USDA United States Department of Agriculture
Forest Service
Pacific Northwest Region
1997

Bull Run Watershed Analysis

Mt. Hood National Forest

United States Department of Agriculture
Forest Service
Mt. Hood National Forest
Zigzag Ranger District
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File Code: 2500

Date: April 17, 1997

Dear Bull Run Watershed Analysis Reviewer/User:

Enclosed is your copy of the Bull Run Watershed Analysis. Comments received from reviews have been incorporated into this first iteration final report. If you have a previous review copy, please recycle and replace it with this document.

Watershed analysis is an ongoing, iterative process. This report is a dynamic document and intended to be revised and updated as new information becomes available.

Copies of the Bull Run Watershed Analysis are also available for use in the following libraries and we encourage use of the library system for these documents: Multnomah County Central Library, Science and Business section, 801 SW 10th, Portland; Gresham Public Library, 385 NW Miller, Gresham; Sandy Public Library, local reference section, 38980 Proctor Blvd., Sandy.

If you have any questions or comments regarding the analysis please contact any of the following individuals: Nancy Lankford, Watershed Analysis Team Leader at 668-1663; Todd Parker, Hydrologist, at 622-3191; or Alan Smart, Watershed Steward, at 622-3191.

Thank you for your interest in the Bull Run Watershed.

Sincerely,

E R Hardman

E. R. HARDMAN
District Ranger

Bull Run Watershed Analysis

Mt. Hood National Forest

April 1997

Preface

Dear Reader,

This document describes an in-depth, comprehensive analysis of the Bull Run Watershed. Although the full logic of the analysis tracks from chapters one to seven, the document may be approached in more than one manner depending on your needs.

If you're interested in a summary of the watershed analysis, the Key Question discussions in Chapter 6 provide synthesized, interpreted results. Changes in ecological conditions and their probable causes are examined and explained, including implications for watershed management objectives. Chapter 7 displays recommendations for management activities.

For detailed information on conditions within the watershed, Chapter 4, Current Conditions and Trends, provides a comprehensive discussion. This chapter provides the supporting evidence to answer the Key Questions and to develop recommendations. It also provides substantial information for further project planning. Within, or at the end, of most sections of this chapter, you will find conclusions or highlights which summarize the overall discussions.

In addition, since watershed analysis is an ongoing, iterative process, there are important components to our work that go beyond the pages of this document. These products are stored at the Zigzag Ranger District and include:

- **Databases:** A large array of data was organized and analyzed. These databases will be beneficial for further planning efforts within the watershed.
- **Spatial data layers:** Many layers representing spatial resource information (ARC-Info format) were compiled, refined or newly constructed.
- **Maps:** A large number of mylar and paper map layers have been produced from the electronic spatial data mentioned above. An aerial photo mosaic of the watershed was created as well.
- **Analysis file:** Includes additional written documentation of assumptions, methods, results, background material, and review comments.
- **Contributors:** Part of any work is the knowledge gained from the process. The analysis team members together with resource specialists, stewards, and outside contributors provide a valuable knowledge base of the Bull Run Watershed and of the tools and products mentioned above.

-- *The Watershed Analysis Team*

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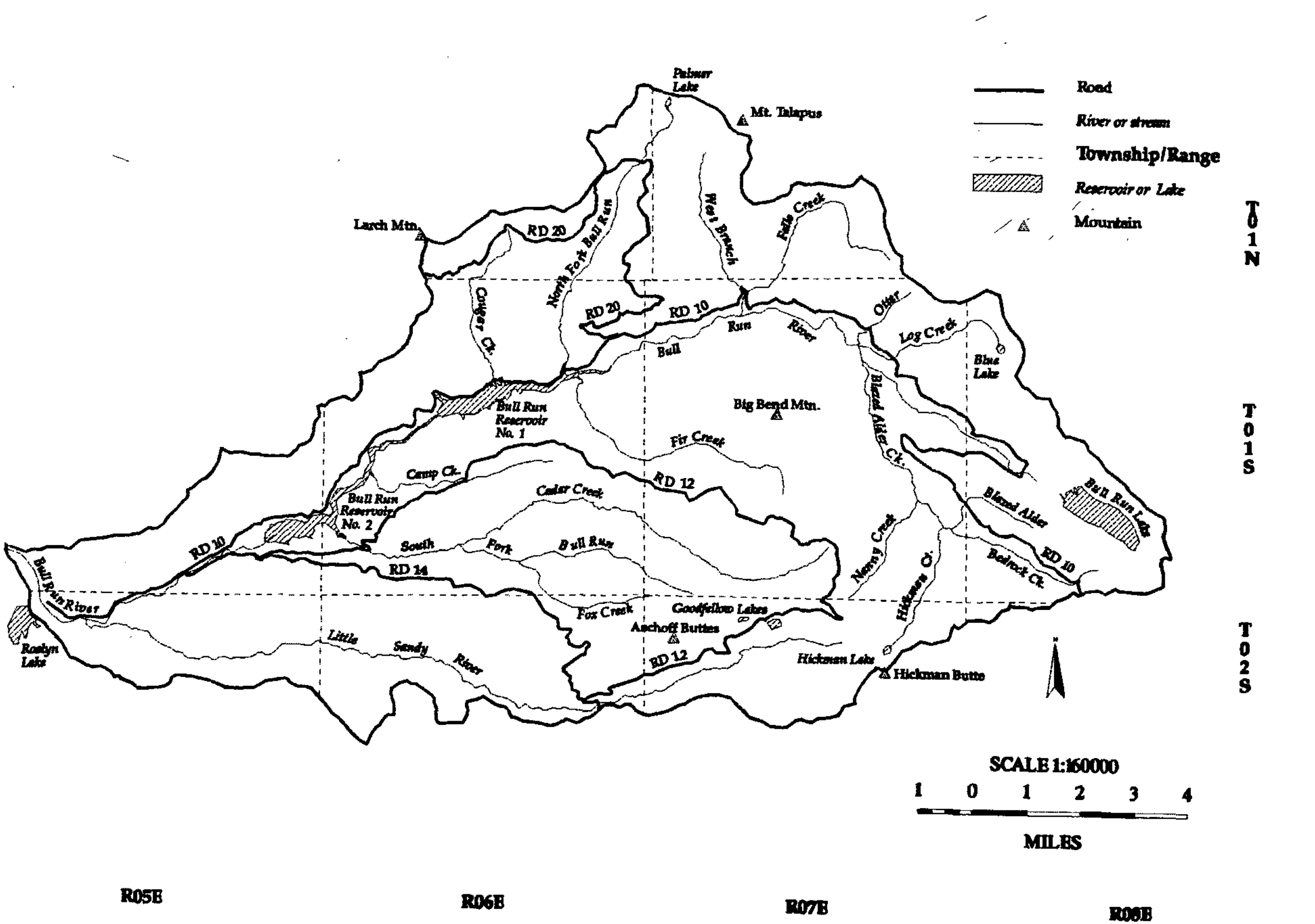


Road
River or stream
Township/Range
Reservoir or Lake
Mountain
T01N
T01S
T02S
Palmer Lake
Mt. Talapus
Larch Mtn.
RD 20
North Fork Bull Run
West Branch
Falls Creek
Cougar Ck.
RD 10
Otter
Log Creek
Blue Lake
Bull Run River
Bull Run Reservoir No. 1
Big Bend Mtn.
Fir Creek
Blazed Alder Ck.
Bull Run Lake
Camp Ck.
Cedar Creek
RD 12
Blazed Alder
Bull Run Reservoir No. 2
South Fork Bull Run
Nanny Creek
Bedrock Ck.
RD 14
Hickman Ck.
Fox Creek
Goodfellow Lakes
Aschoff Buttes
Roslyn Lake
Little Sandy River
Hickman Lake
Hickman Butte
SCALE 1:160000
1 0 1 2 3 4
MILES
R05E
R06E
R07E
R08E

Chapter 1 -- Introduction

Purpose of Watershed Analysis

Watershed Analysis is a procedure used to document a scientifically-based understanding of the ecological structures, functions, processes, and interactions that occur within a watershed -- providing a process to identify trends, conditions, and restoration opportunities.

Watershed Analysis essentially serves as ecosystem analysis at the watershed scale, providing the general type, location, and sequence of appropriate management activities within a watershed. Watershed Analysis, however, is not a decision-making process. It is, rather, the stage-setting process whose results establish the context for subsequent decision-making processes, including planning, project development, and regulatory compliance.

Watershed analysis is an ongoing, iterative process. This report is a dynamic document. It is intended to be revised and updated as new information becomes available.

Watershed Analysis serves as one of the principal analyses for implementing the Aquatic Conservation Strategy (ACS) set forth in the Northwest Forest Plan (*Record of Decision* [ROD] *for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl,* USDA, USDI 1994).

Watershed Analysis Contributors

A core team from the US Forest Service took the lead in the Bull Run Watershed Analysis with substantial input from District interdisciplinary resource specialists. Representatives from other agencies -- including the City of Portland, Bureau of Land Management, U.S. Fish and Wildlife Service, and Portland General Electric -- also helped the Watershed Analysis Team identify and explore a full range of management issues and resource concerns within the Bull Run Watershed.

A public meeting was held on January 25, 1996 to explain the purpose of watershed analysis and receive input on draft key questions. A similar meeting was held with the City of Portland's Water Quality Advisory Committee. Letters and phone calls have been received which provided input into the analysis. Another public meeting was held on February 8, 1997 to share the highlights of the analysis. In addition, on February 4^{th} and 12^{th}, the watershed analysis was presented and discussed with the Water Quality Advisory Committee for the City of Portland.

In February, 1997, review copies of the document were distributed to other agencies, organizations, individuals, and the Multnomah County Central and Sandy libraries. Since this is an analysis, not a decision-making process, reviewers were asked to focus on technical accuracy, supported conclusions, and consistency with guidelines in the Northwest Forest Plan and the Federal Guide for Watershed Analysis. Responses to comments are summarized in Chapter 10.

Watershed Analysis Report/Document Organization

As outlined in the *Federal Guide for Watershed Analysis* (August 1995), the following six-step process was used to conduct the Bull Run Watershed Analysis and provides the framework for this report:

Step One -- Characterize the Watershed

This initial step identified the dominant physical, biological and human processes or features that affect the watershed's ecosystem functions and conditions. Significant land allocations, plan objectives and regulatory constraints that influence resource management within the watershed were identified. *(Chapters One and Two)*

Step Two -- Identify Issues and Key Questions

To help focus the analysis, Key Questions were identified based on management objectives, human values, and resource conditions within the watershed. *(Chapter Three)*

Step Three -- Describe Current Conditions

Detailed information associated with the watershed's processes, conditions and Key Questions was developed. The current range, distribution, and condition of the relevant ecosystem elements were documented. *(Chapter Four)*

Step Four -- Describe Reference Conditions

How the watershed's ecological conditions have changed due to human influence and natural disturbance was explored and explained. A reference was developed to compare current conditions with key management plan objectives. *(Chapter Four)*

Step Five -- Synthesize and Interpret Results

Changes in ecosystem conditions and their probable causes were examined and explained, including implications for watershed management objectives. *(Chapters Four through Six)*

Step Six -- Develop Recommendations

The Watershed Analysis Team applied the results from steps one through five and developed recommendations for management activities that are responsive to the issues and Key Questions from Step Two. *(Chapters Six and Seven)*

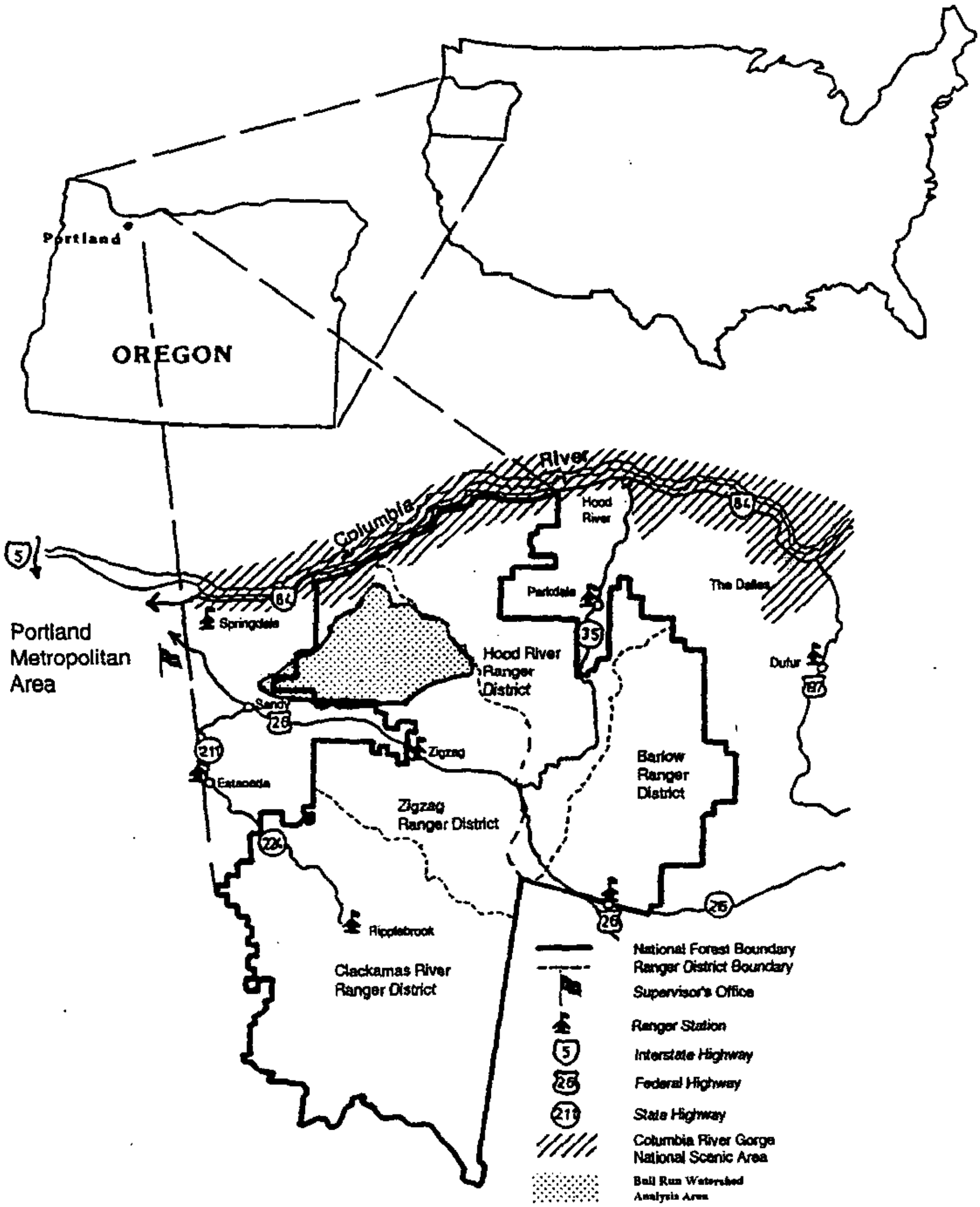
Watershed Characterization

Administrative

The Bull Run Watershed is located approximately 20 miles east of Portland and 5 miles west of Mount Hood on the forested slopes of the northern Oregon Cascades. **The watershed includes the Little Sandy Watershed (collectively referred to hereafter as the Bull Run Watershed)** and includes portions of Multnomah and Clackamas counties. The watershed currently serves as the primary source of water for approximately 800,000 Portland metropolitan area residents -- one-fourth of the state's population.

