbed condition (USDA 1990). The Mt. Hood National Forest uses the Aggregate Recovery Percent (ARP) model to model the potential risks due to rain on snow events. Figure 3-20 displays the ARP for each subwatershed. Most of the subwatersheds are above the LMP threshold of 65%. All but the Pot and Last subwatersheds have ARP values above 70%. The Pot subwatershed is the only subwatershed below the 65% level at 60%. As discussed above, there is little evidence of noticeable changes in channel condition and hydrology due to the extensive management activities within the watershed.

Figure 3-19. Stream drainage network expansion due to roads by subwatershed.

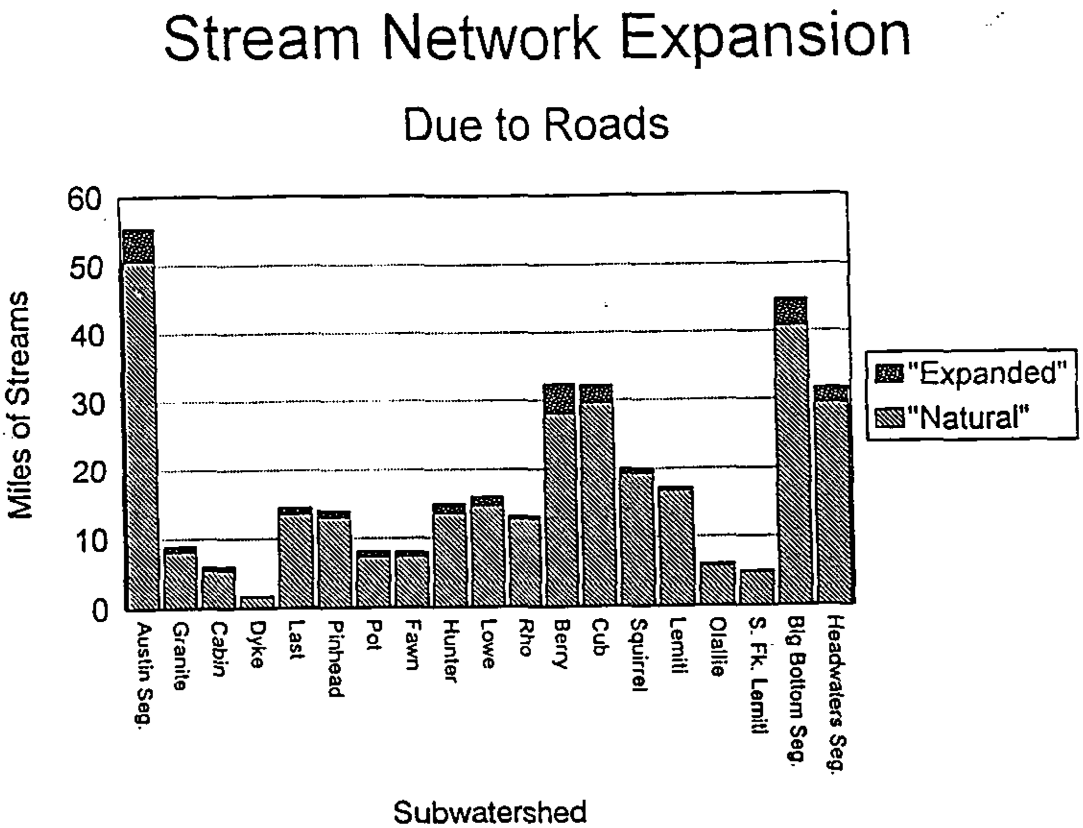
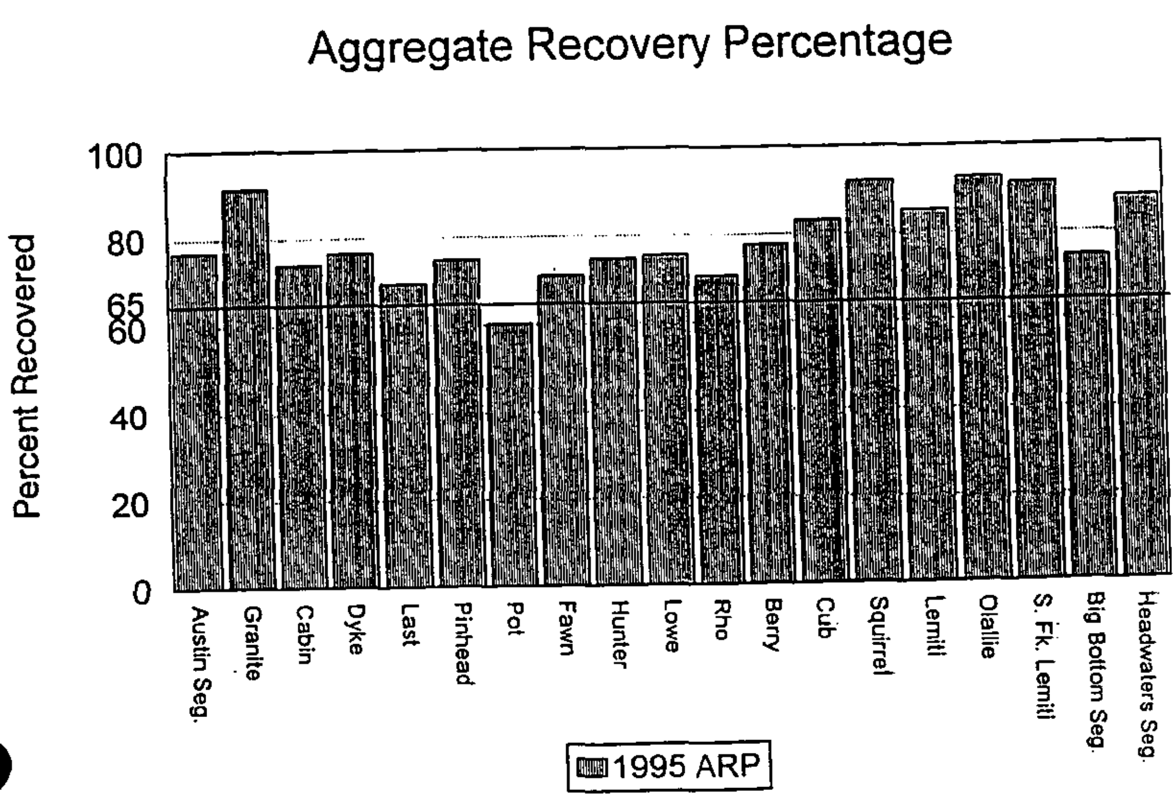


Figure 3-20. Aggregate Recovery Percentage by subwatershed.



Water Quality

The Clackamas River has excellent water quality relative to administrative standards (Oregon Administrative Rules, Chapter 340, Division 41, Department of Environmental Quality). Water quality sampling conducted within the past 5 years shows that the mainstem and tributaries have very low concentrations of measured constituents. Most of the samples were collected during the fall when flows were lowest. The results of the analyses for some key constituents are displayed in Table 3-31. In general, the water in the watershed can be classified as very good. It has a pH in the neutral to slightly alkaline range, with low conductivity and with very low concentrations of sodium, potassium, calcium, and dissolved nitrogen and phosphorus. For example, the mean annual phosphorus concentration in small forested streams are typically less than 0.06 mg/L (Naiman et al., 1992). The measured values for phosphorus concentration at the date the samples collected were below the expected annual value (Table 3-31).

There is a possibility of increased bacteria levels due to the extensive dispersed camping within the riparian zones of the river and lakes. No water quality sampling for bacteria has been conducted.

The temperature regime of the tributaries and mainstem Clackamas River upstream of the Collawash River is also indicative of cold, spring fed systems. Water temperature of the mainstem Clackamas River rarely exceeded 11°C with frequent temperatures in the 8 to 10°C range. The annual fluctuation for the past few years was 11°C The maximum and minimum recorded temperatures were 11 and 0°C, respectively.

Figure 3-21 shows the water temperatures for six areas in the watershed during the late-summer and fall, 1994. The climatic conditions were very dry and unseasonably warm as evidenced by the very severe fire season in the Pacific Northwest. Based on this, one could consider measurements taken at that time to represent some of the more extreme conditions. Cub Creek, the largest tributary to the Upper Clackamas River within the watershed, had the highest temperature of just over 11°C during late August. The mainstem Clackamas River, at a point just upstream of the mouth of Cub Creek, barely exceeded 9°C for the same period. Figure 3-21 also shows the effect of the mid-September rainfall on water temperatures. In most cases, the rain caused a drop of 1 to 2° C in temperatures. Pinhead Springs actually had an increase in water temperature due to the rainfall. Figure 3-21 also shows the effect of springs on the temperature regime of the Upper Clackamas River and Pinhead Creek. The water temperatures were between 5 and 6°C and did not vary by more than 1°C. Pinhead Springs had less than 0.2° C variation in temperature.