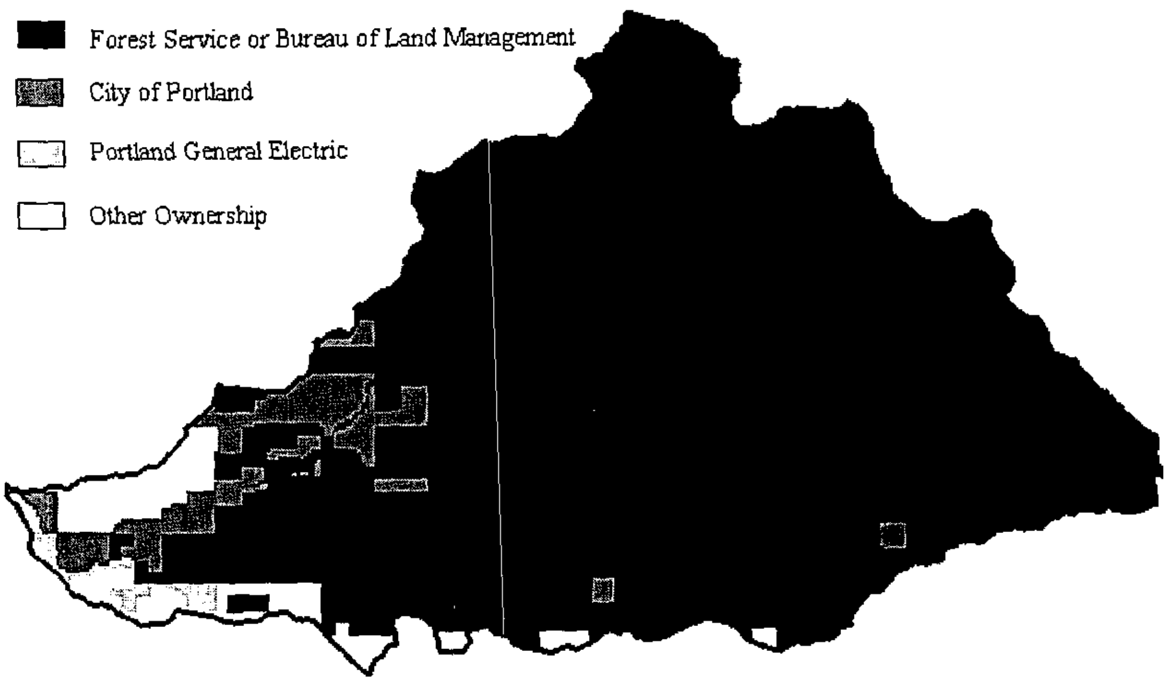
Figure 1-1 - Mt. Hood National Forest Vicinity Map displays the watershed's location relative to the rest of the Mt. Hood National Forest, Portland, and Oregon State. In the beginning of Chapter 1, there is a clear mylar location map of the analysis area. This location map displays the major streams and roads of the Bull Run Watershed as well as township and range lines, and prominent geographical features such as peaks, reservoirs and lakes. It is intended to be used as a locator/orientation overlay with any of the full page maps in the rest of the document.

Figure 1-1 - Mt. Hood National Forest Vicinity Map



Federal lands account for 89 percent of the watershed with the Mount Hood National Forest serving as land steward for the vast majority of these lands. A small amount of Bureau of Land Management (BLM) land occurs in the Little Sandy and northwest of the reservoirs. The City of Portland's Water Bureau owns and manages 5 percent of the watershed and operates city water supply facilities on federal land under Forest Service special-use permits. The watershed is also comprised of Portland General Electric (PGE) and other privately-owned parcels.

Figure 1-2 Land Ownership



On the lower sections of the Bull Run River, the City of Portland operates two dams which impound two reservoirs, storing a combined estimated 17 billion gallons of water. The Forest Service has also issued the City a special-use permit to utilize the 486-acre Bull Run Lake as a water supply facility. In addition, the City owns two hydroelectric plants inside the watershed. Electric power is sold by contract to Portland General Electric.

Protection of the Bull Run Watershed for use as a water source began in 1892 when U.S. President Benjamin Harrison established the Bull Run Forest Reserve. In 1895 the City of Portland began using Bull Run water. Public entry into the watershed was later prohibited by the "Trespass Act," signed in 1904 by U.S. President Theodore Roosevelt.

The framework for present and future management activities inside the watershed was set in 1977 with Public Law (PL) 95-200 which established the 95,382-acre "Bull Run Watershed Management Unit (BRWMU)." According to the law, the principle management objective within the Unit is ***"the continued production of pure, clear, raw potable water for the City of Portland."***

As required by PL 95-200, a management plan was prepared (Bull Run Land Management Plan Final Environmental Impact Statement 1979) which is incorporated in the Mt. Hood Forest Plan (*Mt. Hood Forest Land and Resource Management Plan, Final Environmental Impact Statement, Mt. Hood National Forest*, 1990). Administrative direction is also provided by the Northwest Forest Plan.

The Oregon Resource Conservation Act of 1996 (ORCA) recently amended PL95-200 and outlines specific management direction. (See Chapter Two.)

Figure 1-3 -- Administrative Boundaries of the Bull Run Watershed displays the different administrative boundaries of the Bull Run Watershed. Since it is easy to confuse these boundaries, they are briefly defined below:

Bull Run Watershed Analysis Area - The fifth field watershed covered in this Watershed Analysis. Includes the area of the Bull Run and Little Sandy Watersheds which both drain to a common point, the Bull Run River.

Bull Run Water Supply Drainage - The land area that drains into the Bull Run River at headworks, the municipal water supply intake for the City of Portland.

1996 Oregon Resource Conservation Act - Lands included in the Oregon Resource Conservation Act of 1996 where cutting of trees is generally prohibited with some exceptions.

Bull Run Watershed Management Unit - The management unit as established by PL95-200.

Little Sandy Watershed - A subwatershed to the Bull Run that flows into the Bull Run River below the City of Portland municipal source of water at headworks. Often referred to separately from the Bull Run since it does not directly provide municipal water.

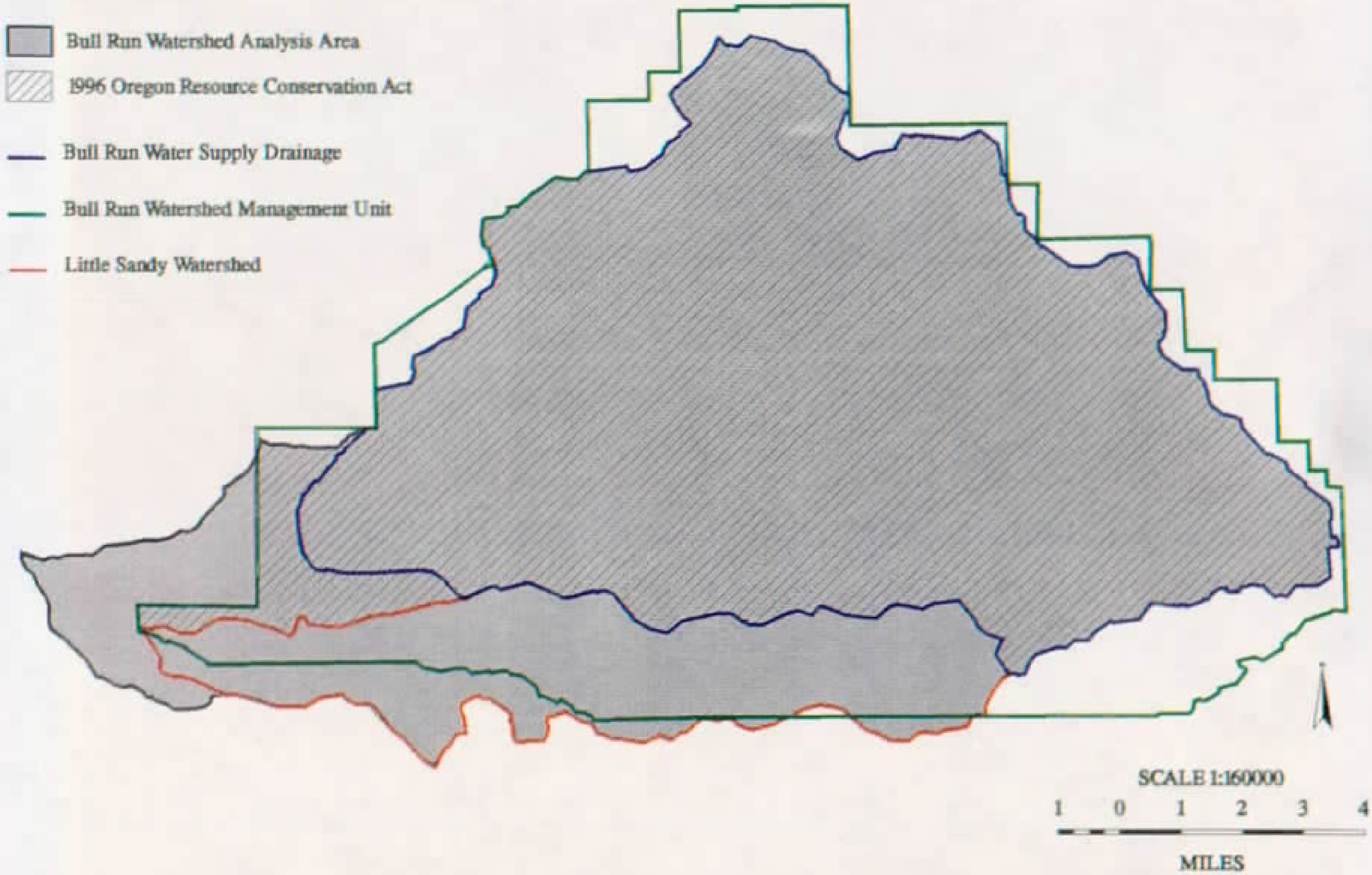
Oregon Resource Conservation Act Little Sandy Study Area - that part of the Little Sandy Watershed that is within the Bull Run Watershed Management Unit.

Table 1-1 Ownership by Administrative Category[1]

Administrative Category	Forest Service and BLM	City of Portland[2]	Portland General Electric[3]	Other Private Ownership[4]	Total
Watershed Analysis Area	78899	4426	595	5042	88962
Water Supply Drainage[5]	63052	2208	0	188	65448
Bull Run Watershed Management Unit[6]	76968	3191	67	309	80534
ORCA Hydrographic Boundary of the Bull Run River Drainage[7]	65339	3018	0	203	68560
ORCA Little Sandy Study[8]	11493	165	67	99	11824
Little Sandy Watershed[9]	13320	165	289	2109	15885

[1] These acres are derived from a raster database with 2.47 acre cells. This will result in some rounding of acreage figures
[2] Ownership derived from taxlot coverage obtained from Clackamas County and land status coverage. Current land allocation maps are in error in classifying Reservoir 1 in federal ownership
[3] Ownership derived from taxlot coverage obtained from Clackamas County
[4] Ownership derived from taxlot coverage obtained from Clackamas County
[5] Boundary derived by combining all the subwatersheds within the water supply drainage
[6] Boundary from Bull Run Management Unit MOSS layer at Columbia Gorge
[7] Boundary from MASTER2.db
[8] Boundary from MASTER2.db
[9] Boundary from Little Sandy subwatersheds

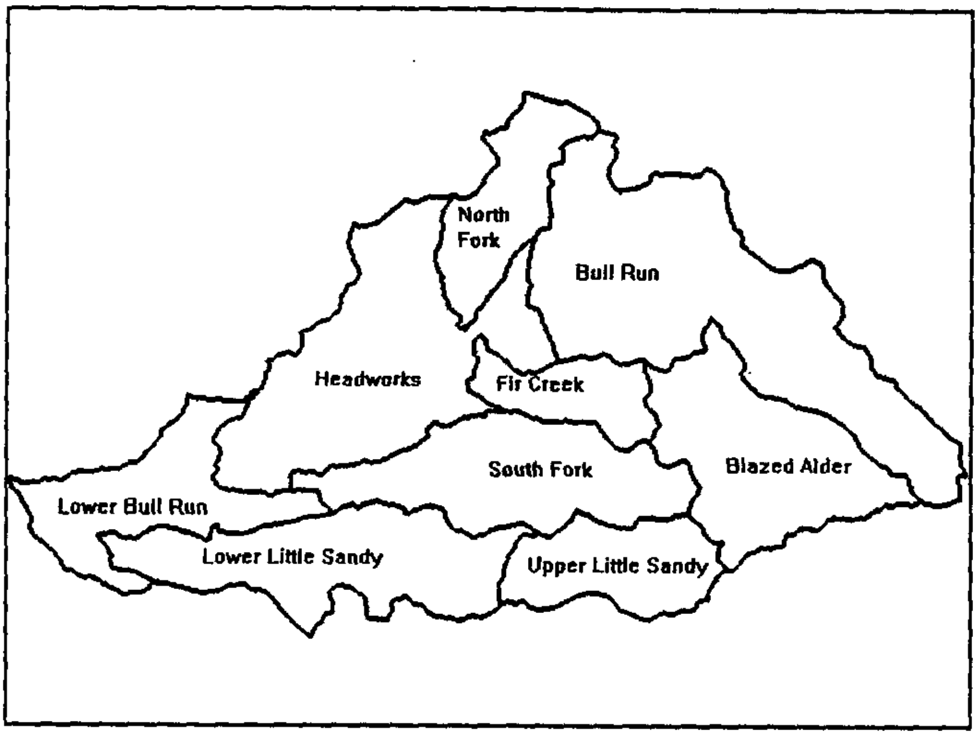
Bull Run Watershed Administrative Boundaries



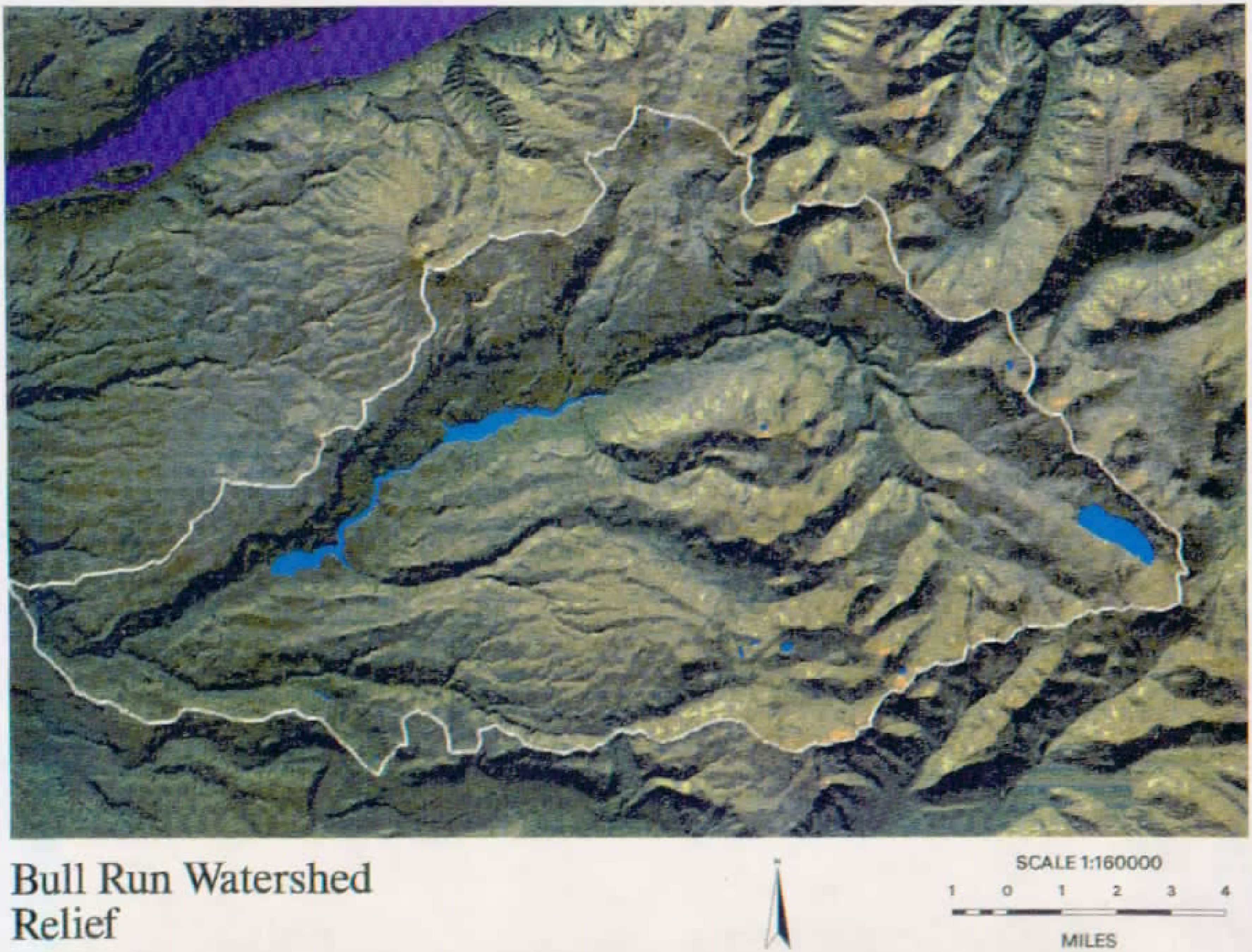
Setting

The 88,962-acre (139 square mile) Bull Run Watershed analysis area encompasses nine subwatersheds, Figure 1-4, including: the Bull Run (20,135 acres), Lower Bull Run (7,615 acres), Lower Little Sandy (10,288 acres), Upper Little Sandy (5,597 acres), Headworks (15,781 acres), Blazed Alder (10,423 acres), South Fork (10,065 acres), North Fork (5,338 acres), and Fir Creek (3,705 acres). Subwatersheds are often used in this report as a smaller scale stratification within the watershed for analyzing some processes or to summarize results.

Figure 1-4 -- Subwatersheds of the Bull Run



Elevations within the watershed range from 260 feet at the watershed's western edge to 4,750 feet at Buck Peak on the watershed's northeastern boundary. The watershed's topography is relatively gentle, varying from low-relief lava flow surfaces to steep-walled canyons. (See Figure 1-5.) Many valleys rise to rounded ridgetops and approximately 88 percent of the watershed is comprised of slopes of less than 50 percent.



Bull Run Watershed Relief

The Bull Run Watershed's predominate east-west oriented major drainages help usher in the region's preponderance of westerly, moist marine storms. This process creates the warm, wet conditions within the watershed's interior which, in turn, produce its dominant lush, productive plant communities.

These seasonal moist storms deliver from 54 to as much as 120 inches of annual precipitation within the Bull Run Watershed (DRAFT precipitation estimates [Daly et al., 1994]). Portland averages 37.5 inches of annual rainfall. Snowfall in the watershed is rare below 2,000 feet, but often reaches from 6 to 10-foot depths above 4,000 feet. Summers are typically dry and warm. Annual temperatures range from 10 to 100 degrees Fahrenheit, with a 50 degree Fahrenheit average.

Rain is the primary source of water in the Bull Run Watershed during the summer months. This makes the municipal water system different from many others in Oregon and from water systems that rely on permanent snowpack. Rain in May and June often keeps the reservoirs full into July. Although the watershed is in the northwest foothills of Mt. Hood, snowpack and glaciers on Mt. Hood do not drain into the Bull Run Watershed. The Sandy River Gorge and Lolo Pass between Mt. Hood and the headwaters of the Bull Run Watershed prevent such drainage.

The Western Hemlock Zone encompasses most of the watershed's lower elevations while lands above 3,000 feet are dominated by the Pacific Silver Fir Zone. Dominant tree species within the watershed include: Douglas fir, western hemlock, Pacific silver fir, and western red cedar. In both zones, common understory vegetation in moist sites consists of: devil's club, oxalis, Alaska huckleberry, swordfern, bunchberry, and vine maple. In both zones, common understory vegetation in dry sites consists of: dwarf Oregon grape, salal, rhododendron, and bear grass.

While the watershed is comprised mainly of late-successional forest, conspicuous breaks in canopy continuity have been created by: fire, reservoir construction, past timber harvest, recent blowdown events, and salvage logging. Approximately 20 percent of National Forest lands within the Bull Run Watershed have experienced clearcut timber harvest activity since the 1950's. As much as 30 percent of the watershed has experienced fire since 1850. Stand-replacing, high-severity fire occurred on 40 percent of the watershed's area between 1600 and 1850.

Chapter 2

Management Objectives

Chapter 2 - Management Objectives

The management objectives for the Bull Run Watershed's National Forest lands are established in the Mt. Hood Forest Plan as amended by the Northwest Forest Plan.

This chapter discusses these plans and explains their relationships by outlining the following:

- Relationship of Existing Plans and Standards and Guidelines
- Northwest Forest Plan Allocations
- Mt. Hood Forest Plan Allocations
- General Management Objectives (derived from both the Northwest Forest Plan and Mt. Hood Forest Plan)
- Key Watersheds

Relationship of Existing Plans and Standards and Guidelines

Public Law 95-200 designates the principal management objective within the Bull Run Watershed Management Unit, BRWMU, as the continued production of **"pure, clear, raw, potable water for municipal use." The law required a management plan which was completed in 1979 and incorporated into the 1991 Mt. Hood Forest Plan.**

The recently passed **Oregon Resource Conservation Act of 1996 (ORCA) amends PL95-200. The Act "prohibits the cutting of trees in that part of the unit consisting of the hydrographic boundary of the Bull Run River Drainage, including certain lands within the unit and located below the headworks of the city of Portland."** The Act also prohibits salvage sales in this area. Exceptions in the Act permit cutting of trees for the protection, enhancement, or maintenance of water quality and quantity, or for the construction, expansion, protection or maintenance of municipal water supply facilities. It also includes some exceptions for transmission of energy and hydroelectric facilities.

The **Oregon Resource Conservation Act of 1996 also requires a study of the Little Sandy Watershed** that is within the BRWMU. The study shall determine the impact of management activities on the quality of drinking water provided to the Portland metro area and identify ecological and cultural features and other significant values within the Little Sandy Watershed. The study shall also include both legislative and regulatory recommendations from the Secretary of Agriculture to Congress regarding future management of the study area. **Timber sales are prohibited for two years from the date of the Act while the report to Congress is prepared and reviewed.**

In 1994, the Northwest Forest Plan amended the Mt. Hood Forest Plan and other forest plans within the range of the northern spotted owl. The Northwest Forest Plan adds new resource management goals and objectives and several major land allocations, each with its own set of standards and guidelines. **These land allocations overlay the 1991 Mt. Hood Forest Plan land allocations.**

Each plan and its accompanying land allocations have specific management standards and guidelines. The standards and guidelines govern appropriate activities within the land allocations and prescribe the environmental conditions to be achieved and maintained.

The standards and guidelines of the Northwest Forest Plan supersede other direction except treaties, laws, and regulations unless that direction is more restrictive or provides greater benefits to late-successional forest related species (ROD A-6, C-1). Standards and guidelines and land allocations in existing plans not directly superseded will remain in effect (ROD. A-2). Thus, standards and guidelines from the Mt. Hood Forest Plan apply when they are more restrictive than the Northwest Forest Plan.

Standards and guidelines from the Northwest Forest Plan do not apply where they would be contrary to existing law or regulation, or where they would require agencies to take actions for which they have no authority (ROD A-6, C-1). For example, the standards and guidelines from the Northwest Forest Plan are implemented to the extent they are consistent with PL 95-200 as amended by the Oregon Resource Conservation Act of 1996 (ORCA), but do not apply where they are contrary.

Northwest Forest Plan Land Allocations

The Northwest Forest Plan overlays the following designated areas in the watershed: Late Successional Reserves, Riparian Reserves, and Administratively Withdrawn Areas. The ROD applies the Matrix allocation to all the remaining federal lands within the watershed outside of these three designated areas.

Some overlap occurs within these designated areas. For example, Riparian Reserves within Late-Successional Reserves. For acreage and display purposes, the following mapping hierarchy is used: 1) Late-Successional Reserves, 2) Administratively Withdrawn Areas, 3) Riparian Reserves, and 4) Matrix (ROD A-5). These are displayed in Table 2-1 -- Northwest Forest Plan Land Allocations and Figure 2-1 -- Northwest Forest Plan Land Allocations. (Acres are approximate.)

Table 2-1 -- Northwest Forest Plan Land Allocations

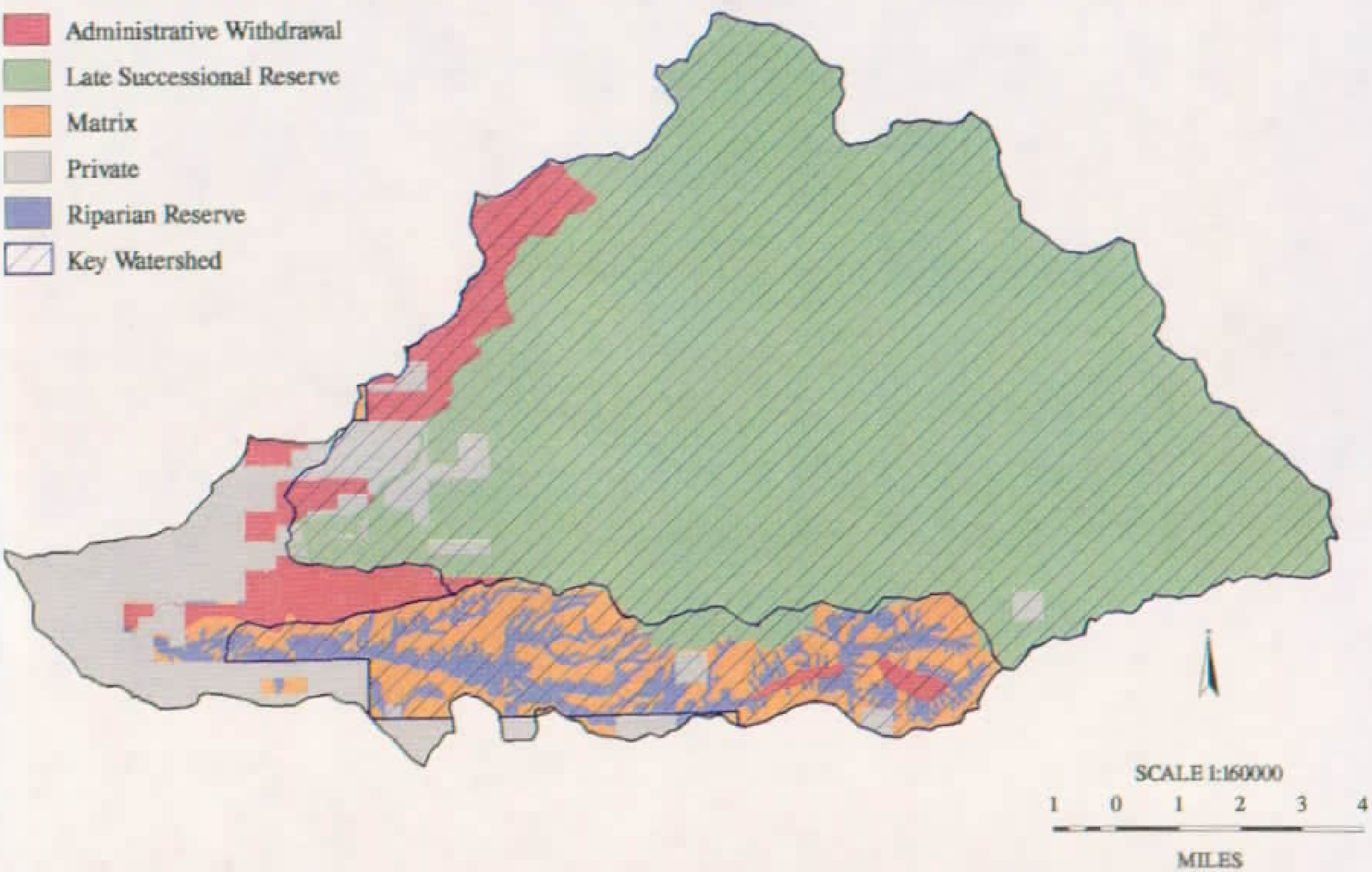
Northwest Forest Plan Land Allocation	Acres in Watershed
Private Land	9,732
Late Successional Reserves*	61,205
Administratively Withdrawn Areas*	5,942
Riparian Reserves	4,981
Matrix	7,120
Total Acres	88,980

*Note: Since the time that the Northwest Forest Plan was authorized, administratively withdrawn lands and late successional reserves in the physical drainage and below headworks have been congressionally protected under ORCA (see pg. 2-1 and Figure 1-2).

Bureau of Land Management (BLM) lands are also guided by the Northwest Forest Plan. Three small parcels of Matrix lands are located in the Little Sandy subwatershed. Another small parcel is located northwest of the reservoirs which is designated as Matrix but recommended to be changed to District Designated Reserve during the Bureau of Land Management plan amendment process. District Designated Reserves are managed similar to late successional reserves.

Privately owned lands within the watershed are shown for display purposes only. These private lands are not subject to Northwest Forest Plan or Mt. Hood Forest Plan standards and guidelines. They are, however, subject to state and county laws and ordinances, including State Forest Practices Regulations.

Bull Run Watershed
Northwest Forest Plan



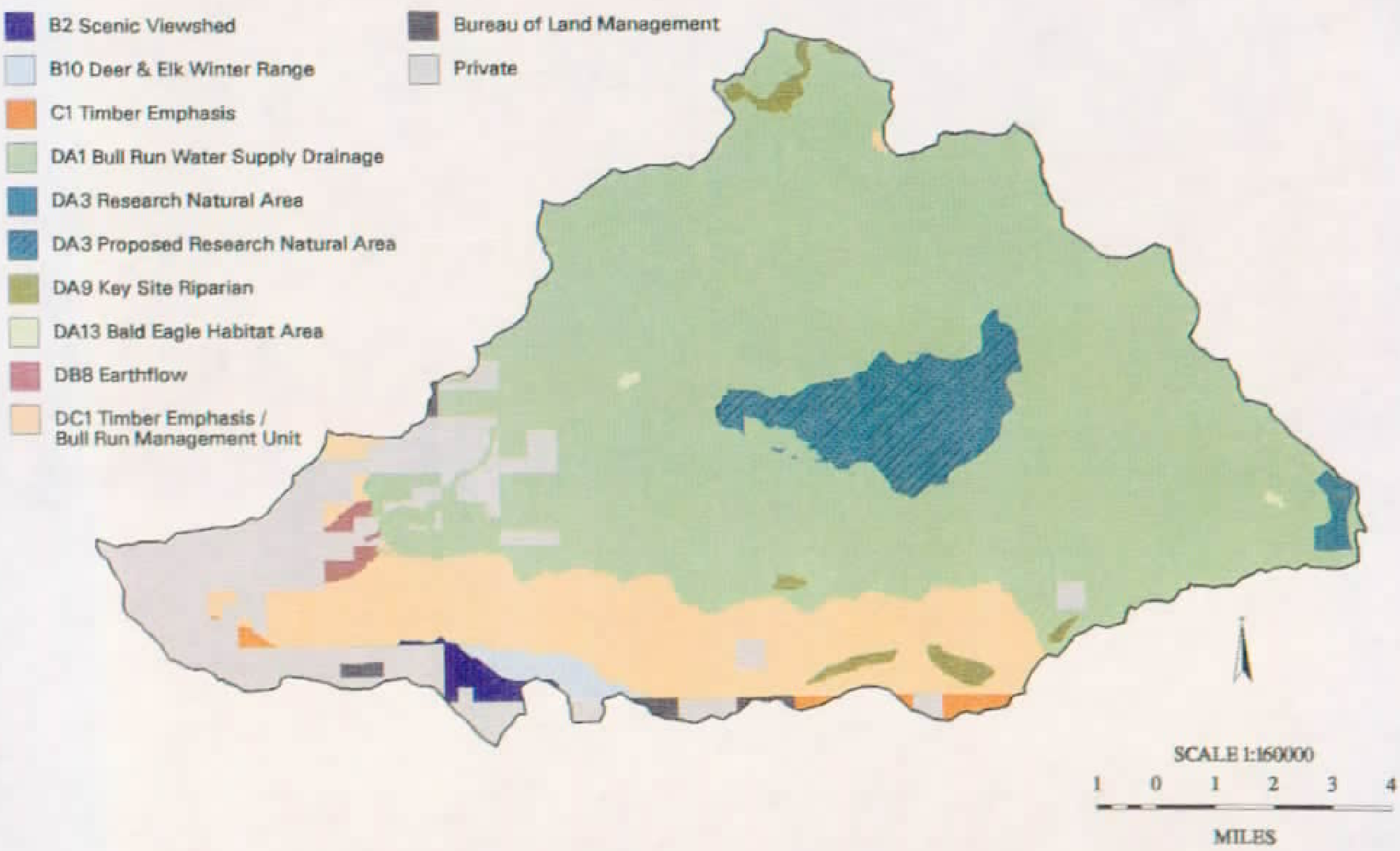
Mt. Hood Forest Plan Land Allocations

The Northwest Forest Plan allocations overlay and amend land allocations prescribed in the Mt. Hood Forest Plan. (Table 2-2 -- Mt. Hood Forest Plan Allocations and Figure 2-2 -- Mt. Hood Forest Plan Land Allocations.) Acres are approximate.