The measured water temperatures in 1994 approximate the optimum range of preferred temperatures for salmonids (Meehan and Bjornn 1991) (Figure 3-22). The temperatures are considerably below the upper biological threshold for salmonids and stayed at least 1°C below the Oregon Department of Environmental Quality management threshold (OAR Chapter 340, Division 41).

The Clackamas River within the watershed tends to have the most stable and coolest temperature regime within the subbasin upstream of North Fork Dam (Figure 3-23). Within the upper subbasin, the Collawash River tends to be the warmest and has the greatest annual fluctuation, with the Oak Grove Fork of the Clackamas River being intermediate to the Collawash and the Clackamas Rivers.

Table 3-31. Measured water quality parameters.

Clackamas Ranger District Water Quality Measurements																	
STREAM	DATE	TOTAL KJEL.N MG/L	DISS TOTAL-P MG/L	DISS P04-P MG/L	N03-N N02-N MG/L	DISS SILICA MG/L	NH3-N MG/L	pH	ALKAL HCO3-C MG/L	CONDUCT. umho per cm	SUSPD. SED MG/L	DISS. SOLIDS MG/L	DISS. NA MG/L	DISS K MG/L	DISS CA MG/L	DISS MG MG/L
quirrel Ck	8-9-90	0.045	0.042	0.025	0.004	2.453	0.018	7.2	5.539	43.4		54	2.45	1.17	3.97	1.164
emiti Ck	8-9-90	0.026	0.06	0.045	0.002	12.751	0.005	7.7	5.736	50.13	0.47	51	3.02	1.13	3.84	1.124
ub Creek	8-9-90	0.102	0.036	0.022	0.003	10.568	0.007	7	4.776	40.06	1.71	47	2.24	0.82	4.09	1.047
erry Creek	8-9-90	0.064	0.01	0.001	0.014	5.976	0.01	7.2	4.308	35.09	15.41	27	1.55	0.17	3.69	0.869
unter Creek	8-9-90	0.081	0.017	0.003	0.002	8.986	0.012	7.2	5.588	47.35	3.62	46	2.01	0.6	4.22	1.084
lack. RM 75	7-10-90	0.098	0.06	0.036	0.002	12.369	0.004	7.6	5.618	48.36	0.22	50	2.91	1.05	3.96	1.17
ub Creek	7-10-90	0.015	0.042	0.015	0.001	10.608	0.007	7.7	5.667	45.77	0.15	48	2.69	0.88	4.22	1.178
inhead Creek	11-27-90	0.008	0.043	0.03	0.005		0.01	7.8	8.621	67.61		63				
quarius Spring	8-29-90	0.014	0.037	0.021	0.014	9.516	0.006	8.3	9.39	76.8	0.11	51	3.37	0.88	6.79	2.75
amp Creek	8-29-90	0.048	0.02	0.005	0.004	8.085	0.013	7.3	4.4	35.84	1.9	34	1.85	0.32	2.84	1.351
ıst Creek	8-29-90	0.01	0.037	0.02	0.008	11.285	0.004	7.7	8.898	71.68	2.11	57	2.73	0.52	6.52	2.754
oop Creek	8-29-90	0.02	0.026	0.007	0.008	9.952	0.024	7.5	8.21	67.2	0.78	55	2.78	0.5	6.15	2.496

Figure 3-21. Upper Clackamas River and tributary water temperatures from August through October, 1994.

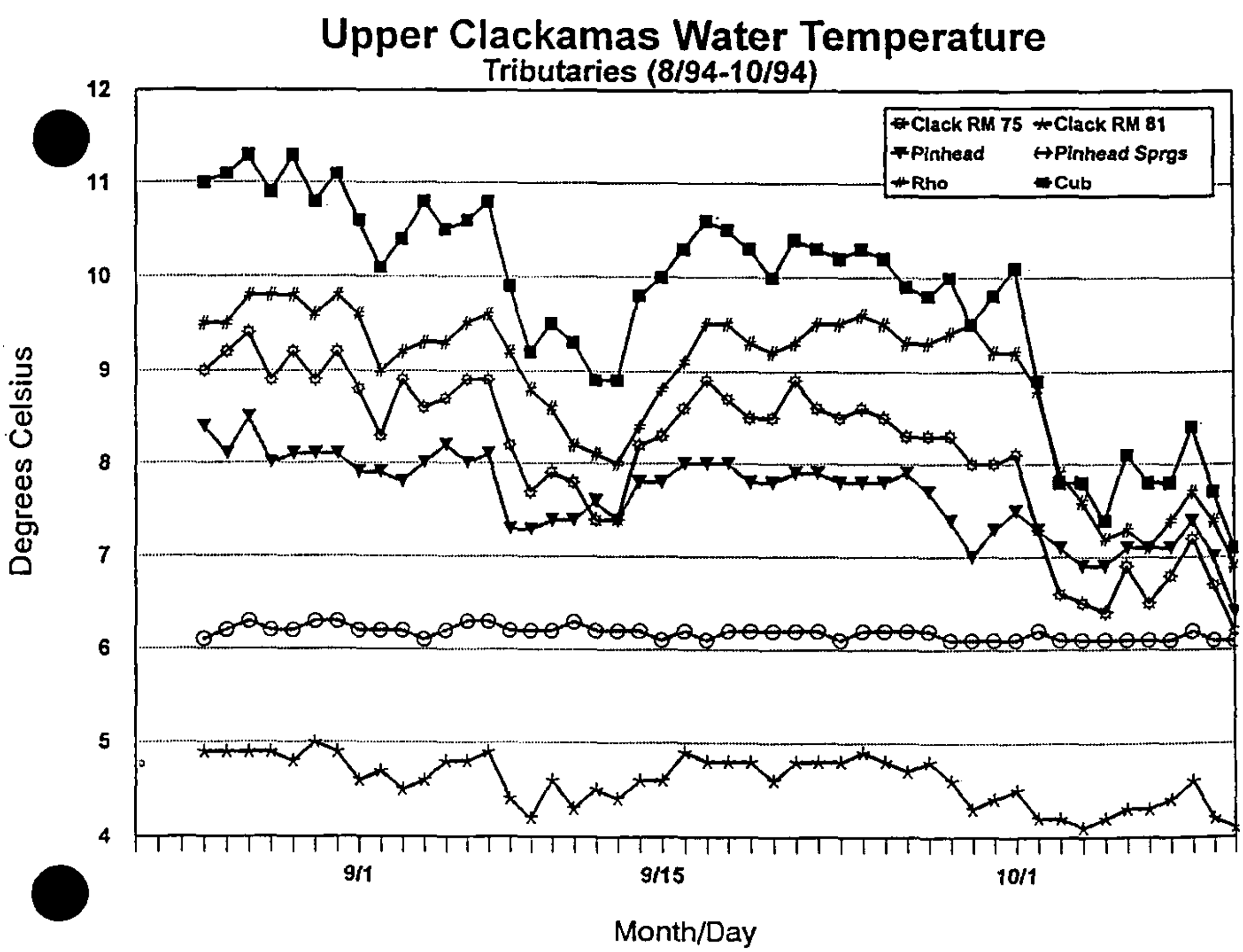


Figure 3-22. Biological and administrative thresholds with measured water temperatures.