Table 2-2 -- Mt. Hood Forest Plan Allocations

Mt. Hood LRMP Allocation	Acres in Watershed
Private Land	9794
DA1 Bull Run Physical Drainage	57,240
DA2 North Buffer	37
DA3 Research Natural Area	5,350
DA9 Key Site Riparian	946
DA13 Bald Eagle Habitat Area	84
DB8 Earthflow	345
DC1 Timber Emphasis	12,876
B2 Scenic Viewshed	573
B10 Deer and Elk Winter Range	857
C1 Timber Emphasis	468
BLM	390
Total Acres	88,980

Bull Run Watershed
Land & Resource Management Plan



General Management Objectives

Because the Northwest Forest Plan allocations overlay land allocations designated in the Mt. Hood Forest Plan, general management objectives reflect and describe both plans. Two or more overlapping land allocations may occur on one site. In addition, when allocations overlap, more than one set of standards and guidelines may apply. For example, where Riparian Reserves occur within Late-Successional Reserves, the standards and guidelines of both designations apply.

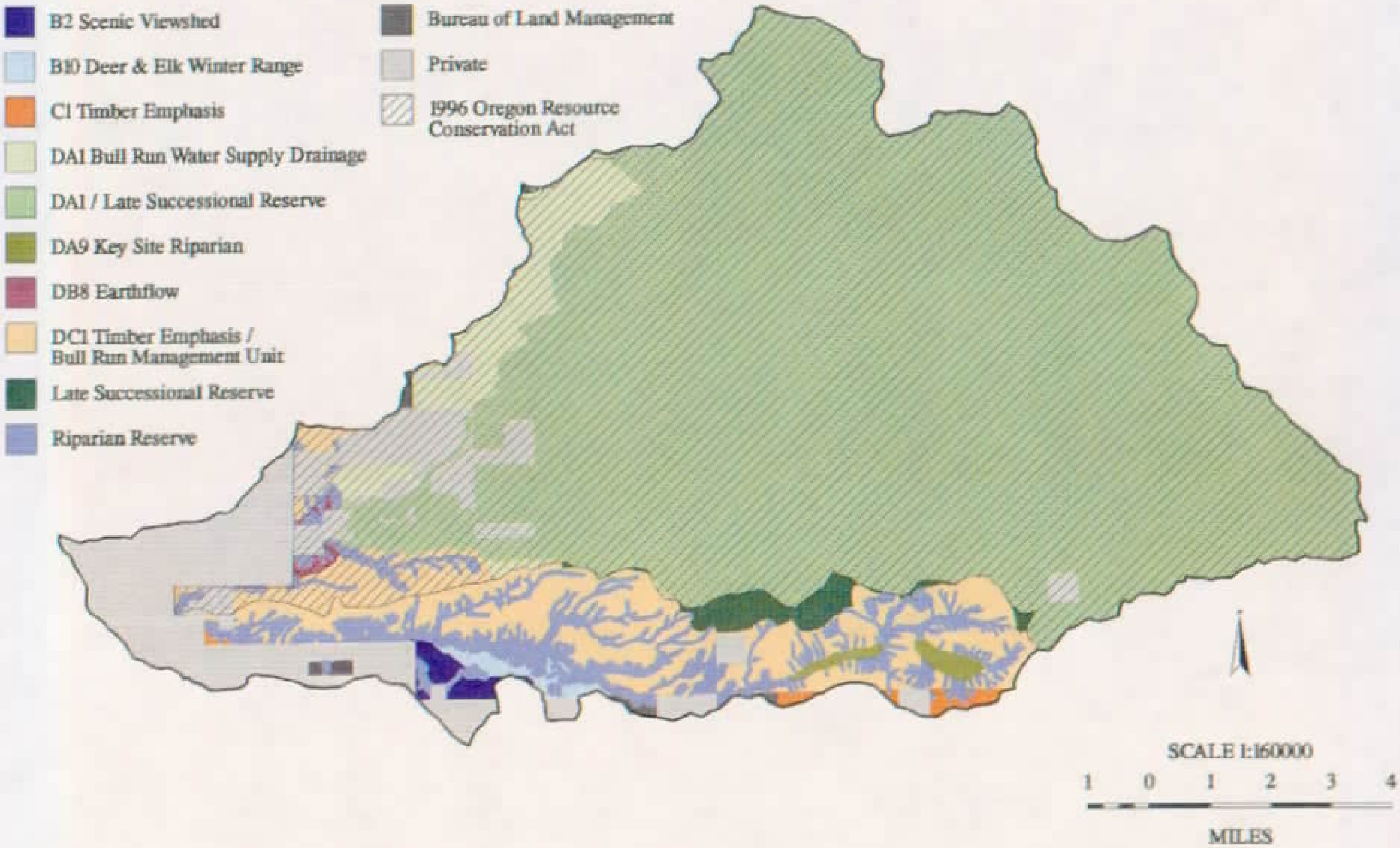
General management objectives are derived from these overlapping standards and guidelines. Standards and guidelines which are more restrictive or provide greater benefits to late-successional forest-related species will generally apply first. Northwest Forest Plan standards generally provide greater benefits to late-successional forest-related species. The Mt. Hood Forest Plan is often more site-specific and provides benefits to other resources. In Matrix lands, standards and guidelines from the Mt. Hood Forest Plan apply, as well as Northwest Forest Plan standards and guidelines that apply to all land allocations. (Also see section on Relationship of Existing Plans and Standards and Guidelines.)

The land allocations listed in Table 2-3 and Figure 2-3 reflect a summary of both plans and also display the acres included in the Oregon Resource Conservation Act. In addition to the summary table and map, underlying land allocations and their standards and guidelines still occur. Where two or more land allocations are generally consistent with each other, both allocations are shown.

Table 2-3 -- General Management Direction

LAND ALLOCATIONS included in Oregon Resource Conservation Act of 1996 (ORCA)	ACRES IN ALLOCATION
Bull Run Physical Drainage / Late Successional Reserves (DA1/LSR)	60,068
Bull Run Physical Drainage (DA1)	2,999
Bull Run Watershed Management Unit Timber Emphasis (DC1)	1,509
Riparian Reserves	761
Bull Run Watershed Management Unit Earthflow (DB8)	116
100 Acre LSRs	57
LAND ALLOCATIONS not included in ORCA	**ACRES IN ALLOCATION**
Private Land	9,796
Bull Run Watershed Management Unit Timber Emphasis (DC1)	5,780
Riparian Reserve	4,836
Late Successional Reserves (LSR)	1,064
Bull Run Watershed Management Unit Key Site Riparian (DA9)	395
Scenic Viewshed (B2)	420
Deer and Elk Winter Range (B10)	375
Timber Emphasis (C1)	301
100 Acre LSRs	193
BLM General Forest Management Area	272
Total watershed acres -	88,980

Bull Run Watershed General Management Objectives



Descriptions of General Management Objectives for Land Allocations

D-series land allocations include all lands within the Bull Run Watershed Management Unit as established by Public Law 95-200. The principle objective of D series lands is the production of "pure, clear, raw, potable" water. The secondary management objective is the protection, management, and utilization of renewable resources.

A-lands are administratively withdrawn lands where scheduled timber harvest is precluded. All of the administratively withdrawn lands in the watershed are within the BRWMU as identified in both the Northwest Forest Plan and Mt. Hood Forest Plan.

DA1 Bull Run Watershed, Physical Drainage

This management area includes the territory within the physical watershed boundaries of the Bull Run River upstream from the headworks at Reservoir No. 2. The principle objective of this allocation is the continued production of clear, clean, raw potable water. The secondary objective is the protection, management and utilization of renewable resources found within the Management Unit. However, all of these acres are now included in the Oregon Resource Conservation Act of 1996 (ORCA) which generally prohibits the cutting of trees.

Late-Successional Reserves

The objective of Late-Successional Reserves (LSR) is to protect and enhance conditions of late-successional and old-growth forest ecosystems which serve as habitat for late-successional and old-growth related species, including the northern spotted owl. The vast majority of these acres are also included in ORCA, which generally prohibits the cutting of trees. However, 1,064 are not included. Therefore, to promote late-successional structure, some of these acres may still be considered for silvicultural treatments if they are less than 80 years old, and treatments are justified through a LSR Assessment.

DA1/LSR Bull Run Physical Drainage/Late Successional Reserve

This allocation includes the area where the Late-Successional Reserve overlaps the Bull Run Physical Drainage. Standards and guidelines in this area are a blend of the direction for both allocations. DA1 Bull Run Physical Drainage is the overriding direction for this allocation. However, LSR direction applies as long as it is consistent with standards and guidelines for the Bull Run Physical Drainage. Furthermore, all of these acres are included in ORCA which generally prohibits cutting of trees.

DA9 Key Site Riparian

These areas are notable for their exceptional diversity, high natural quality, and key role in helping meet the needs of riparian-dependent species. In most cases, Riparian Reserves overlay the Key Site Riparian designations.

DB8 Earthflow

The secondary management goal of earthflow lands is to maintain the hydrologic and physical balances to prevent reactivating or acceleration of large, slow moving earthflow areas. The management and utilization of forest resources is allowed through the use of special management practices, however these lands are included in ORCA which generally prohibits the cutting of trees.

DC1 Timber Emphasis

The secondary management goal of this allocation is to provide lumber, wood fiber, and other forest products on a fully regulated basis, based on the capability and suitability of the land. An additional goal is to enhance other resource uses and values that are compatible with timber harvest. 1,509 acres are included in ORCA which generally prohibits the cutting of trees, whereas 5, 780 acres are not included in ORCA and potentially available for harvest.

The following general management objectives are listed for lands outside the Bull Run Watershed Management Unit and are therefore not included in D-series or A-land allocations.

100-Acre Late Successional Reserves

100-acre LSRs are to be designated around each known (as of Jan. 1, 1994) spotted owl activity center not already protected by another reserve (ROD C-10). Two known owl activity centers occur in Matrix lands within the Bull Run Watershed that are surrounded by 100-acre LSRs.

B2 Scenic Viewshed

Scenic viewshed management objectives are to provide attractive, visually appealing forest scenery with a wide variety of natural-appearing landscape features. Vegetation management activities are used to create and maintain desired landscape character. The visual character of the landscape results from prescribed visual quality objectives within distance zones from selected view points.

B10 Deer and Elk Winter Range

The principal management objectives of this allocation are to provide high quality deer and elk habitat for use during most winters, and to provide for a stable population of Roosevelt Elk on the west side of the Cascades. Secondary management objectives include maintenance of a healthy forest condition through a variety of timber management activities.

C1 Timber Emphasis

The principal objective of this allocation is to provide lumber, wood fiber, and other forest products on a fully regulated basis, based on the capability and suitability of the land. A secondary goal is to enhance other resource uses and values that are compatible with timber harvest.

Bureau of Land Management Lands:

District Designated Reserve - these lands are managed similarly to Late Successional Reserve. The parcel of BLM Matrix land northwest of the reservoirs has been recommended for change to District Designated Reserve during the BLM's plan amendment process.

General Forest Management Area - objectives are to manage for timber production while providing for long-term site productivity, forest health, cavity nester habitat, and biological legacies.

In addition, the Oregon Resource Conservation Act of 1996 includes land exchanges involving federal lands and Longview Fibre lands mainly within the Upper Sandy Watershed. Two parcels of Longview Fibre lands, however, are located on the southern boundary of the Little Sandy Watershed that will potentially be exchanged to BLM. Exchanges shall be consummated not later than one year after the date of enactment of the Act.

Those lands that can be seen from Highway 26 shall be managed primarily for the protection of scenic values. Management prescriptions for other resource values associated with these lands shall be planned and conducted for purposes other than timber harvest, so as not to impair scenic quality. This potential exchange is not displayed on the maps within this watershed analysis, nor are acres altered at this point in time.

Riparian Reserves

Riparian Reserves provide an area along all streams, wetlands, ponds, lakes, reservoirs, and unstable and potentially unstable areas where riparian-dependent resources receive primary emphasis. Riparian Reserves are also important to the terrestrial ecosystem, providing habitat within the riparian upland/transition zone, as well as providing connectivity within the watershed and among Late-Successional Reserves.

Direction for designating Riparian Reserve widths is stated in the ROD (Standards and Guidelines, pages C-30 and C-31). For the Bull Run Watershed Analysis, measured site-potential tree heights within major vegetative zones were used to delineate the interim Riparian Reserve widths. (See Chapter Seven for detailed information on the assumptions used for developing the interim Riparian Reserve widths.)

The following is a summary of the interim Riparian Reserve widths, expressed in slope distance, used in this analysis. For the purpose of mapping, horizontal distances were used. On most lands (except steep slopes), the difference between slope and horizontal distance is minimal.

Unstable and potentially unstable areas should be field verified during project planning, and delineated by a soil scientist or geologist. Final location of all Riparian Reserves will be based on site-specific analysis.
Major vegetative zones and their measured site-potential tree heights:

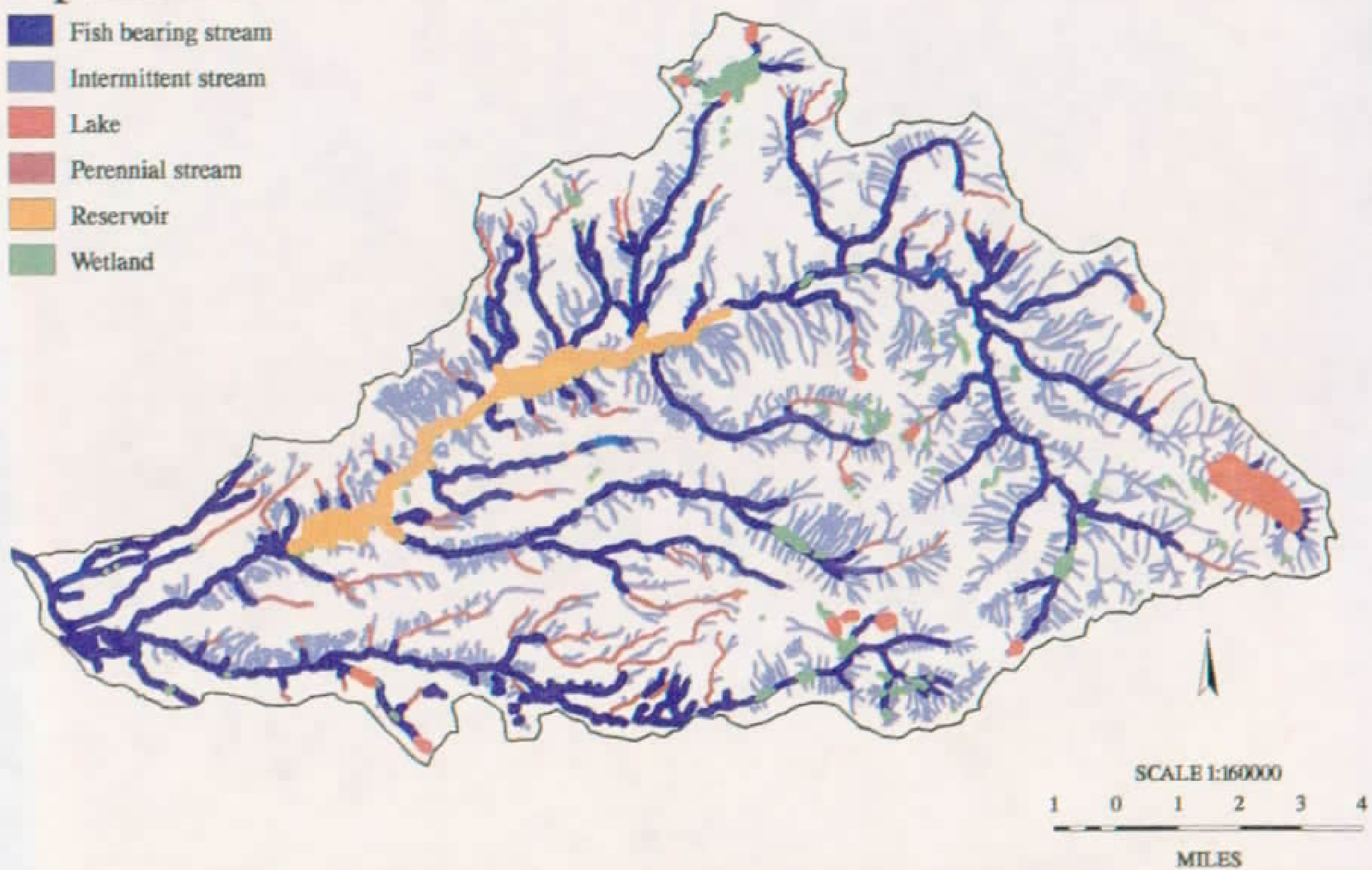
- Western Hemlock Zone -- Douglas-fir measured tree height 210'
- Pacific Silver Fir Zone -- Douglas-fir measured tree height 170'
- Mountain Hemlock Zone -- Use defaults from the ROD.