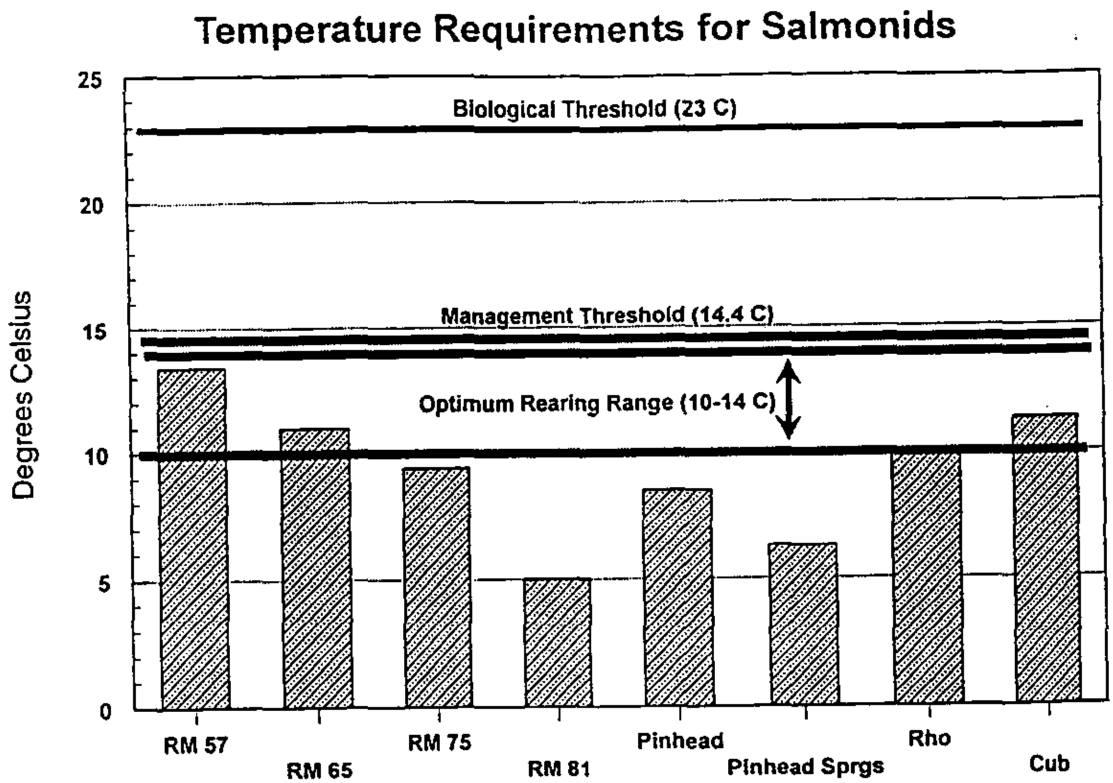
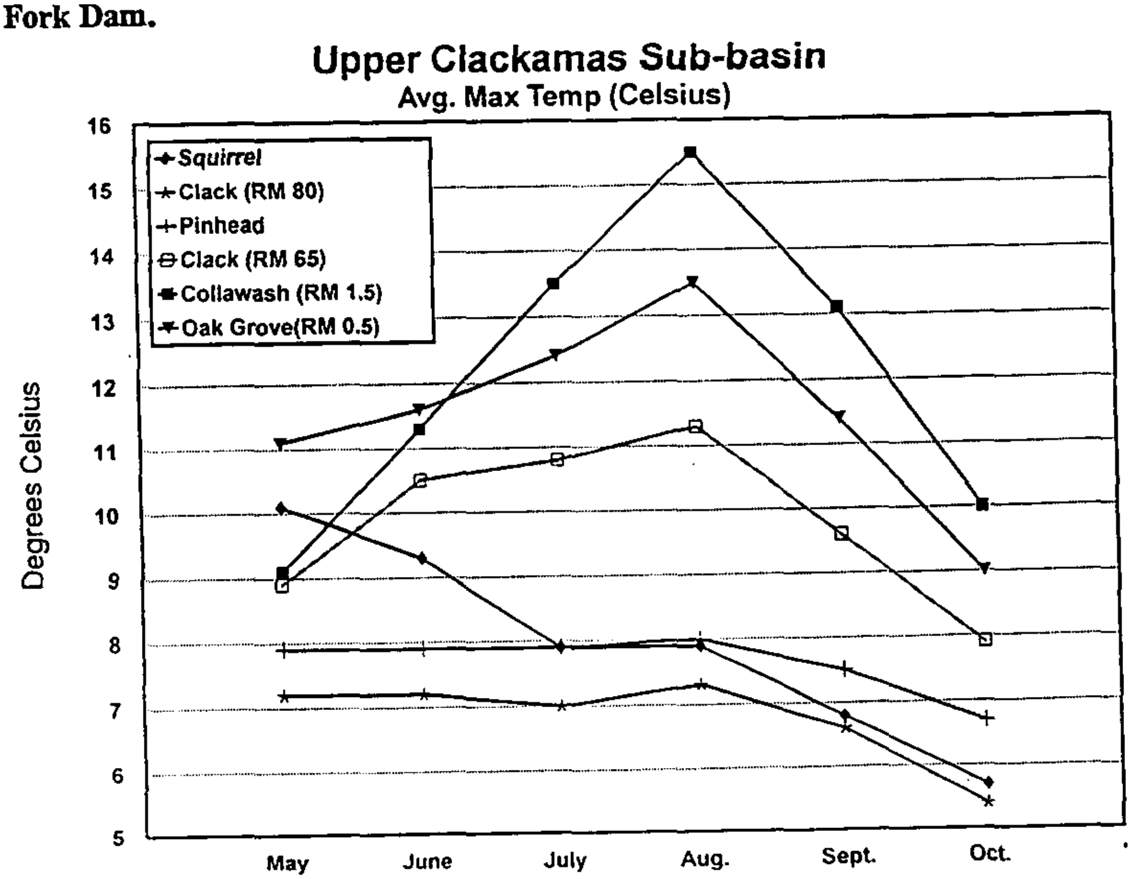


Figure 3-23. Temperature regimes throughout the Clackamas River subbasin upstream of North Fork Dam.



The two points within the mainstem Clackamas River within the watershed showed a relatively narrow range in average maximum temperatures throughout the year. For example, the absolute difference between the highest and lowest average maximum temperatures for the Clackamas River just downstream of Big Bottom and just downstream of the source spring in the headwaters was 3 and 2°C, respectively.

All measured water temperatures within the watershed met Department of Environmental Quality water quality standards for water temperature (OAR Chapter 340, Division 41, Department of Environmental Quality).

The Upper Clackamas River does not flow turbid very often. The general consensus of Clackamas Ranger District personnel for the last 10 years shows that there are less than 10 days a year where one can not see the substrate during the high flow periods. In fact, it is very easy to locate sediment sources because of the relatively clear conditions. Sediment source monitoring the past three years shows that cut banks along Forest Road 46, and one in particular near RM 64, accounts for most of the turbidity during high flow events. The water typically darkens to a tea coloration during the fall rains due to leaching from deciduous leaves but rarely gets brown from suspended sediment.

Sediment levels within the substrate of streams is relatively low and are within acceptable limits for salmonid production. The percent fines in pools and riffle stability for Fish Creek, Roaring River, and the Upper Clackamas subwatersheds are relatively stable (USDA 1993f). One measure of sediment composition in the substrate is called the Wolman pebble count (Wolman 1954). Wolman pebble counts for Cub Creek show that the substrate contained less than 6% fines (Bergamini 1993). The combination of hydrology, geology, and topography of the watershed show that it is one of the more stable watersheds within the administered by the Forest Service.

The Upper Clackamas River system has very low bedload movement. This is based on input from specialists in fisheries, hydrology, and geomorphology with local knowledge and is based on subbasin level monitoring and visual monitoring of the side channels constructed from 1988 to the present. The first is a V* measure used to determine riffle stability (USDA 1993f). The V* information for Berry Creek showed it to be a relatively stable riffle. One could conclude that there is little channel scour occurring based on the V* information. There has been no noticeable aggradation of sediment or bedload materials at the entrances to the side channels that affected flow into the channels river since their construction. The side channels were constructed at the inside of outside bends in the river. The inside or smaller radius bank of bends in rivers is typically the area of greatest aggradation.

Social

Heritage Resources - Prehistoric

Heritage Resource surveys within the Upper Clackamas watershed have been completed over a period of 18 years, covering 22,180 acres. During these 75 surveys, 90 prehistoric sites have been discovered. Site types are lithic scatters (39), peeled cedars (38), stacked rock features (4), and/or a combination of site types (9). Within the area that has been surveyed, it is likely that not all prehistoric sites have been found. Survey techniques have substantially improved over the time.