Table 2-4 -- Interim Riparian Reserve Widths

STREAM/RIPARIAN ZONE TYPE	WESTERN HEMLOCK ZONE	PACIFIC SILVER FIR ZONE	MOUNTAIN HEMLOCK ZONE
Fish bearing streams (uses two site-potential tree heights)	420'/side 840' total	340'/side 680' total	300'/side 600' total
Non-fish bearing, permanently flowing streams (uses one site-potential tree height)	210'/side 420' total	170'/side 340' total	150'/side 300' total
Seasonally flowing or intermittent streams (uses one site potential tree height)	210'/side 420' total	170'/side 340' total	100'/side 200' total
Lakes and natural ponds (uses two site potential tree heights)	420' surrounding	340' surrounding	300' surrounding
Wetlands, reservoirs (uses one site-potential tree height)	210' surrounding	170' surrounding	150' surrounding
Unstable and potentially unstable areas (uses one site-potential tree height)	210' surrounding	170' surrounding	100' surrounding

Figure 2-4 -- Riparian Reserve Network, displays the Riparian Reserves of the Bull Run Watershed. *(Riparian Reserves are a federal land allocation only, although displayed in this map on private lands as well.)*

Bull Run Watershed
Riparian Reserve Network



Key Watersheds

In addition to land allocations, the Aquatic Conservation Strategy (ACS) focuses on maintaining and restoring ecosystem health at the watershed and landscape scales to protect fish habitat and other riparian-dependent resources. The strategy consists of four components: Key Watersheds, Riparian Reserves, Watershed Restoration, and Watershed Analysis. These components provide the land management agencies with the tools to maintain and restore the productivity and resiliency of riparian and aquatic ecosystems. (Objectives of the Aquatic Conservation Strategy are listed in the ROD, page B-11.)

As a component of the ACS, Key Watersheds overlay the land allocations of designated areas and Matrix, and place additional management direction and analysis on activities in those areas. Key Watersheds serve as refugia for maintaining and recovering habitat for at-risk stocks of anadromous salmonids and resident fish species. These refugia include high quality habitat as well as degraded habitat with high potential for restoration (ROD B-18).

Tier 1 Key Watersheds were selected for directly contributing to anadromous salmonid and bull trout conservation.

Tier 2 Key Watersheds were selected as sources of high quality waters and may not contain at-risk fish stocks (ROD B-19). The majority (78,467 acres) of the Bull Run Watershed is Tier 2 Key Watershed. The lower end of the watershed, below Headworks on the Bull Run River and below the diversion on the Little Sandy River, is a non-Key Watershed.

The management emphasis within Key Watersheds is to reduce existing system and non-system road mileage, and to receive priority for restoration.

Chapter 3

Key Question Development

Chapter 3

Key Question Development

One of the first steps in the Watershed Analysis process is to identify key attributes most relevant to management questions, human values, and resource conditions within the watershed.

A key attribute was identified as:

- Having a stature in the watershed that we cannot ignore.
- An item of administrative or legislative significance (i.e. species addressed under the Endangered Species Act).
- Tied to the Northwest Forest Plan.
- Distinct or unique at the watershed, basin, or provincial scale.

Identified key attributes are then formulated into more specific Key Questions to help focus the analysis. These Key Questions are designed to:

- Focus on ecosystem elements that influence and are influenced by potential management activities
- Be measured at the watershed scale
- Promote integration among elements
- Be answered during watershed analysis.

The Key Questions are then answered based on indicators most commonly used to measure or interpret ecosystem processes and conditions. For synthesis, these processes and conditions are analyzed and presented under the same Key Question in Chapter 6.

The Watershed Analysis team held a work meeting on Dec. 11, 1995 with Zigzag Ranger District resource specialists and stewards, and members of the Portland Water Bureau and US Fish & Wildlife Service to develop a set of draft key questions and other items to consider during the analysis. These were presented for additional review at a public meeting in January and at a Water Quality Advisory Committee meeting. The final list of Key Questions includes revisions derived from this public input.

Key Questions and Rationale

Key Question #1: How do conditions of the watershed contribute to habitat needs for species of concern associated with aquatic, riparian, terrestrial and special habitats?

Rationale: The Northwest Forest Plan directs Watershed Analysis to characterize the aquatic, riparian and terrestrial features within a watershed (ROD p. 10, B-20 and B-21). Watershed analysis is also expected to address implementation of the Aquatic Conservation Strategy and species of concern in riparian and aquatic habitats. Species of concern include species listed as Threatened, Endangered, or Sensitive, as well as Survey and Manage species (ROD p. C-4). Watershed analysis is one of the principle analyses to meet ecosystem management objectives of the ROD standard and guidelines (ROD E-20). As such it addresses beneficial uses such as dispersal habitat and locally significant habitats ROD E-21).

Key Question #2: How do conditions of the watershed affect the ability to meet the Aquatic Conservation Strategy Objectives?

Rationale: The Aquatic Conservation Strategy (ROD p B-9) was developed to protect fish and other riparian dependent resources and species. Under the Aquatic Conservation Strategy, the Bull Run and Little Sandy Watersheds have been designated ***Tier 2 Key Watersheds***, sources of high quality water. The Watershed Analysis process is also required to provide the basis for determining riparian reserves, and to develop the baseline from which to assess maintaining or restoring the watershed's existing condition (ROD page B-10 and B-12).

Key Question #3: How do conditions of the watershed influence habitat for species dependent on late-successional habitat?

Rationale: Impetus to evaluate this Key Question comes from the Northwest Forest Plan and the extent of late-successional habitat within the Bull Run Watershed. More than one-half of the Bull Run watershed is comprised of the Late-Successional Reserve land allocation. The Northwest Forest Plan designates Late-Successional Reserves as areas to protect and enhance old-growth forest ecosystems to serve as habitat for late-successional and old-growth related species, including the northern spotted owl (ROD p. A-4).

Key Question #4: How do conditions of the watershed affect the capabilities of the Bull Run Watershed Management Unit to meet the principle management objective of Public Law 95-200, as set forth in the Mt. Hood Forest Plan?

Rationale: Public Law (PL) 95-200 required and established the Bull Run Watershed Management Unit and The Bull Run Planning Unit Land Management Plan. The plan was completed in 1979 and incorporated into the 1991 Mt. Hood Forest Plan. PL 95-200 designates the principle management objective of the Bull Run Watershed Management Unit as the continued production of "pure, clear, raw, potable" water for municipal use. Management direction for this objective comes from the 1979 Plan.

Key Question #5: What is the relationship between land allocations, watershed conditions, and commodity production for: timber and other wood products, plant materials, and minerals?

Rationale: There are approximately 301 acres within the Little Sandy Watershed where timber production is the primary emphasis (C1 lands). There are an additional 6575 acres in the Little Sandy Watershed where timber production is a secondary management objective (Mt. Hood Forest Plan allocations DC1, B2, B10). The Northwest Forest Plan land allocations and standards and guidelines provide for a steady supply of timber sales and non-timber resources that can be sustained over the long term without degrading the health of the forest or other environmental resources (ROD p.3). The Northwest Forest Plan responds to multiple needs, of which the two primary needs are for forest habitat and forest products (ROD p.25).

Key Question #6: What is the road network that supports the existing infrastructure and long-term management needs? How do the conditions of the watershed affect the road network?

Rationale: The infrastructure within the Bull Run watershed includes water storage reservoirs, water supply conduits, hydroelectric plants, powerline and utility corridors, and roads. A Key Watershed guideline is to reduce the existing road mileage through road decommissioning (ROD B-19). The Watershed Analysis will evaluate -- at the landscape level -- the road system necessary to maintain the existing infrastructure, and will also meet the objectives for watershed restoration from the Northwest Forest Plan.

Chapter 4

Current Conditions and Trends

Chapter 4 -- Current Conditions and Trends

This Chapter describes the condition of the Bull Run Watershed in terms of the processes and functions critical to addressing the Key Questions.

Included is a description of the watershed's existing condition, the range of natural variation, and trends based on current management direction. How conditions have changed over time as a result of human influence and natural disturbances is also documented.

Throughout this section standard analysis methods were used to ensure scientific credibility and to integrate with other watershed analysis processes. These analysis methods and techniques are widely accepted by local resource specialists. Analysis methods were incorporated from Section II of Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis, Analysis Methods and Techniques, Version 2.2 and Washington Forest Practices Standard Methodology for Conducting Watershed Analysis, Version 2.2. Other terrestrial analysis methods are described or referenced in the text. Methodologies are incorporated by reference, therefore the original source should be consulted for more information on individual methods.

Social/Historical

Social expectations regarding the Bull Run Watershed are perhaps best summarized by the requirements of Public Law 95-200 which established the Bull Run Management Unit in 1977. It designated the watershed's principal management objective as the continued production of "pure, clear, raw, potable" water for the City of Portland and adjacent municipalities. A great amount of history belies this concise, single, overriding objective for an otherwise complex -- publicly popular, yet for the most part ironically unseen -- ecosystem.

Early Conservation/Bull Run Forest Reserve

The protection of the Bull Run Watershed is directly linked to the establishment of the first national forest reserves in Oregon. During the late 1800s a budding conservation awareness was blossoming across the United States. This preservation recognition was most likely nurtured by the witness of increased extraction of commodities from public lands, as well as the evidence of overgrazing on these lands.

Public-owned forests were beginning to be identified as resources worthy of protection for a variety of values (Pinchot, 1947). Thus in 1892, U.S. President Benjamin Harrison created the Bull Run Forest Reserve -- Oregon's first National Forest -- to protect the watershed as the proposed future source of Portland's drinking water. The Bull Run Forest Reserve later merged with the Cascade Range Forest Reserve, a portion of which eventually became the Mount Hood National Forest.

Meanwhile, in this country, Manifest Destiny had run its course. The Oregon pioneers had reached the Pacific Ocean. Our final frontier had been realized. A growing cognizance was most likely occurring concerning at least a theoretical limit to what the natural ecosystem could continue to provide without adverse impacts. This insight might have been the stimulus for Portland's founders' visionary action to ensure pure drinking water. For, by the mid-1880s, the value of a pristine source of water was painfully clear to Portland's populace (Harmon, 1995). Personal wells had been contaminated, the impacts of urban development had caused Caruthers and Balch creeks to be abandoned as water sources, and the Willamette River had become polluted. Therefore, as in other growing cities at this same time a non-threatened natural source for clean water was sought -- and found. Since January 2, 1985, water has flowed from the Bull Run to the City of Portland and has remained Portland's primary source of drinking water. Raw water quality is exceptional, with a chemical make-up close to rainfall.

Cultural Heritage

Even though the archaeological and ethnographic record for the Bull Run Watershed area is limited, the region was most likely used seasonally by the original indigenous people for berry harvest, collection of cedar bark, medicinal sites, and anadromous fisheries.

In 1843, the great immigration to the Oregon territory began. The Barlow Road, located south of the watershed, was constructed in 1845 which basically was a one-way east to west route that delivered pioneer emigrants to the rich agricultural lands of the Willamette River valley. Some however chose to settle lands along the trail adjacent to the watershed. These early homesteads were minimal in size and scope in relationship to the watershed ecosystem.

In 1851, Portland was incorporated and received its charter from the state legislature. Portlanders received their water exclusively from wells until the mid 1850's and then from surface water from the Willamette River or local creeks. In the 1880's, the idyllic environs of Bull Run became the focus of a quest to procuring a superior source of water (Short, 1983). The natural purity of Bull Run water has been revered by many since it first flowed into the City of Portland in 1985.

The first legislative effort to protect Bull Run occurred in 1904 with "The Trespass Act" which restricts access to the Bull Run Watershed. Watershed protection is, and continues to be, a tradition for this resource. This tradition of watershed protection and reverence for Bull Run water form a cultural heritage.

While the general public has been officially excluded from the Bull Run Watershed for almost a century, its management activities -- including fire prevention, timber harvest, and water supply -- have provided a cultural legacy.

Today's water system in the watershed include Bull Run Lake, (first dam and dike completed in 1917), Dam 1, (completed in 1929), Dam 2, (completed in 1962), and three 26-mile long conduits which bring water to Portland by gravity flow. Two hydroelectric plants are located below Bull Run Dams 1 and 2.

Lookouts were constructed across the watershed to help detect wildfire. The remaining historic Hickman Butte Lookout was completed in 1952, while its original predecessor was built in 1931. The lookouts that once stood on Hiyu Mountain, Aschoff Butte, and Big Bend Mountain were destroyed in the 1960s.

In addition, Forest Service guard stations were once located in Latourell Prairie and Walker Prairie. Remains of a trail shelter and cabin dating back to the 1920s have also been identified near the headwaters of Falls Creek. The once-standing Little Sandy River Guard Station was constructed in 1908, two years before today's historic Zigzag Ranger Station was built.

A 1912 USGS map shows a Forest Service cabin located near Bull Run Lake. Gifford Pinchot, first Forest Service Chief, visited the lake in 1905. While the first Bull Run water flowed into the City of Portland's system in 1895, it wasn't until 1915 that Bull Run Lake became utilized as a water storage facility for the city. That year, construction began on a low timber and rock-filled dam across the lake's natural high-water outlet, and also on an earth-fill dike located in the lake's northwest corner. Three City of Portland-owned buildings remain at the lake today -- testimony to the historic use of Bull Run Lake as a water storage supply facility.

From the 1880s to the 1930s, the Bridal Veil Lumber Company conducted railroad logging operations in the Gordon Creek drainage and adjacent Larch Mountain. This railroad logging also extended to the headwaters of Bear and Cougar creeks within the Bull Run Watershed. In 1958 a major timber harvest and road construction program was launched inside the watershed's National Forest lands that continued into the 1960s.

Bull Run Hydroelectric Project

In 1907 the Forest Service issued the Mt. Hood Railway and Power Company a "special privilege agreement" for operation of the Bull Run Hydroelectric Project. The agreement allowed construction of a conduit to transport water diverted from the Little Sandy River to a power plant for operation of the company's electric railroad. The company eventually merged with a predecessor of the Portland General Electric Corporation (PGE), which now maintains the hydroelectric project's facilities and operation. Initial power generation began in 1912 using Little Sandy River water. Construction of the Sandy River diversion dam, canals, tunnels, and historic flume was completed the following year.

Today, as originally designed, flows are diverted on the Sandy River at Marmot Dam (Figure 4-33). This diverted water flows through a complex series of concrete canals and lengthy tunnels toward the Little Sandy Dam on the Little Sandy River. Sandy River water is then combined with water in the Little Sandy River for a short distance, after which both river flows are diverted into a wooden box flume. The diverted water flows for three miles in this flume before discharging into the human-made 140-acre Roslyn Lake. From Roslyn Lake, water flows to the Bull Run Powerhouse and into the Bull Run River.

In addition, surplus water has been purchased from the City of Portland since 1958. This water is diverted from Bull Run reservoirs into Roslyn Lake, adding additional power generation.

The Bull Run Hydroelectric Project generates about 102,040 megawatt hours (MWh) per year. This average annual power generation from the Bull Run Hydroelectric Project provides enough electrical energy to supply the needs of more than 8,000 average PGE households for an entire year (PGE, 1995). The Federal Energy Regulatory Commission (FERC) reissued the Bull Run Project license in 1980. The license expires in 2004.

City of Portland Hydroelectric Power

The City of Portland has two hydroelectric power plants located below Bull Run Dams 1 and 2. In an average year, the plants generate about 83,237 megawatt hours (MWh). This average annual power generation from the City of Portland's Hydroelectric Project provides enough electrical energy to supply the needs of more than 6,000 average households for an entire year. The hydroelectric plants operate under a license from the Federal Energy Regulatory Commission, as well as permits from certain State of Oregon agencies. The FERC license expires in 2029. Portland General Electric maintains and operates the hydropower facilities, and purchases the output of the generators.

Water Rights

Bull Run River -- In 1886, the City of Portland filed a water rights registration with the Oregon Water Resources Department claiming: "full flow of the Bull Run River or as much as the City shall need into the indefinite future." In addition, the Oregon Legislature has granted the City of Portland "exclusive use to the waters of the Bull Run River." Beside the City's, no other known water rights exist on the Bull Run River.

Little Sandy River -- The City of Portland and PGE both filed water rights registration statements in 1992 for water from the Little Sandy River. PGE bases its claim on a 1906 notice of appropriation and subsequent development and operation of the company's (existing) Little Sandy River diversion project, which provides water to Roslyn Lake and PGE's Bull Run Hydroelectric Project. The City bases its claim on the enactment of the 1892 Bull Run Forest Reserve, which included much of the Little Sandy River. The City asserts that the creation of the Reserve for the purpose of protecting its water supply produced a unique federal reserved water right on the Little Sandy (as well as the Bull Run). To date, however, the City has not developed any projects to divert water from the Little Sandy River.

Similar to the Bull Run River, the Oregon Legislature has also granted the City of Portland exclusive use of Little Sandy River waters -- subject only to rights vested prior to February 1909. PGE claims water rights to the river prior to 1909. No other competing Little Sandy River water claims exist. The validity of the City and PGE claims will be determined in the future, either in a formal adjudication for the Sandy Basin, or in direct litigation or negotiation between the two parties.

City Council Resolutions

The Portland metropolitan area public's obvious and implied social expectation for the Bull Run Watershed is the continued availability and supply of high-quality potable water. Accordingly, a general expectation exists that all land management activities within the watershed will ensure the production of high-quality water. For more than 100 years, the City of Portland has had a policy position supporting protection and management of the Bull Run Watershed and surrounding area, including the Little Sandy. In recent years, the Portland City Council is on record numerous times supporting cessation of timber harvest activities in the Bull Run and Little Sandy watersheds. This record includes the following resolutions.

Passed in October 1993, Resolution No. 35203 requests Congress to enact protective legislation to increase the size and revise the Bull Run Management Unit. This requested legislation would direct the federal government to cease and prohibit all commercial and non-commercial timber harvest and any activity not intended to maintain or enhance water quality or quantity within the expanded management unit. The Resolution requests that the Bull Run Management Unit include additional physical buffers to protect the quality and quantity of Bull Run River and Little Sandy River waters (approximately thirteen square miles around the Little Sandy and eastern portion of the Bull Run drainage).

In December 1995, the Portland City Council also adopted Resolution No. 35477 to provide further input to the Regional Water Supply Planning process. Within this resolution, the City: rated raw water quality as its most important water policy value, resolved to maintain a key leadership role in protecting the Bull Run and Little Sandy watersheds, and confirmed its responsibility to "secure maximum protection for the Bull Run and Little Sandy watersheds."

In November 1996, the Portland City Council adopted Ordinance No. 170721 which authorized the City to join the Regional Water Providers Consortium and to endorse the Regional Water Supply Plan of October 1996. This ordinance reiterated the City's support for previous resolutions, including Resolution Nos. 35203 and 35477 described above. It also confirmed the Council's commitment that Portland retail customer's sole source of potable drinking water is the Bull Run with the exception of seasonal and emergency supplements.

Watershed Analysis is a tool for implementing the Northwest Forest Plan and its existing land allocations. It therefore considers public desires for future conditions within the framework of the standards and guidelines of the Northwest Forest Plan, the Mt. Hood Forest Plan, and laws regulating usage in the area including PL95-200 and the Oregon Resource Conservation Act. This Watershed Analysis, as previously stated, is not a decision document. Rather, it provides a technical assessment of watershed conditions and provides recommendations at the landscape level to improve aquatic and terrestrial conditions. It is not within the scope of the watershed analysis to change land allocations. For these reasons, Resolution 35203 and its provisions are not further addressed in this document.

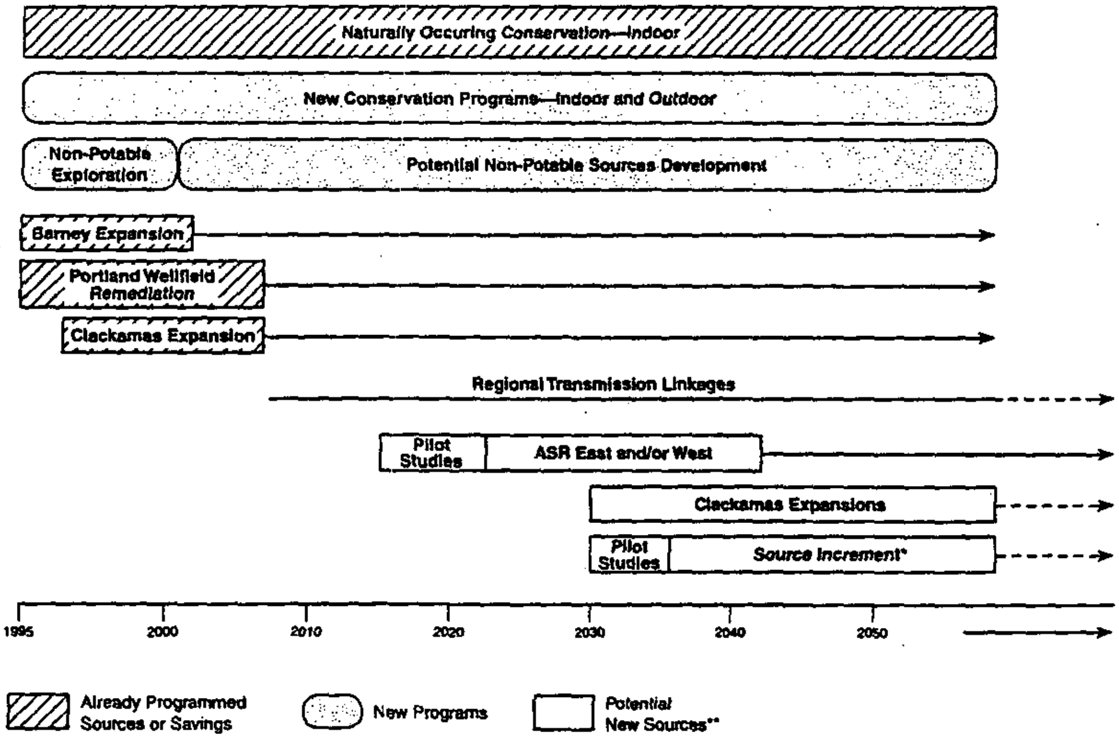
The City of Portland and its Water Quality Advisory Committee, as well as several other groups and individuals, provided watershed analysis review comments that the Forest Service should adhere to City Council Resolution 35203 and prohibit timber harvesting in the Little Sandy Watershed. The Little Sandy Study, as required by the Oregon Resource Conservation Act, will provide both legislative and regulatory recommendations from the Secretary of Agriculture to Congress on future management of the Little Sandy Watershed that is within the Bull Run Watershed Management Unit. Public recommendations for this study will be from two sources: the City of Portland through its Water Quality Advisory Committee and public input to that advisory committee; and from the Willamette Provincial Advisory Committee (PAC). The PAC is a public advisory group sanctioned by the Federal Advisory Committee Act and includes members of local, state, tribal and federal governments, as well as citizens representing a broad variety of interests.

Potential New Water Supply Sources

The Regional Water Supply Plan Final Report (Oct. 1996) and proposed revisions was co-sponsored by the water providers of the Portland metropolitan area. The plan contains water resource strategies which include in general chronological order:

- New water conservation programs (with a focus on outdoor uses).
- Non-potable sources development, exploration, and water recycling.
- Expansion of Barney Reservoir (Trask/Tualatin System).
- Columbia South Shore well field remediation.
- Clackamas River use expansions.
- Regional water supply transmission linkages.
- Aquifer storage and recovery.
- Second-phase Clackamas River use expansions.
- Pilot studies of, and potential additional new supply from the Bull Run, Columbia, and/or Willamette rivers.

Recommended Resource Strategy—
Regional Water Supply Plan



*Last Source Increment is unidentified, but could be Bull Run, Columbia, or Willamette

- - -➤ *Option may not be needed until after 2050*

**The need and timing for the *Potential New Sources* will depend on factors such as growth of demand, the need to meet all hottest peak events, transmission, small source development, and the actual savings due to conservation programs and development of non-potable sources. The time bands represent the possible years within which these sources might be needed and developed.

The representative site for potential new storage in the Bull Run is located upstream from the existing Reservoir No. 1. This representative site for a potential third reservoir is located on the Bull Run River, approximately 0.4 miles downstream from its confluence with Log Creek. The report indicates that, based on preliminary geotechnical, economic, and environmental assessments, the Log Creek site seems to provide some key advantages over other locations. (Regional Water Supply Plan, Final Report, Oct. 1996.) However, additional siting analysis would need to be performed before an actual site would be selected.

As identified in the City of Portland's interim report "Bull Run Dam No. 3 -- Preliminary Site Selection Evaluation of Potential Dam Sites" (Squier Associates, 1994), the potential Log Creek storage facility would be a 400-foot high dam that could impound a total storage volume of 67,520 acre-feet -- or 22 billion gallons. The proposed reservoir would have a maximum surface area of 466 acres at its 2,000-foot spillway elevation.

As of 1996, actual long-term future regional water supply source selection (Bull Run Watershed, Willamette or Columbia rivers) has been deferred to allow participating agencies to develop additional water quality and environmental information. The Little Sandy River is not included in the final resource strategy of the current Water Supply Plan, which is projected to the year 2050. It is identified in the plan for protection as a potential future source.

The need for longer-term, additional potential new sources, such as Bull Run Reservoir #3, may not be needed until after 2035. The Regional Water Supply Plan also indicates additional Bull Run supply can be obtained through filtration that would amount to a maximum peak day capacity of 35 to 45 million gallons per day. This would be approximately 3.5 to 4.5 billion gallons storage over a 90 to 100 day drawdown period. (Water Source Option Study, City of Portland, Water Bureau, February 1992.)

Meanwhile, specific Bull Run Watershed implementation activities proposed in the Regional Water Supply Plan include advocating protection of both the Bull Run and Little Sandy basins as potential long-term water supply sources.

Geology

This section discusses the role of geology in the watershed and its contribution to hillslope and stream geomorphology. From the geology and slope mapping, landform units were created that describe the role of surface erosion and mass wasting in the watershed. Additionally, The reflection of hillslope processes on channel morphology and condition are evaluated.

Geologic Units

The geology of the Bull Run Watershed is well documented. This Watershed Analysis draws upon the previous geologic mapping of Beaulieu (1974) as modified by Schulz (1980). Additional mapping by Sherrod (1989) in the Bull Run Lake area was also used. Geologic contacts in the Little Sandy River valley area based on the morphology and mapping by Meyer (1979).

The following nine major geologic units (listed here from oldest to youngest) comprise the watershed:

Columbia River Basalts (Tcr)

This unit, the oldest in the watershed, is primarily exposed in the gently sloping valley bottom of the mainstem Bull Run River in the central part of the watershed, and in the steep lower valley walls of the upper Bull Run River and Blazed Alder Creek drainages. The basalt flows are resistant to fluvial erosion and function as an erosional "floor" in this watershed. The Columbia River Basalt flows originated in northeastern Oregon and partially filled an ancestral channel of the Columbia River near the Bull Run River's present location.

Rhododendron Formation (Tmpr)

The pyroclastic flows of the Rhododendron Formation filled topographic depressions on the eroded surface of the Columbia River Basalts. Rock types include laharic breccia, tuff, pyroclastic breccia, and lapilli tuffs. Most of the Rhododendron Formation material is highly altered and weakly resistant to erosion. The breccias contain widespread red clay pods and the matrix material of all the rock types weathers to clay. An exception is the well-cemented cliff-forming laharic breccias of the lower Bull Run River and Little Sandy River valleys. Elsewhere, this geologic unit is exposed discontinuously in the moderately sloped lower valley walls of the Bull Run River, the Little Sandy River, and Blazed Alder Creek. The Rhododendron Formation originated as pyroclastic flows and lahars from ancestral Cascade volcanoes.

Troutdale Formation (Tpt)

The Troutdale Formation overlies the Rhododendron Formation in the extreme western portion of the watershed, west of the confluence of the Little Sandy River and the Bull Run River. This sedimentary formation contains siltstone, sandstone, and conglomerate with an estimated total thickness of 200 feet. These fluvial deposits are derived from the erosion of local volcanic rocks (Tpv) and metamorphic sources east of the Cascades. The Troutdale Formation forms steep valley walls.

Pliocene volcanics (Tpv)

Basaltic andesite lava flows and minor flow breccias of the Pliocene volcanic rock unit cover about 75 percent of the Bull Run Watershed. This unit caps the Rhododendron Formation in the watershed's western portion. Erosion and landsliding of the Rhododendron Formation has undercut the Pliocene volcanic rocks, resulting in valley sideslopes that steepen upwards. Above the valleys, the flows form relatively thin and gently sloping lava plains. In the eastern part of the watershed, the Pliocene volcanic rocks are more than 2000 feet thick. They have been steepened and modified by glacial and fluvial erosion to form rugged mountains and ridges. Presumably, the source of the lava flows was near the watershed's eastern boundary. While the lava flows are resistant to erosion, the flow breccias -- which measure up to 50-feet thick -- partially weather to clay and are not resistant to erosion.

Quaternary volcanic - intrusive complex (Qvic)

Three mountains in the southeast portion of the watershed, Blazed Alder Butte, Halfway Hill, and Burnt Peak, were constructed by recent andesite flows and possibly volcanic plugs. This Quaternary volcanic-intrusive complex consists primarily of andesite flows and minor andesite breccia. These rocks are well-indurated and are resistant to erosion.

Quaternary cinder cones (Qcc)

Three cinder cones have been mapped in the watershed: an unnamed topographic high in Walker Prairie, and both of the Aschoff Buttes. The bedded cinders are poorly consolidated and easily eroded.

Quaternary terraces (Qtg)

Large Quaternary-age terraces are present in the lower Little Sandy River drainage and along the Bull Run River west of its confluence with the Little Sandy River. These erosional terraces were formed by recent downcutting of these rivers, most likely during a time of much higher runoff associated with melting glaciers in the eastern part of the watershed. Some terraces are now 500 feet above the present river channels. The flat terraces are mantled with gravel and sand deposits.

Quaternary landslides (Qls)

Large Quaternary-age landslide deposits dominate the lower Bull Run River valley's northern valley walls. The material in these landslide deposits is usually weathered Rhododendron Formation with some rafted material from the overlying Pliocene volcanic rocks. Other large, old landslide deposits have been mapped in the North Fork of the Bull Run River valley and in the upper Bull Run River valley. The upper Bull Run River valley landslide deposit has formed a natural dam that created or possibly enlarged a preexisting Bull Run Lake. Landslide deposits are generally moderately sloped, with many surface irregularities.