Knowledge of prehistoric use within the Upper Clackamas watershed is somewhat limited due to the lack of data recovery projects. One site within the analysis area and several sites outside of the analysis area have had either data recovery or site testing completed. The information gained from these archaeological projects indicate that the native people that inhabited the area did so during the late spring, summer and early fall months. The purpose of their travels into the area would have been for the gathering of food and medicinal herbs, tool manufacturing, hunting and collecting cedar bark for making baskets, mats and clothing. Due to lack of data recovery projects, the time of occupation within the watershed is unknown. The watershed may have been peripheral territory for the ancestors of both the Confederated Tribes of the Warm Springs and the Willamette Valley tribes (Molalla, Clackamas, and Willamette); again, excavation data is lacking.

Known sites are concentrated along the Clackamas River and its confluences with creeks. This is the area where surveys have been concentrated and may not reflect actual distribution of sites. The Clackamas River provided a rich resource base with large runs of anadromous fish that occurred in the late spring, summer and fall months. The wet areas and creek confluences with the Clackamas River are an excellent growing environment for western redcedar. This corridor was also a likely travel route when the native Americans would travel from one place to another.

Literature analysis, historic records, and known site locations indicate a huckleberry gathering area in the Olallie Scenic Area and along Rhododendron Ridge, a hunting area in the southeast portion of the watershed, and a general camping area in the McQuinn Strip along the eastern edge of the watershed. Ethnographic information from the Confederated Tribes of the Warm Springs indicates frequent or intensive resource gathering throughout the southern half of the watershed, east of the Clackamas River. The same ethnographic data does not mention use of the Rhododendron Ridge area, but indicates use of Bull of the Woods Wilderness. This data is considered applicable from treaty times (1885) to present. Rhododendron Ridge data may derive from use by Willamette Valley tribes. All of the gathering areas are at higher elevations and were likely to have been used in summer and early fall months due to deep snow packs in the winter and spring.

Heritage Resources - Historic

It is likely that the first Euro-American activities within the Upper Clackamas watershed consisted of a few wandering trappers and miners exploring the region in the late 1800's, although solid documentation to support this is lacking. It is known that some of the area was surveyed and mapped by the Government Land Office in the 1890's. The Clackamas River drainage in particular, having neither a broad flood plain nor a low pass connecting the east and west Cascade slopes, remained virtually ignored for most transient purposes well into the 20th century. With the establishment of the National Forest system in the early 1900's, the first significant permanent presence along the upper reaches of the Clackamas River was the U.S. Forest Service with the establishment of several guard stations in 1910.

Travel Corridors and Resource Utilization

There were three major travel routes that were used for access within the watershed; the Clackamas River Trail, the Skyline Trail and the Rhododendron Ridge Trail. Each trail represented different trends in resource utilization yet shared certain characteristics.

The Clackamas River Trail

The first trail known to be used by Euro-Americans to access the upper Clackamas River was from Estacada to Austin Hot Springs, in 1899. Since the presence of the hot springs was relayed to Seth Austin by an American Indian, it is very likely the Indians had a trail into the area prior to Euro-American arrival. Seth Austin homesteaded Austin Hot Springs in 1904 and established the first and, to date, the only piece of privately owned property in the Upper Clackamas watershed. In 1907 Austin sold his holdings at the hot springs to a Mr. Cary who established a resort. This created the first major influx of recreationists to the upper Clackamas River. The resort ran until at least 1914 and was sold to the Portland Railway, Light and Power Company in 1920. The company established two cabins in the Big Bottom area along the Clackamas River for surveying and exploring the potential diversion of part of the Clackamas River for hydroelectric generation. Although most Portland Railway, Light and Power activities were focused in the Oak Grove drainage, the railway they constructed up along the Clackamas River to their hydroelectric projects opened the door for additional forest visitors when the railroad was converted to a automobile road and opened to the public in 1938. Even though this road did not penetrate the Upper Clackamas watershed, it provided a convenient jumping off point for individuals wishing to explore the upper reaches of the Clackamas River via the Clackamas River Trail. This trail also provided Forest Service personnel access to the Olallie Meadow Guard Station near the headwaters of the Clackamas River established in 1910. Over the years the Clackamas River Trail was the trunk of an increasing network of trails connecting it with other guard/ranger stations. A road along the Clackamas River past its confluence with the Collawash River was not established until the Austin access road was completed in 1946. The first timber harvesting occurred in 1947, however the harvested unit was not accessed via the Austin Road, now FS Road 46. By the mid 1950's, however, FS Road 46 penetrated the Clackamas River drainage as far south as Cub Springs, and for the most part followed the tread of the Clackamas River Trail. The establishment of the road accelerated both resource utilization and recreational activities in the drainage.

The Skyline Trail

Of the three main trails accessing the upper reaches of the Clackamas River drainage only the Skyline Trail was established for the sole purpose of being a Forest Service access/administrative trail. It is possible that this route was also followed by American Indians, but documentation to support this is lacking. This trail was established at the same time as the guard stations as part of a network of trails linking other remote ranger stations with the Olallie Meadow Ranger Station, the only ranger station in that area at the time.

Increased demand for recreational access to the upper reaches of the Clackamas River, and to Olallie Lake in particular, spawned the formal creation of the Skyline Trail, open to the public, in 1916. The trail traverses north/south along the southeastern portion of the Upper Clackamas watershed. In the 1920's the Skyline Trail was converted to an automobile road to further accommodate the demand for recreational access to the furthest most reaches of the Clackamas River. With this conversion, the Skyline Trail was relocated to the east. Over the years portions of the trail were relocated in various areas. In 1968 the trail was renamed the Pacific Crest Trail and was moved to its current location. This trail served as the premier recreational use trail in the watershed since its conception in 1916 to present times. Two lookouts (West Pinhead and Sisi) could be reached by roads spurring off the Skyline Road. By 1927 the Skyline Road reached Olallie Lake, and in 1932 the Olallie Lake Resort was opened to the public. These two factors greatly increased the influx of recreationists to the Olallie area, however access to the rest of the watershed remained limited.

The only resources utilized in the Olallie Lake Scenic are those associated with recreational activities and the informal gathering of huckleberries. A report in 1949 states that "conditions are not conductive to the growth or harvesting of valuable, commercial timber." The Olallie Lake Scenic Area was created in 1965, and timber harvesting has not taken place within the boundaries since that time. A few scattered areas harvested prior to 1965 do exist within the northwest boundary.

A portion of the eastern watershed lies within the Confederated Tribes of the Warm Springs Reservation. The Olallie Lake Scenic Area shares its eastern boundary with the Warm Springs Reservation. The location of the western and northern boundaries of the Reservation was a debate for many years. The Confederated Tribes of the Warm Springs Reservation was created in 1855 as part of a treaty settlement between the Unites States and the American Indians residing in the area. In 1871 T. B. Handley completed a survey to determine the Reservation's boundaries. Because of errors in his surveying, the boundaries he mapped on the north and west of the reservation were further to the south and east, respectively, than the Indians had agreed upon. This erroneous line was known as the Handley-Campbell Line. Because of Indian outcry, the boundaries were resurveyed in 1887 by John A. McQuinn, for the U.S. government, and were found to be as the Indians had claimed, further to the north and west than the Handley survey had indicated. This survey line was (and still is) known as the McQuinn Line. The disputed area lying in between the lines became known as the McQuinn Strip. The dispute over this strip was finally settled in 1972, awarding the contested lands to the Confederated Tribes of the Warm Springs. After a 20 year transition period, the land was formally transferred to the Confederated Tribes in 1992.

The Rhododendron Ridge Trail

The first formal commodity utilization in the upper drainage began in the 1920's with the issuance of the Rhododendron Ridge Sheep Grazing Allotment. The herders entered the district with their sheep at ranger stations located along the eastern boundary of the watershed and traveled across the southern portions of the watershed utilizing grazing areas along the way to their grazing allotment.

The grazing allotment was located at the southern portion of Rhododendron Ridge, and was active until the early 1940's. Many trails were blazed in the watershed by the sheep herders moving the sheep from one grazing area, usually a meadow, to another. These trails were also used by Forest Service personnel as needed. One large fire in the watershed can be attributed to sheep herding activities; the Rhododendron Ridge fire in 1919 burned approximately 700 acres. Informal resource utilization occurred in the form of camping, hunting and huckleberry picking.
In the 1930's and '40's the administrative presence of the Forest Service was increased with the establishment of several lookouts and an increased myriad of networking trails to link the lookouts with ranger/guard stations and to facilitate access to remote, roadless areas.

Many trails and camping areas, usually because of their prime location, were undoubtedly used by both American Indians and, later, Euro-Americans. The purpose for traveling the trails, however, differed between the two groups. The American Indians would travel the trails to get from one area of subsistence activities to another, or to rendezvous with neighboring tribes for trading purposes. Euro-Americans, however, traveled the trails mostly for recreation or to get from one administrative site to another. Also, the American Indians utilized the resources they had at hand for subsistence, whereas the Euro-Americans tended to utilize the forests resources for economic gain. The most marked resource utilization has been in the form of timber harvesting which was greatly accelerated by the construction of roads in the watershed.

Road History

The earliest road construction in the watershed started in the late 1920's with construction of the Skyline Road (Road 4220) to the Olallie Lake area. Portions of the 5720/5730 road system were constructed in the 1930's and 1940's..

Road 46 was first constructed from 1942 to 1944 as part of State Highway 224 by the Bureau of Public Roads. It was originally constructed as a single lane native surface road to just beyond the Road 63 junction. By 1948 it was extended about 2:5 miles past Austin Hot Springs, and by 1955 was completed up to Hunter Creek. The last section of Road 46 was tied through to the Willamette National Forest in 1965.

The majority of roads were constructed in the watershed in the 1960's. By 1969, 60% of the present road system had been completed. A major reconstruction program converting aggregate to paved surfaces occurred in the 1970's. The last reconstruction to paved surface took place in 1990. Table 3-32 is a summary of construction and reconstuction by decade and surface type.

Historic Features

There are 27 documented historic sites located within the Upper Clackamas watershed. These sites can be divided into two categories or classifications; 1) Forest Service administrative sites, which are sites associated with the implementation of Forest Service practices, policies and other management activities, and 2) Non-administrative sites, which are associated with resource/commodity utilization or recreational activities.

Table 3-32. Road construction and reconstruction by decade and surface type.

Decade	Activity	Surface Type			New Roads by Decade	System Totals
		Native	Aggregate	Asphalt		
1940-1949	Construction	23.4				
	Reconstruction					
	Total	23.4			23.4	23.4
1950-1959	Construction	6	54.9			
	Reconstruction		6			
	Total	23.4	60.9		60.9	84.3
1960-1969	Construction	61.2	149.5			
	Reconstruction		1	25		
	Total	83.6	186.4	25	210.7	295
1970-1979	Construction	15.8	74.2			
	Reconstruction		1	35.8		
	Total	98.4	225.8	60.8	90	385
1980-1989	Construction	6.7	90.7			
	Reconstruction					
	Total	105.1	309.5	67.8	97.4	482.4
1990-1994	Construction	2.9	7.1			
	Reconstruction			3.3		
	Total	108	313.3	71.2	10	492.5

Of the eleven documented administrative sites, seven are lookouts (Oak Grove Butte, Peavine Mountain, Burnt Granite, Mt. Lowe, West Pinhead, Sisi and Hawk Mountain), three are shelters/cabins, and one is classified as miscellaneous. The sixteen documented non-administrative sites within the watershed consist of cabins, trails, trap lines, sheep camps, and miscellaneous site types.

Sisi Lookout was evaluated for eligibility for listing on the National Register of Historic Places on September 29th 1994. It was recommended that it not be eligible, and the State Historic Preservation Office concurred. Hawk Mountain Lookout has not been evaluated for listing, however it is believed to be eligible. The Olallie Meadow Guard Station has been evaluated and is eligible for listing on the National Register of Historic Places. However, the official declaration of listing, involving a formal management plan and allocation of funds, has not been received from the Mt. Hood National Forest Supervisors Office. The cabin is currently in excellent condition and receives yearly inspections and maintenance. The Olallie Lake Guard Station is currently listed on the National Register of Historic Places. It is occupied yearly by USFS recreation guards, and receives annual inspections and maintenance as required. It is currently in excellent condition.

The non-administrative sites consist of cabins, trails, trap lines, sheep camps, and miscellaneous site types. None of the non-administrative sites warrant listing on the National Register of Historic Places.

Summary of Heritage Resource Information

Certain historic contexts are not represented in the Upper Clackamas watershed. Late Paleoindian occupation is absent. Archaic or Formative sites may not be present or may remain undetected until archaeological excavations are performed. Protohistoric sites are abundant, particularly peeled cedars. On present evidence (lack of any Euro-American artifacts such as beads or metal objects), lithic scatters are of pre-contact time, roughly pre-1775. Historic contexts are limited to recreation and Forest Service administration. On present evidence, none of the historic sites are associated with important events or important persons.

Commodities

Timber Harvest

The first timber harvest within the Upper Clackamas watershed began in the late 1940's. The earliest harvest units were located in the lower portions of the Upper Clackamas within the Austin Segment and Granite subwatersheds. By the end of the 1950's approximately 880 acres had been clearcut harvested using mainly tractor skidding techniques.

During the 1960's, harvest levels increased over those in the 1950's. The majority of the harvest was done using the clearcut method with both tractor and highlead harvesting techniques. By this time, some level of harvesting has taken place in all 19 of the subwatersheds within the Upper Clackamas watershed. By the end of the 1960's an additional 7,393 acres had been clearcut harvested within the watershed.

Harvest rates increased during the next 25 years. Approximately 21,000 acres of regeneration harvest occurred from 1970 to 1994. During this time both clearcut and shelterwood harvest methods were used. All types of harvesting techniques were also used including helicopter, skyline, highlead and tractor skidding.

Currently, the majority of the acres under contract to harvest are planned to be commercially thinned. These include plantations that were harvested in the 1950's and natural stands that were the result of numerous large fires around the turn of the century. There are also some timber sales currently under contract that plan to salvage trees blown down during a wind storm that occurred in 1990.

In addition to the harvesting history described above, there have been many other types of harvest activities that have been poorly documented. These include numerous windthrow and bark beetle salvage sales as well as large acreages that were partially logged where only selected trees were harvested within a stand. Salvage occurred after major windstorms in the 1970's, 1980's and 1990's. There were 2 major bark beetle salvage operations within the Upper Clackamas. Both were within the Big Bottom area. The first was in the 1950's and the second was in the 1970's. Much of the partial logging of stands took place in the early 1970's. Due to the poor documentation of salvage harvest and some of the partial logging, there is not an accurate figure for the number of acres where these activities have taken place.

Table 3-33 displays the history of regeneration harvest in the watershed from 1950 to 1994. The estimated volume removed is based on an assumption of a net of 50 MBF per acre which is a reasonable average to use for this area. Regeneration harvest, predominantly by clearcut and shelterwood systems, has occurred on over 29% of the watershed which has resulted in the removal of approximately 1.5 billion board feet of commercial timber products.

Table 3-33. Historic regeneration harvest.

	1950's	1960's	1970's	1980's	1990-94	Totals
Harvest Acres	880	7,393	6,766	9,828	4,329	**29,196**
Estimated Volume (MMBF)	44	370	338	491	216	**1,460**

Special Forest Products

The history of special forest product use coincides with the development of access into the Upper Clackamas watershed. Historically, there has been firewood collection, Christmas tree harvest, huckleberry harvest and harvest of cedar for shakes and bolts. There is also traditional use by the Confederated Tribes of Warm Springs for products such as huckleberries, beargrass and alder wood.

In recent years there has been an increased use of the area for many additional forest products. These include transplants, beargrass, mushrooms, floral material, yew bark, yew wood, boughs and medicinal plants.

Special forest products are sold both commercially and under personal use permits. Due to the increased value that society is placing on these products, demand for special forest products is growing each year. The proximity of the watershed to a large metropolitan area makes it a popular place for people to gather special forest products. For Fiscal Year 1994, the Clackamas and Estacada ranger districts sold approximately $425,000 worth of special forest products. This was more then 95% of the entire amount of special forest products sold on the Mt. Hood National Forest. A significant portion of this came from the Upper Clackamas watershed.

Recreation

The Upper Clackamas watershed plays an important role in the provision of recreation opportunities within the Clackamas River drainage, the Mt. Hood National Forest, and the greater Portland metropolitan area. Nationally, the Omnibus Oregon Wild and Scenic Rivers Act of 1988 added the Clackamas River to the Federal Wild and Scenic River system for its noted values in the areas of botany, ecology, fisheries, wildlife, cultural resources, and recreation. The Clackamas River is also designated as a State Scenic Waterway. Located within a two hour drive of the Portland Metropolitan area and rural communities of Estacada, Molalla, and Sandy, the Clackamas River is an important recreation destination for both the urban and rural recreationist. Within the context of the

Mt. Hood National Forest, the Clackamas River offers more opportunities for river based dispersed recreation than the Highway 26 corridor with an equivalent driving time from Portland. Unlike the Lower Clackamas watersheds, the Upper Clackamas watershed provides relatively few developed recreation facilities but a higher number of dispersed recreation opportunities. The Upper Clackamas watershed provides dispersed camping and fishing along the Wild and Scenic River, scenic driving along Forest Road 46 which is a Scenic Byway Nominee, camping and hiking in the Olallie Lake Scenic Area, hunting for elk and deer, and hiking on over sixty miles of trails which encircle the watershed.