Quaternary alluvial deposits (Qal)

Recent alluvial deposits are mapped at the mouth of the Bull Run River. Elsewhere, recent alluvial deposits are too small and too narrow to display on maps. Alluvium consists of unconsolidated gravel, sand, and silt.

Glaciation

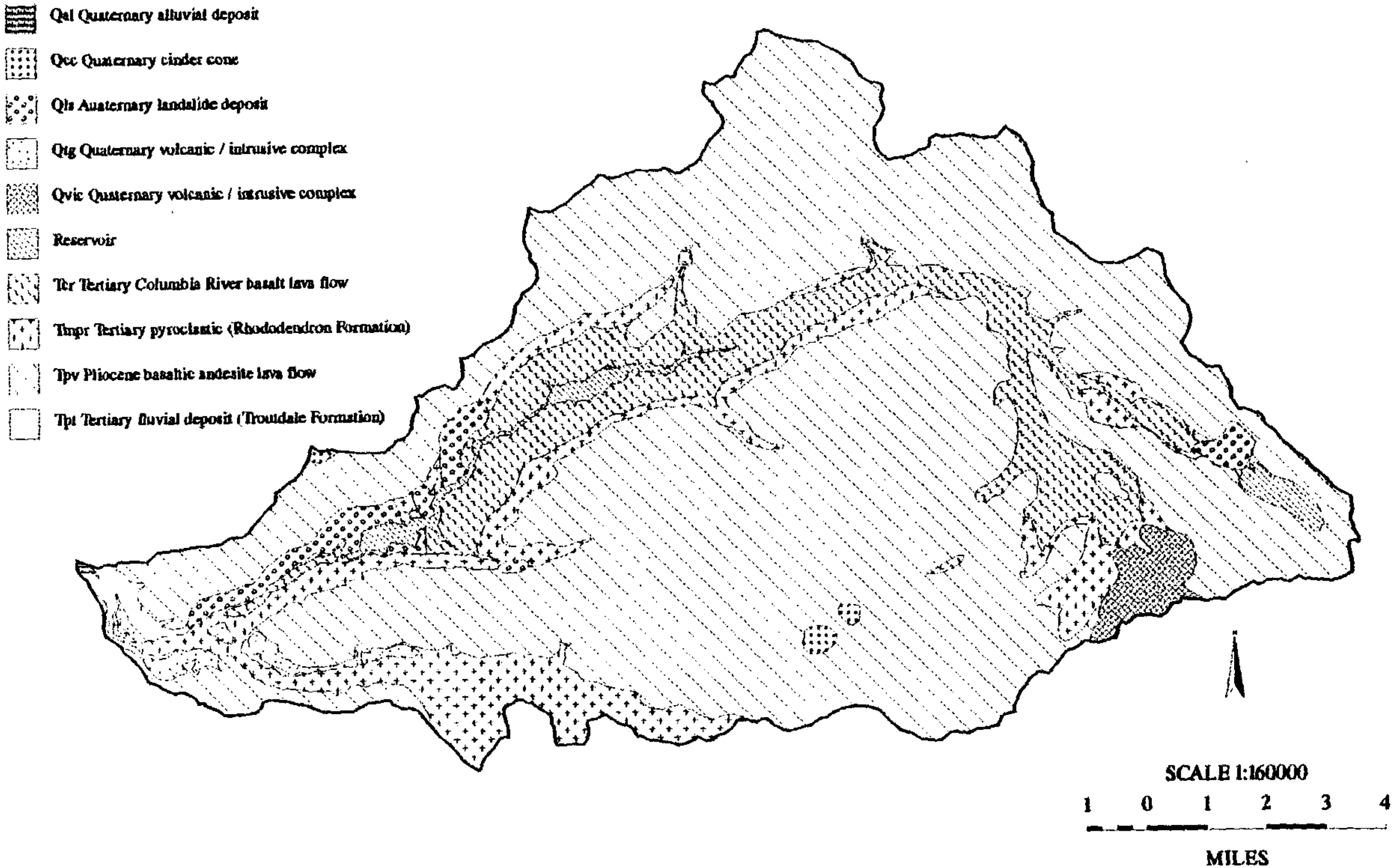
Only very small scattered glacial deposits have been previously mapped in this watershed. Glacial deposits are not displayed on this chapter's geology map. The extent of glaciation within the watershed varies with source consulted. The upper Bull Run River and Cedar Creek valleys seem to have been enlarged and modified by large valley glaciers, probably more than 70,000 years ago.

Many classically shaped alpine glacial cirques are located in the watershed's eastern portion, including the cirques at the headwaters regions of Log Creek, Hickman Creek, North Hickman Creek, Nanny Creek, and two at the headwater regions of Fir Creek. In addition, well-developed alpine glacial cirques are found at the headwater regions of some unnamed creeks: two on the north side of Big Bend Mountain, one on the north side of North Mountain, and one 1.2 miles northwest of Thimble Mountain.

All are northeast to northwest facing cirques that were probably occupied by ice during the last ice age, approximately 20,000 years ago. The cirque floor elevations range from 3000 to 3700 feet. In the eastern portion of the watershed, headwater regions with aspects other than northeast-to-northwest received a preponderance of direct sunlight which prevented the formation of glaciers large enough to create a classically shaped cirque.

In the western portion of the watershed, elevations were not sufficient to maintain a year-round snowpack at any aspect.

Bull Run Watershed Geology



Hillslope Geomorphology

Landforms

For analysis purposes, the geologic units were broadly grouped into 10 landform types based on resistance to weathering, slope angle, drainage density and susceptibility to landsliding. The bedrock geology units Tcr, Tpv, and Qvic were classified as "resistant". The bedrock geology units Tmpr and Tpt were classified as "weak". Three slope classes (0-25%, 26-50%, 50%+) were used to further stratify the bedrock geology units (Figure 4-2). The surficial geology units are all unconsolidated material. Because of their narrow range of slopes, the surficial units were designated as individual landform types. This grouping facilitates analysis based on similar geologic features. Landform characteristics are summarized in Table 4-1.

Figure 4-2 – Slope Gradient illustrates the slope classes in the watershed. Steep slopes (those greater than 50% gradient) encompass less than one-tenth of the entire watershed area. Slopes less than 25% dominate, comprising over one-half of the watershed area.

Figure 4-2 – Slope Gradient

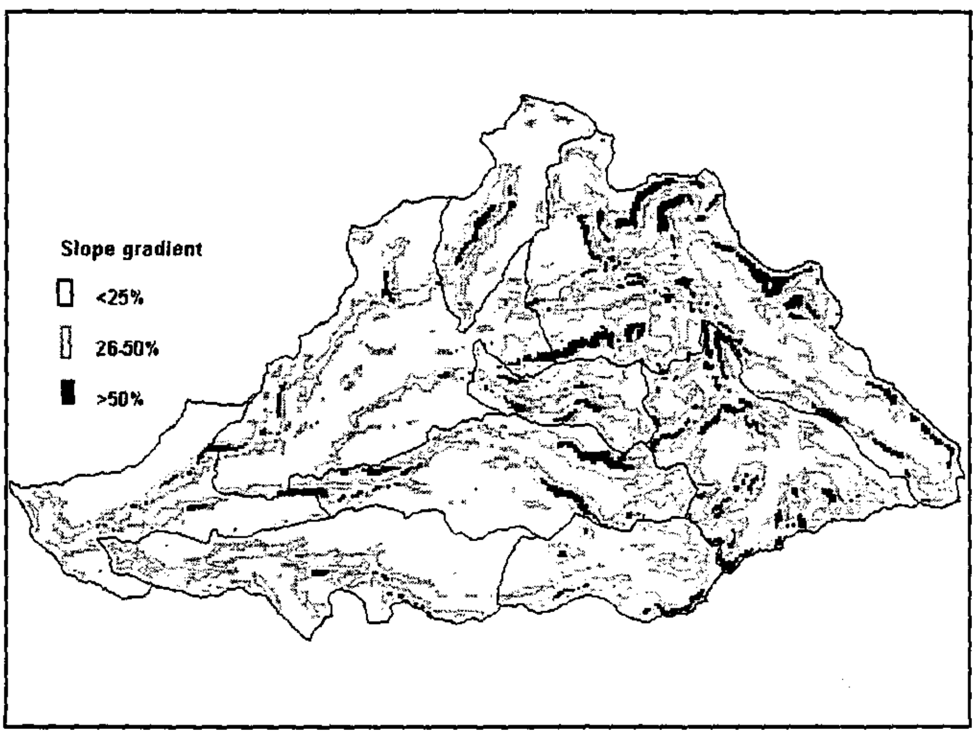


Table 4-1 – Landform Characteristics

Landform unit	Geologic type	Physical characteristics
Resistant rock steep slopes (RRSS)	Columbia River basalts, Pliocene volcanics (platy andesite, minor basalt and breccia), Quaternary volcanic-intrusive complex (andesite flows and minor flow breccias).	Slope angles typically exceed 50%. Found on steep tributary sideslopes and headwalls throughout the watershed.
Resistant rock moderate slopes (RRMS)	Columbia River basalts, Pliocene volcanics (platy andesite, minor basalt and breccia), Quaternary volcanic-intrusive complex (andesite flows and minor flow breccias).	Slopes range from 26-50%. Generally found on mid-lower slope positions throughout the watershed.
Resistant rock gentle slopes (RRGS)	Columbia River basalts, Pliocene volcanics (platy andesite, minor basalt and breccia), Quaternary volcanic-intrusive complex (andesite flows and minor flow breccias).	Slopes range from 0-25%. The most common landform in the watershed, RRGS are located on all slope positions throughout the watershed.
Weak rock steep slopes (WRSS)	Tuff, lapilli tuff, laharic breccia and pyroclastic breccia; fluvial conglomerate, sandstone and micaceous sandstone	Slope angles typically exceed 50%. Located on steeply sloping canyon walls of the lower Little Sandy river, Cedar creek and lower South Fork Bull Run river.
Weak rock moderate slopes (WRMS)	Tuff, lapilli tuff, laharic breccia and pyroclastic breccia; fluvial conglomerate, sandstone and micaceous sandstone	Slopes range from 26-50%. Found on mid-lower slope positions in the Bull Run river and Little Sandy rivers and in the Hickman creek drainage.
Weak rock gentle slopes (WRGS)	Tuff, lapilli tuff, laharic breccia and pyroclastic breccia; fluvial conglomerate, sandstone and micaceous sandstone	Slopes range from 0-25%. Located on midslopes of the Bull Run river and Camp creek, and on north facing valley walls in the Little Sandy drainage.
Cinder Cones (Qcc)	Unconsolidated bedded cinders	Slopes range from 20-60% Located within the watershed at Aschoff Buttes and an unnamed topographic high in Walker Prairie.
Terrace Gravels (Qtg)	Unconsolidated surficial sand and gravel deposits (perhaps glaciofluvial in origin)	Slopes range from 0-10%. Present in the lower Little Sandy river drainage and along the Bull Run river west of its confluence with the Little Sandy.
Quaternary Landslide Deposits (Qls)	Unconsolidated surficial deposits of debris from ancient landslides	Slopes range from 10-60%. Predominantly located on the northern valley walls of the lower Bull Run river valley also found in the North Fork and upper Bull Run valleys.
Alluvium (Qal)	Unconsolidated deposits of gravel, sand and silt.	Slopes range from 0-10%. Found in a small area at the mouth of the Bull Run river.

Bull Run Watershed Landforms

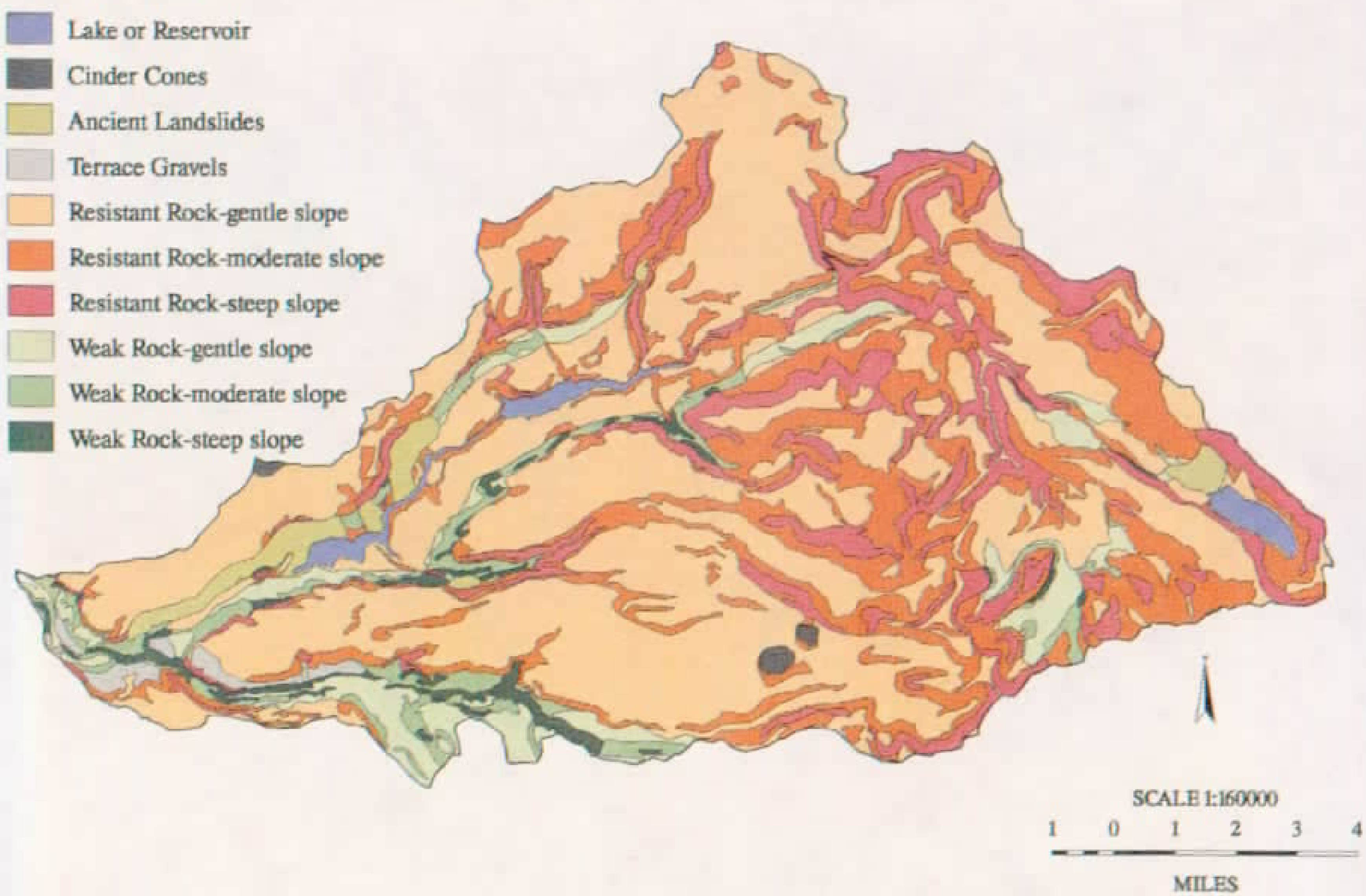


Figure 4-3 -- Landforms of the Bull Run Watershed is similar to the landform maps produced for other Mt. Hood National Forest watersheds. Landform types can be used to represent areas of approximately equal mass wasting potential and sediment delivery potential in watersheds. This methodology assures comparison between watersheds on the forest. Table 4-2 (below) uses the landform mapping to compare the landslide potential of the Bull Run watershed to other watersheds in the Sandy Basin.

The Bull Run Watershed is characterized by a low landslide frequency. When compared to other areas in the Pacific Northwest, it is considered relatively stable geologically (Schulz, M.G. 1980).

Table 4-2 -- Landslide Potential -- Sandy Basin Watersheds (percent of watershed)

WATERSHED	HIGH	MODERATE	LOW
Bull Run / Little Sandy	17%	27%	55%
Salmon River	62%	18%	20%
Zigzag River	20%	35%	45%

[Note: Additional information on the landform based method of rating landslide potential can be found in the Analysis File.]