In many ways, the current recreational use patterns in the watershed are a continuation of historic and prehistoric patterns with the emphasis on seasonal migration and use, hunting, fishing, and dispersed camping because use is a function of existing landscape characteristics. Different areas and elevations of the watershed are used for different activities according to the season. Low elevation camps are used along the river during the extended summer recreation season, while high elevation camps are used during deer and elk hunting season. Winter use is minor. The primary destinations and circulation routes are still the Clackamas River corridor, the Olallie Lake Scenic Area, and Rhododendron Ridge in a pattern essentially unchanged from the earliest human use of the watershed. This is because of a preference for circulation routes which are easy to traverse like ridges and river valleys and the biological products of a landscape like fish, huckleberries, and big game.

The pattern of recreation use is also a function of management direction as well landscape characteristics. Road access is a primary tool for managing the type and amount of recreation use in the watershed. Road closures are used in the watershed to limit use in riparian areas, reduce wildlife harassment, and to prevent use migrating to Warm Springs Reservation. Road condition is also used as a tool to control use. If Road 4220 were improved, for example, use levels would increase in Olallie Lake Scenic Area. Winter recreation in the watershed is limited by the lack of consistently plowed roads, not a lack of snow. Administrative designations also determine recreation opportunities by retaining preferred settings.

Current recreation use is also a result of user preference as well as the types of settings and opportunities available within the landscape as refined by management direction. The uses preferred and available within the watershed include camping in both dispersed and developed sites, fishing in the river and backcountry lakes, hunting for deer and elk, hiking, and scenic driving. It is important to note that few recreation activities occur in isolation. While camping, users may also fish, hike, study nature, and take a scenic road trip. Destination settings which are in the highest demand in the watershed usually include the opportunity for secondary activities like huckleberry picking although the setting was chosen for a primary or multiple recreation opportunities.

The diverse landscapes which compose the Upper Clackamas watershed vary in the type and importance of recreation settings which are available. The primary recreation destinations are the Clackamas River corridor and the Olallie Lake Scenic Area which offer a number of opportunities for water based recreation opportunities which are in the highest recreation demand. The limited number of opportunities for water based recreation is a key factor for determining recreation potential within the watershed. Rhododendron Ridge with its high elevation trail system also ranks high for use and opportunity relative to the landscape within the watershed because of its vistas and meadows. Few other landscapes within the watershed have features which draw recreation use like lakes and rivers or scenic vistas. Some recreation use can, however, be expected throughout the watershed although the pattern of use is not tied to a specific landscape or destination. All open roads, for example, can have some recreation use by hunters or adventure seekers although such use can be sporadic or opportunistic. Some recreation settings are also just not present in the watershed like large bodies of water for motorized boating. In other cases, administrative designation under the LMP for roaded recreation and unroaded recreation in the Sisi Butte and Lemiti area have no developed trail or facility support system and so remain unused.

For the purpose of this analysis, recreation opportunity is discussed by landscapes within the watershed instead of activity. The primary landscapes in terms of recreation use are the Clackamas River corridor, the Olallie Lake Scenic Area, Rhododendron Ridge, and the northeast section of the watershed north of the Scenic Area boundary.

Clackamas River Corridor

The Clackamas River corridor is the primary use area in the watershed as it is in the entire river drainage. The landscape character of the river corridor is a narrow river valley with steep forested slopes from the confluence of the Collawash River and the Clackamas south to Big Bottom where the river valley becomes broad and the river moves more slowly. From the south end of Big Bottom to the headwaters of the Clackamas at Big Spring in the Olallie Lake Scenic Area, the landscape again becomes a narrow, steep river canyon and the river diminishes in size until it is little more than a mountain stream. Unlike the downstream portion of the river, the river corridor in the Upper Clackamas watershed remains primarily undeveloped with a remote and rustic quality. Forest Road 46 was constructed to a slower and narrower design standard. This lack of developed facilities in the river corridor in the Upper Clackamas watershed also contributes to its primitive character. Recreation use as well as facilities both diminish in number and intensity with distance upriver from Portland and the Forest boundary.

The primary recreation opportunities in the Clackamas River corridor include camping, both dispersed and developed, fishing, scenic driving, and hunting. Recreation use is seasonal in the river corridor. It is heaviest in the summer season, with active spring and fall weekend use. Winter and weekday use is relatively light, and it occurs primarily outside developed recreation sites. Only one developed campground, Riverford, exists in the river corridor in the Upper Clackamas watershed. Located at the confluence of the Clackamas and Collawash Rivers, Riverford Campground marks the end of developed recreation sites in the entire river corridor. Of the approximately 250 developed camping units in the corridor, only 10 exist in the Upper Clackamas watershed at Riverford. Developed camping facilities are not available to the user again until Olallie Lake Scenic Area.

Dispersed camping is, however, increasing in importance as both a recreation destination and as overflow sites from developed campgrounds. From a study conducted in 1991, it is estimated that 70% of recreational activity in the entire river corridor is camping and 30% of use is day use. Approximately two-thirds of weekend use occurs in developed sites with the remainder occurring in dispersed recreation sites. The combination of roaded access and flat areas suitable for camping next to the river, particularly in the Big Bottom area are the key landscape characteristics that support this recreation in addition to user preference. The site attributes which make these camping areas important include fishing access, forested cover, and scenic views as well as privacy and the absence of management presence or fees. There are approximately 43 camping areas in the riparian zone from the confluence of the Clackamas with the Collawash to Forest Road 4690 and many of these camping areas contain multiple units. They are estimated to cover over 38 acres of riparian area. Several of these units serve as informal campgrounds such as the Pot Creek site, which was developed originally as an industrial camp, the 4670 site which was a landing, and the Cub Creek site, which has multiple units and shows signs of expansion. As a landscape resource, these flat areas near water which are suitable for camping are a finite resource. In addition, the Big Bottom area was identified during the PULSE project as a Special Old-Growth area. Overuse and crowded conditions have caused site impacts such as soil compaction and erosion, damage to overstory trees, reduced understory and ground cover, litter, and human sanitation issues. This has led to a degradation to site attributes important to recreation such as a lack of privacy and reduced scenic quality. Current management direction in accordance with the Clackamas Wild and Scenic River Plan and the LMP includes site specific control of automobiles, education, and monitoring while permitting recreation access. From road 4690 to the headwaters of the Clackamas, the river enters a steep canyon with few flat areas close to the river or road so dispersed camping activity is minimal.

Fishing opportunities include summer steelhead, catch and release wild trout in Big Bottom, and planted trout downstream from the Road 4650 bridge. Freshwater fishing from boats is currently minimal and is limited by boat launch availability, sufficient river depth, and potential conflicts with other river uses. Whitewater use is also considered minimal within the upper stretch of the river.

The primary circulation route through the watershed is still the river corridor although Road 46 and 4690 have replaced the original riverside trail. Road 46 is the main route from the southern Mt. Hood Forest boundary to the Willamette National Forest and to the Olallie Lake Scenic Area via Road 4690. Traffic use on the road is a combination of commercial, administrative, and recreational and occurs primarily in snow free months. Again, the intensity of use decreases with distance up river. Approximately 1,100 vehicles travel Highway 224 on an average summer day but use drops off at the junction of Forest Roads 46 and 57 to 30% of use at the Forest boundary, or to 750 trips. Another change occurs at the 46/4690 junction where average daily traffic on Forest Road 4690 is less than 100 trips or 4% of use level at the Forest boundary. Although Road 46 has no designated bike lanes, it does receive occasional use by bicyclists. The narrow road also provides very few places for parking and river access. The Clackamas River corridor is also a scenic viewshed in accordance with the Wild and Scenic River designation and the LMP. Highway 224/Road 46 is also a Scenic Byway nominee. From the confluence of the Clackamas and Collawash to Road 4690, the viewshed is primarily natural appearing except for some timber harvest units along the south facing slope and to the west. From Road 4690 to Big Spring, the headwaters of the Clackamas, scenic quality is generally compromised because of the geometric patterns of harvest units viewed from the road. Scenic quality along Road 46 south of the 46/4690 junction is also compromised because of geometric harvest units visible in both the foreground and middleground from the road.

One of the main use attractions in the river corridor is a 155 acre parcel of private land, Austin Hot Springs. It receives both day use and overnight camping although current use level is not known. It is also unknown whether recreational use has been authorized by the owner and hot springs guide books continue to describe this site as it was prior to private purchase.

Olallie Lake Scenic Area

As in the past, the Olallie Lake Scenic Area still attracts seasonal recreation use and is accessed by Forest Road 42 or 4690 to Road 4220. Approximately one-third of the Scenic Area is in the Upper Clackamas watershed which also includes the headwaters of the Clackamas at Big Spring. A high elevation plateau straddling the crest of the Cascades, the Olallie Lake Scenic Area is considered scenic because of the presence of over two hundred lakes in a region dominated by rivers and streams. Accessed by only one primitive road, the landscape also has a remote and primitive character. Two historic forest service guard stations and a campground built by the Civilian Conservation Corps add to the remote character. Open meadows and buttes contribute to the scenic qualities. An estimated 30,000 users visit the Scenic Area during the summer and early fall season to camp, hike, and fish. Recreation use is concentrated along the four largest lakes, which are south of the watershed boundary. Road 4220 serves as the only road access for recreation, administration, and emergency fire evacuation. Thirty-five of the two hundred lakes are stocked by the state for fishing. Berry picking is also a popular activity in the Scenic Area although it is not a primary destination for huckleberry harvest. Winter recreation is restricted by road conditions although limited snowmobile service has been offered by the Olallie Lake Resort in the past. Only three of the eight developed campgrounds in the scenic area are in the watershed, Olallie Meadows, Triangle Lake, and Lower Lake. Together the three campgrounds contain 21 of the 102 camp units in the Scenic Area. Of the three campgrounds, Triangle Lake was designed specifically for equestrian use and barrier free accessibility. Additional dispersed camping occurs at First Lake and along Road 4220 although management direction has been to restrict dispersed camping access in the riparian zone. Backcountry hiking and camping occurs along trails outside the developed facilities.

Of the 38 miles of developed trail in the Scenic Area, 23 miles are within the Upper Clackamas watershed. Many of these trails serve as internal linkages between lakes and buttes and the Pacific Crest Trail, which is a long distance trail of regional and national importance. Hikers, mountain bikers, and equestrians share use on the trails, except the Pacific Crest Trail where mountain bike use is not allowed. Campgrounds often serve as base camps for day use on the trails.

Additional trails and dispersed recreation occur from the Scenic Area boundary north to Lemiti Creek. There are nine miles of the Pacific Crest Trail from Olallie Meadow to Lemiti Meadow administered by the Forest but located on the Warm Springs Reservation. Off highway vehicle use occurs along the powerline which forms the northern boundary of the Scenic Area and is accessed by Road 4691. It is the only off-highway vehicle destination site in the watershed. Additional dispersed camping and fishing occurs at Si, Surprise, and Fish lakes.

Rhododendron Ridge

As in historic times, Rhododendron Ridge still serves as a primary trail route in the Upper Clackamas watershed. Location of the trail along the spine of the ridge reflects a pragmatic human preference for traversing along flat ridges instead steep side slopes as well as a valuation of scenic vistas. The landscape of Rhododendron Ridge is a high elevation north/south ridge with numerous open meadows, rocky outcrops, and opportunities for scenic vistas as well as forest stands of various ages. The elevation ranges from 3,000 to 5,500 feet and offers users views of the surrounding landscape from Mt. Lowe and Hawk Mountain. Other rocky outcrops, benches, and talus slopes offer a diversity of wildflowers as well as scenic vistas.

There are currently 24.4 miles of trail on Rhododendron Ridge under current maintenance or reconstruction by the district, but the existing trail segments are not continuously linked. All users, mountain bikes, hikers, and equestrians are permitted on the trails but use is light because maintenance or design standards do not encourage all use. In addition to the existing trails, Rhododendron Ridge has been identified as the last stretch in the proposed Urban Link Trail (ULT) which will connect the Portland Metropolitan area with the Pacific Crest Trail through the Olallie Lake Scenic Area. The Urban Link Trail is envisioned as a trail with regional significance for all users, hikers, equestrians, and mountain bikers. The plan for the Urban Link Trail includes reconstruction of existing trails, construction of connecting trails between existing segments, construction of an ascending trail on the northwest side of Rhododendron Ridge up from the Collawash River, and utilization of decommissioned roads to serve as trail.

The Rapidan Trail, which is managed by the Willamette National Forest, traverses the boundary between the two national forests at most southern part of the watershed. It is proposed as an east west connector for the Urban Link Trail between Rhododendron Ridge, the Olallie Lakes Scenic Area, and the Pacific Crest Trail. Along with the proposed trail segments, new trailheads are proposed to facilitate increased numbers of trail users in particular a developed trailhead to accommodate equestrian use at Graham Pass. The design specifications for the trail include routing the trail away from sensitive habitat areas, erosive slopes, and utilizing existing roadbeds. Additional opportunities exist on Rhododendron Ridge to add loop and day use trail opportunities utilizing decommissioned roads.

As well as the scenic viewpoints and high meadows which the existing and proposed sections of trail access, they also pass through a landscape of numerous clearcuts, logging roads, young plantations, and two major powerlines corridors. The scenic quality of the trail viewshed has been evaluated as unacceptable modification in both the foreground and middleground according to LMP visual standards. Many of the current vista viewpoints are also created openings instead of natural openings and are not expected to persist in the landscape as the forest stands grow. It is recommended in the Urban Link Trail Environmental Assessment that special consideration be given to planning rehabilitation timber harvest and vegetation management in the trail viewshed.

Uplands

The recreation use pattern also changes seasonally in the watershed with the advent of fall hunting season. It is estimated that 70% of the hunting activity in the Clackamas River drainage occurs south of the Ripplebrook Ranger Station. An estimated 1,500 deer hunters were recorded at the Memaloose three day check point in 1992-93 with another estimated 500 hunters who did not stop at the check point. The numbers for elk hunters are lower at an estimated 200 hunters which could be a result of a shorter season. Elk hunting in the watershed is considered among the best in the Forest and above average for deer. Hunters come from Portland, Salem, and the Willamette Valley as well as Estacada, Canby, Mollalla, and other smaller communities. While deer and elk are the primary game species, hunting activity also occurs for grouse, upland birds, mountain quail, bear and cougar. Bear and cougar hunting has been relatively high in the past with primary hunting areas in Lemiti

Creek, Slow Creek, north of Olallie, and Rhododendron Ridge. Hunting opportunities for grouse, upland birds, and mountain quail are considered below average and the activity is minor.

The dispersal pattern of recreation also changes seasonally with the advent of fall hunting season. Unlike summer recreation use, hunting activity occurs throughout the entire watershed but preferred hunting areas are primarily in the high elevation areas. Areas important to elk hunting include the south end of the watershed, Rhododendron Ridge north of Hawk Mountain, the Olallie area, Lemiti Creek, and Berry Creek. Both elk and deer hunting occurs in the north and northeastern sections of the watershed and the Clackamas River as well. Elk hunters appear to have a preference for flatter ground and roaded access, but a lower road density. Deer hunting preference areas can be found on steeper ground, at lower elevation, and with a higher road density. Higher elevation deer hunting areas include Slow Creek, Lemiti Creek, West Pinhead, and Peavine. Poaching occurs throughout the watershed at all times of the year and is dependant upon roaded access.

Although some popular camping areas in the riparian zone of the Clackamas River are used as base camps for hunters, hunting camps are established in the higher elevations closer to hunting areas. These range from traditional hunting camps (often in the riparian zone of creeks) which are revisited annually to opportunistic campsites on timber sale landings.

Appendix B - Glossary

Anadromous - Fish that are born and rear in freshwater, move to the ocean to grow and mature, and return to freshwater to reproduce (i.e. salmon and steelhead).

Basin - River basin such as the Willamette.

C - Degrees Celsius.

Catchment - Analogous to watershed but at a smaller scale than the analytical watershed.

Climax Community - The culminating stage in plant succession for a given site where the vegetation has reached a highly stable condition.

Coarse Woody Debris (CWD) - Portion of a tree that has fallen or been cut and left on the forest floor or in a stream.

Decommission - To remove those elements of a road that reroute hillslope drainage and present slope stability hazards. Another term for this is "hydrologic obliteration."

Debris Flow - A rapid moving mass of rock fragments, soil, and mud, with more than half of the particles being larger than sand size.

Debris Slide - A slow to rapid slide involving downslope translation of relatively dry and predominantly unconsolidated materials, with more than half of the particles being larger than sand size.

Dispersed Site - A non-developed camp site.

Early Seral - The period from disturbance to canopy closure. For this analysis includes: grass/forb/shrub stands; shelterwood and leave tree stands; and open sapling/pole stands (trees greater than 10 feet tall, less than 60% canopy cover.

Earthflow - A mass-movement landform and slow to rapid process characterized by downslope translation of soil and weathered rock over a discrete shear zone at the base, with most of the particles being smaller than sand.

Escapement - The number of fish that return to spawn.

Hummocky - A landscape characterized by small, well-drained areas rising above the general level of poorly drained land.

Hydrograph - A hydrograph shows the relationship of discharge over time. The shape of the hydrograph allows one to examine how a river changes following rainfall or snow melt. A steep curve represents quick or flashy response to rainfall.

Interior Habitat - Late seral, non-edge habitat. Defined in this analysis, as late seral habitat that is at least 500 feet from any natural non-forested opening (rock outcrop, talus slope, meadow, lake, etc.) or
any immature forest stand (shelterwood, grass/forb/shrub, open sapling pole, closed sapling pole).

Landslide - Downward and outward movement of slope forming materials.

Late Seral - Stage in forest development that includes mature and old-growth forest. Defined in this analysis, as stands dominated by conifers at least 21 inches in diameter.

Long-term Soil Productivity - The ability of a soil to sustain a nondeclining yield of timber crop in perpetuity and retain the potential for the targeted species to be grown at the same stocking level and growth rate after each rotation.

Mass Movement - The downslope movement of earth caused be gravity. Includes but is not limited to landslides, rockfalls, debris avalanches, and creep. It does not, however, include surface erosion by running water. It may be caused by natural erosional processes, or by natural disturbances (e.g., earthquakes) or human disturbances (e.g., road construction).

Mature Stand - Stand of trees for which the annual net growth has peaked. Stands are generally greater than 80 years old and less than 200 years old. Mature stands generally contain trees with a smaller average diameter, less age class variation, and less structural complexity than old-growth stands of the same forest type.

Mid Seral - Defined in this analysis as the stage in forest development including closed sapling/pole stands (average stand diameter less than 8 inches, greater than 60% canopy cover) and small sawtimber (average stand diameter of 8-21 inches).

Nutrient Cycling - Circulation or exchange of elements such as nitrogen and carbon between nonliving and living portions of the environment. Includes all mineral and nutrient cycles involving mammals and vegetation.

Old-growth Forest - A forest stand usually at least 200 years old with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; high incidence of large trees, some with broken tops and other indications of old and decaying wood; numerous large snags; and heavy accumulations of wood, including large logs on the ground.

Optimal Cover - A combination of stand structure characteristics that provide forage, thermal protection and hiding cover for elk.

Parent Material - Unconsolidated weathered rock material unaltered by soil forming processes.

River Mile (RM) - A measure of distance used to describe locations along a river. RM 0.0 is at the mouth of a river.

Run - A subset of a fish specie that return in consistent time frames.

Salmonid - Refers to fish of the family Salmonidae. Within the range of the northern spotted owl these include all salmon, trout, and whitefish.

Seral Stage - The series of relatively transitory communities that develop during ecological succession from bare ground to the climax stage.

Site Potential Tree - A tree that has attained the average maximum height possible give site conditions where it occurs.

Slope Stability - The resistance of a natural or artificial slope or other inclined surface to failure by landsliding (mass movement).

Stand - An aggregation of trees occupying a specific area and sufficiently uniform in composition, age, arrangement, and condition so that it is distinguishable from the forest in adjoining areas.

Structure - The various horizontal and vertical physical elements of a forest stand.

Subbasin - Smaller basin within Willamette such as the Clackamas

Soil Compaction - An increase in soil bulk density (weight per unit volume) and a decrease in soil porosity resulting from applied loads, vibration, or pressure.

Soil Displacement - The removal and horizontal movement of soil from one place to another by mechanical forces such as a blade.

Soil Productivity - Capacity or suitability of a soil for establishment and growth of a specified crop or plant species, primarily through nutrient availability.

Soil Resiliency - The ability of a soil to recover from disturbance.

Stock - A genetically distinct subset of a given species of fish (obtain reference).

Subsoiling - The process of breaking up or loosening compacted soil (e.g., skid trails or spur roads) to better assure penetration of roots and infiltration of water.

Surface Erosion - The detachment and transport of soil particles by wind, water, or gravity. Surface erosion can occur as the loss of soil in a uniform layer (sheet erosion), in many rills, or by dry ravel.

Take - As defined under the Endangered Species Act: to harm, hurt, maim, shoot, harass. Includes negative alterations or impacts to habitat beyond a certain level required to maintain a healthy population.

Talus - A slope landform, typically covered by coarse rock debris forming a more or less continuous layer that may not be covered by duff and litter.

Thermal Cover - Forested cover providing elk protection from thermal extremes; generally includes trees where the average height is greater than or equal to 40 feet and the canopy closure is 70% or higher.

Unconsolidated Deposits - Sediments that are loosely arranged, with particles that are not cemented together. Includes alluvial, glacial, volcanic, and landslide deposits.

Unstable and Potentially Unstable Areas - Lands that need protection to maintain natural disturbance patterns and functions, prevent increased landslide distribution in time and space (rate and frequency), prevent increased delivery of sediment, and maintain landslide-delivered supply of large woody material over several rotations. On-site delineation of unstable and potentially unstable areas considers the probability of landslide-triggering storms within the period of minimum root strength and elevated groundwater (as well as slope adjustments to piping changes), and the probability of channel adjustments that trigger streambank and toeslope failures.

Watershed - The drainage basin contributing water, organic matter, dissolved nutrients, and sediments to a stream or lake. Smaller watersheds within the subbasin such as the Oak Grove Fork, Collawash, and Roaring River drainages.

Watershed Restoration - Improving current conditions of watersheds to restore degraded fish habitat and provide long-term protection to aquatic and riparian resources.

Wolman Pebble Count - A measurement of surface particles to determine the composition of fines in the stream substrate.

Year Class - A cohort of individuals of a fish species born during the same year.

Appendix C - Upper Clackamas Map Layers that are available at Clackamas Ranger District in the Analysis File (Scale 1:31680)

Land Allocations

- Late Successional Reserves and Key Watersheds
- Mt. Hood Forest Plan Land Allocations

Existing Vegetation

- Vegetation Database Cell Delineation
- Managed Stands Year of Origin
- Seral Stages (Early, Mid, Late & Non-Veg)
- Interior Habitat (Late Seral)
- Forest Series
- Stand Age (50yr. Intervals)

Roads and Trails

- Roads Near Streams by Erosion Hazard
- Roads by Surface Type
- Trails and Recreation Sites

Wildlife

- Terrestrial Mosaic (Late Seral)
- Dispersal Habitat (11/40) as Currently Exists
- Pileated Woodpecker/Pine Marten Habitat (B5)
- Area Near or Under Optimal or Thermal standards

Disturbance

- Historic Seral Stages (Early, Mid/Late)

Soils/Geology

- Disturbance Class of Harvest Units
- Slope 0-29, 30-49, 50-69 or 70 percent
- Aspect
- Soil Resilience Class
- Soil Erosion Hazard
- Landform Map
- Earthflow Map
- Road Related Sediment Map
- Existing Landslide Map

Riparian

- Seral Stages within Riparian Reserves
- Riparian Reserves
- Stream and Road Crossings
- Streams by Anadromous, Resident and Non-Habitat

Appendix D - Upper Clackamas Watershed Analysis Team and Persons Consulted

Core Team Members

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Team Members

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The Watershed Analysis Team wishes to provide special thanks to all the people who assisted in data analysis and interpretation. We would also like to extend special thanks to all of the District employees for getting the "other" District work completed while we spent two months concentrating on watershed analysis.

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