Landslide Research in the Bull Run

A research effort by Schulz in 1980 produced a landslide hazard rating similar to landslide potential. Important differences exist however, between the Schulz slope hazard ratings and the landform-based landslide potential ratings. The Schulz system was developed as part of a research project in one watershed and is based on many factors determined from detailed field work in specific parts of the Bull Run watershed. Schulz focused on known unstable areas. The Schulz slope hazard map is much more detailed in some portions of the watershed (near main drainages and roads, for instance) than others. Schulz's findings are useful to hillslope specialists examining the ground in detail during project-level planning or site-specific analysis.

Results of the Schulz investigation are presented in the following sections.

Schulz Landslide Hazard

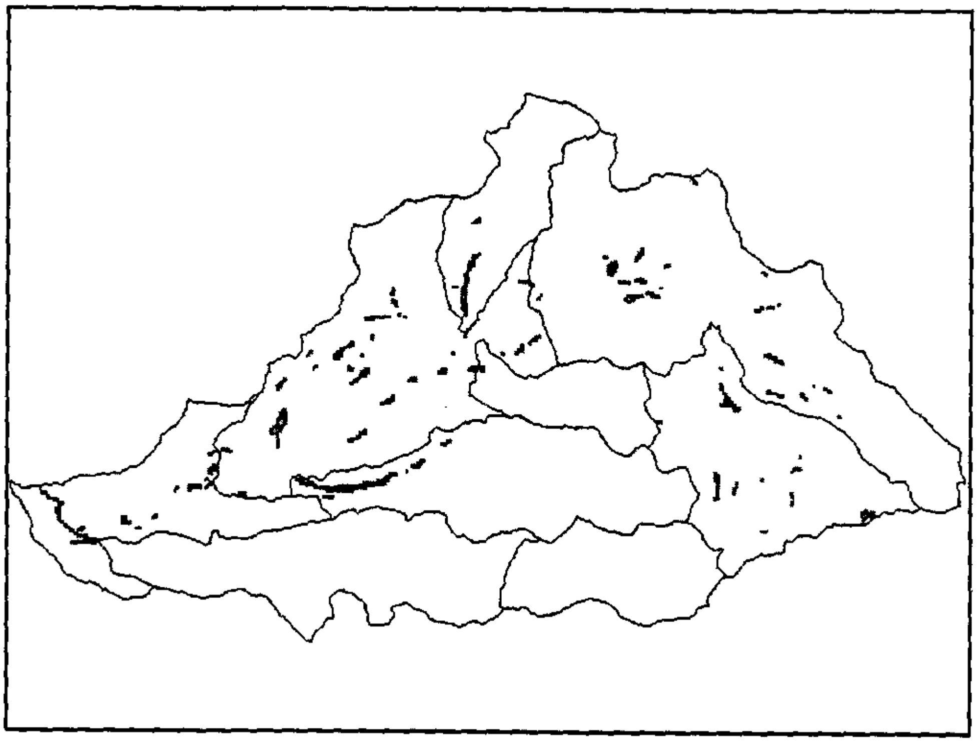
Schulz (1980) inventoried 86 landslides within the Bull Run Watershed Management Unit. In his semi-quantitative study, Schulz used chi-square tests and multiple regression analysis to establish the relative importance of certain geologic factors to mass movement occurrence within this watershed. Schulz summed the weighting points for all the geologic factors present in a given area and produced a mass movement hazard map for the Bull Run Watershed Management Unit.

Schulz used a three-tier hazard rating system (high, medium, low) and classified shallow landslides (debris slide / debris flow) and deep-seated landslides (slump / earthflow) (see Table 4-3). Figure 4-4 combines the shallow and deep landslide ratings for an overall landslide hazard. Those areas with a high landslide hazard rating are shown in Figure 4-4. For the watershed analysis, the Schulz landslide hazard rating was extrapolated outside of the Bull Run Watershed Management Unit to include the entire watershed analysis area.

Table 4-3 -- Schulz Landslide Hazard

DEBRIS SLIDE / DEBRIS FLOW HAZARD	SLUMP EARTHFLOW HAZARD	ACRES	% OF WATERSHED
HIGH	HIGH	264	< 1
HIGH	MODERATE	539	< 1
HIGH	LOW	121	< 1
MODERATE	HIGH	213	< 1
MODERATE	MODERATE	6,832	8
MODERATE	LOW	12,674	16
LOW	HIGH	84	< 1
LOW	MODERATE	4,537	6
LOW	LOW	55,685	69

Figure 4-4 -- Schulz (1980): High Landslide Hazard



Sediment Production

This section describes the principle hillslope processes contributing sediment to the watershed: mass wasting, surface erosion and disturbed lands such as harvest areas and roads. The methods used to assess hillslope processes are standard procedures and are described or referenced below. Watershed wide conclusions regarding the ***relative*** role of mass wasting, surface erosion and disturbed lands in sediment production are summarized at the end of the Hillslope Geomorphology section. Additionally, the role of stream channels in sediment production and delivery are discussed later in Chapter 4.

In using standard methods for evaluating hillslope erosion processes, there are inherent limitations in ***actual*** quantitative comparison between sources (mass wasting, disturbed sites, stream channels). Additionally, accurate conversion of modeled rates of sediment yield to water quality parameters is unreliable.

Mass Wasting

Schulz found the greatest density of slump-earthflows on the Rhododendron Formation, and the greatest density of debris slides on shallow soils in steep canyons formed by Columbia River Basalt. Contacts between geologic units were found to be particularly susceptible to mass movements. Additionally, Schulz reported that weathering of pyroclastic material (such as the Rhododendron Formation) produced zones of clay-rich material that increased the incidence of mass wasting.

The Schulz map accurately noted slope instability that was activated by the November 1995 and February 1996 storm events. All known landslides within the watershed resulting from these storm events occurred on areas mapped by Schulz as "high" hazard.

Sites affected by landslides following these storm events include: the slides at the water supply conduit and West Branch Falls creek (November storm event), and three road-related failures along the 10 Road, below headworks in the Lower Bull Run subwatershed (February storm event).

Surface erosion from landslide scars can deliver fine particles to the stream for many years. Landslide mapping of the Bull Run Watershed by Schulz identified less than 2 percent of the total watershed area in a high landslide hazard rating.

Surface erosion

Surface erosion in forested watersheds has been attributed to exposed and compacted surfaces where mineral soil has been disturbed. Timber harvest, prescribed fire, and road construction are common forest practices that can increase surface erosion rates in forested watersheds.

Field reconnaissance in the Bull Run Watershed by LaHusen (1994) found that stream channel processes were the dominant sources of sediment in the watershed. (See also Chapter 4, Stream Geomorphology, Stream Stability). In contrast, roads and harvest units were not found to be large contributors to the watershed's sediment budget. One exception noted by LaHusen, however, were steep, unvegetated road cuts adjacent to stream crossings.

For this Watershed Analysis, the potential surface erosion from roads and recent harvest units was modeled. Methods used to evaluate the potential for altered surface erosion rates within the watershed closely follow those described in the Washington Forest Practices Board Manual: *Standard Methodology for Conducting Watershed Analysis* (DNR, 1993).

The objective of this methodology as applied to the watershed analysis is to evaluate and document the relative potential for sediment delivery from roads and harvest units and to prioritize activities and locations for restoration.

While this method is based on the current scientific understanding of forest management and watershed processes, its predicted outputs should not be considered as exacting measures of potential sediment yield but instead provide a framework for understanding relative effects of different management activities in the watershed and a comparison of sediment delivery rates among subwatersheds.

Extent of unvegetated road cuts was estimated from aerial photos and erosion control reports.

Natural or undisturbed rates of erosion for the landforms within the watershed are unknown. Swanson and Grant (1982), estimated surface erosion rates for forested areas as low, 0.007 tons/acre/year. Therefore, surface erosion and sediment delivery estimated in this methodology could be considered and increase due to recent management activities. Results of the modeled erosion rates from harvest and roads are presented below.

Harvest

Site recovery following disturbance to surface soils varies within the watershed. On the more productive sites, vegetative recovery is rapid, resulting in a one-to-two-year potential for surface erosion following activities such as timber harvest or broadcast burning. In other areas, recovery of effective ground cover to prevent surface erosion may take up to five years. While forest practices may expose soil to erosive forces, the mechanisms of transport and delivery to stream channels must be engaged to successfully affect water quality. Where vegetated buffer strips are left in place along stream channels, effective filtering of eroded material can limit impacts to water quality.

Harvest adjacent to streams during the last five years was used to approximate erosion rates in Table 4-5-- Summary of Estimated Sediment Yield.

Even as calculated erosion rates from harvest units are low, this method likely over estimates sediment delivery to streams from harvest. This occurs because this method was not able to separate out harvest units that included riparian buffers. In reality, most of the units logged inside the Bull Run Watershed during the last five years *did* include effective riparian buffers. Riparian buffer effectiveness was slightly compromised on skyline harvest units where yarding corridors intersected the buffer, and where blowdown was retrieved from the riparian area.

Roads

Research on the effects of forest roads on surface erosion concludes that paving roads effectively prevents sediment production from road surfaces (Reid and Dunne, 1994; Burroughs and King, 1989). Approximately 50 percent of the watershed's road miles are covered with pavement (asphalt-concrete and bituminous surface treatment -- see Table 4-4-- Road Surface Types in the Bull Run Watershed). Another 32 percent are surfaced with aggregate. Depending on depth and quality of the aggregate, Burroughs and King (1989) found that aggregate surfacing can reduce erosion from roadbeds by up to 79 percent.

Table 4-4-- Road Surface Types in the Bull Run Watershed

ROAD SURFACE	MILES
Asphalt - Concrete	158.74
Aggregate	102.98
Improved	.15
Native	31.42
Bituminous surface treatment	5.06
NO DATA	22.05

Table 4-5-- Summary of Estimated Sediment Yield

SUBWATERSHED	HARVEST (tons/year)	ROADS (tons/year)	TOTAL (tons/yr)
Blazed Alder	.59	34.15	34.74
Bull Run	.90	119.31	120.21
Fir Creek		.45	.45
Headworks		79.17	81.69
Lower Bull Run	1.49	33.90	35.39
Lower Little Sandy	2.39	24.02	26.41
North Fork		20.86	20.86
South Fork		16.77	16.77
Upper Little Sandy		15.29	15.29
Watershed Total	5.37	343.91	349.28

Table 4-4 summarizes the modeled rates of road surface erosion and transport within the watershed. Because vegetation is actively reestablishing on the watershed's lightly traveled road surfaces, the modeled rates of surface erosion from roads likely overestimates actual rates of erosion.

A comparison of similarly modeled erosion rates for other watersheds within the basin is outlined in Table 4-7. When considered on a per-area basis, modeled rates of road erosion in the Bull Run Watershed are on an order of magnitude less than the other Sandy Basin watersheds that have been analyzed. In addition, unlike the Bull Run, the other watersheds have more erosive geology and their road construction practices do not include as extensive road surface paving or erosion control practices.

Table 4-6-- Road Related Sediment Contribution by Subwatershed

SUBWATERSHED	TOTAL ROAD MILES	ROAD DENSITY	ROAD MILES WITHIN 300 FEET OF STREAMS	ESTIMATED ROAD SEDIMENT (tons/year)
Blazed Alder	26.93	1.65	14.21	34.15
Bull Run	53.06	1.69	23.28	119.31
Fir Creek	2.85	.49	.71	.45
Headworks	80.28	3.25	41.27	79.17
Lower Bull Run	26.23	2.20	21.99	33.90
Lower Little Sandy	48.54	3.02	33.89	24.02
North Fork	22.67	2.72	5.31	20.86
South Fork	32.27	2.05	12.27	16.77
Upper Little Sandy	27.38	3.13	9.65	15.29
Watershed Total	320.21	2.30	162.58	343.91

Table 4-7 --Sandy Basin Road Erosion

WATERSHED	WATERSHED ACRES	TOTAL ROAD MILES	ROAD MILES WITHIN 300 FEET OF STREAMS	ESTIMATED ROAD SEDIMENT (tons/year)	ROAD SEDIMENT PER UNIT AREA (tons/acre/year)
Salmon	74,240	150.01	38.44	1832	.02
Zigzag	37,730	80.01	34.78	1349	.04
Bull Run	88,947	320.20	98.48	344	.004

Conclusions: Hillslope Geomorphology

- The proportion of unstable lands within the watershed are low (2-17%).
- Surface erosion from undisturbed forest lands is low.
- Modeled (DNR) and observed rates (LaHusen) of surface erosion from disturbed forest lands within the watershed are low.
- In the Bull Run Watershed, road surfacing and intensive erosion control practices on road cuts within the watershed have been effective at limiting erosion from roads whereas in other forested watersheds, roads are often a principal source of accelerated mass wasting and surface erosion.
- Prior road construction practices have contributed to a minor increase in acres of unstable lands through road-adjacent landslides. The effects to water quality in the water supply drainage however, have been limited.

"Eventually, all things merge into one, and a river runs through it.
The river was cut by the world's great flood
and runs over rocks from the basement of time.
It sings a song of wisdom and life far greater than man can hear."

Norman Maclean

Stream Geomorphology

Channel morphology and condition reflect the input of sediment, water, and wood to the channel, relative of the channel's ability to either transport or store these inputs (Sullivan et al., 1987). Systematic and local differences in transport capacity, coupled with the nature and magnitude of inputs through a channel network, result in a distribution of different channel types throughout a channel network. This reflects spatial differences in channel slope, flow, depth, sediment supply, and the availability of large woody debris. Because of these differences, certain channels are more or less sensitive to similar changes in these input factors (Washington Department of Natural Resources [DNR], 1993).

Stream Stability

To estimate stream stability, the stream's layer was intersected with underlying geology. The combination of streams and associated geology was used to estimate the stream stability with respect to in-stream erosional processes. This assessment includes all stream orders.

In a study completed by the U.S. Geological Survey that assessed variations in stream turbidity within the Bull Run Watershed (LaHusen 1994), it was determined that the most visible sites of erosion are stream channels, streambanks, and roadside ditches. Loose, unconsolidated deposits (such as glacial tills, volcanic tuffs, and breccias) were identified as active sources of turbidity which cause in-stream suspended sediment. Much of the total length of Bull Run Watershed stream channels are incised into massive and competent flows of andesite and basalt. Accordingly, episodes of streamside mass wasting will probably be limited to sections of stream channels in the Rhododendron Formation. In addition, accelerated erosion of unconsolidated and unprotected streambanks can persist for prolonged periods (LaHusen, 1994).

Table 4-8 -- Streambank and Inner Gorge Failure Potential

	Stream Gradient			
Associated Geology[1]	0-2	2.1-4	4.1-10	>10
QAL (alluvial deposits)	Moderate			
QCC (cinder cones)				High
QLS (Quaternary-age landslide deposits)	Moderate	Moderate	High	High
QTG (Quaternary-age terrace)	Moderate	Moderate	High	High
QVIC (Quaternary volcanic-intrusive complex)	Low	Low	Low	Low
RES (reservoir)	Low	Low	Low	Low
TCR (Columbia River Basalt)	Low	Low	Low	Low
TMPR (Rhododendron Formation)	High	High	High	High
TPT (Troutdale Formation)	High	High	High	High
TPV (Pliocene volcanic rock unit)	Low	Low	Low	Low

Within the Bull Run Watershed, the erodibility of the geologic unit serves as the primary factor that controls stream stability. The Columbia River Basalt and andesite flows associated with the QVIC and TPV are resistant to fluvial erosion and are considered very stable. The Rhododendron Formation is easily erodible, is subject to mass wasting, and is therefore considered unstable. In addition, the Troutdale Formation is easily eroded and considered unstable. The Quaternary-age landslide deposits and terraces are considered moderately stable at low stream gradients, and unstable at higher stream gradients.

The unstable stream channels are considered sensitive to disturbances associated with altered streamflows and to sediment inputs with the potential to alter in-stream erosional processes. Once these unstable channels are disturbed, accelerated erosion of unconsolidated and unprotected streambanks can persist for prolonged periods (LaHusen, 1994).

[1] From geology coverage

Bull Run Watershed
Stream Channel Stability

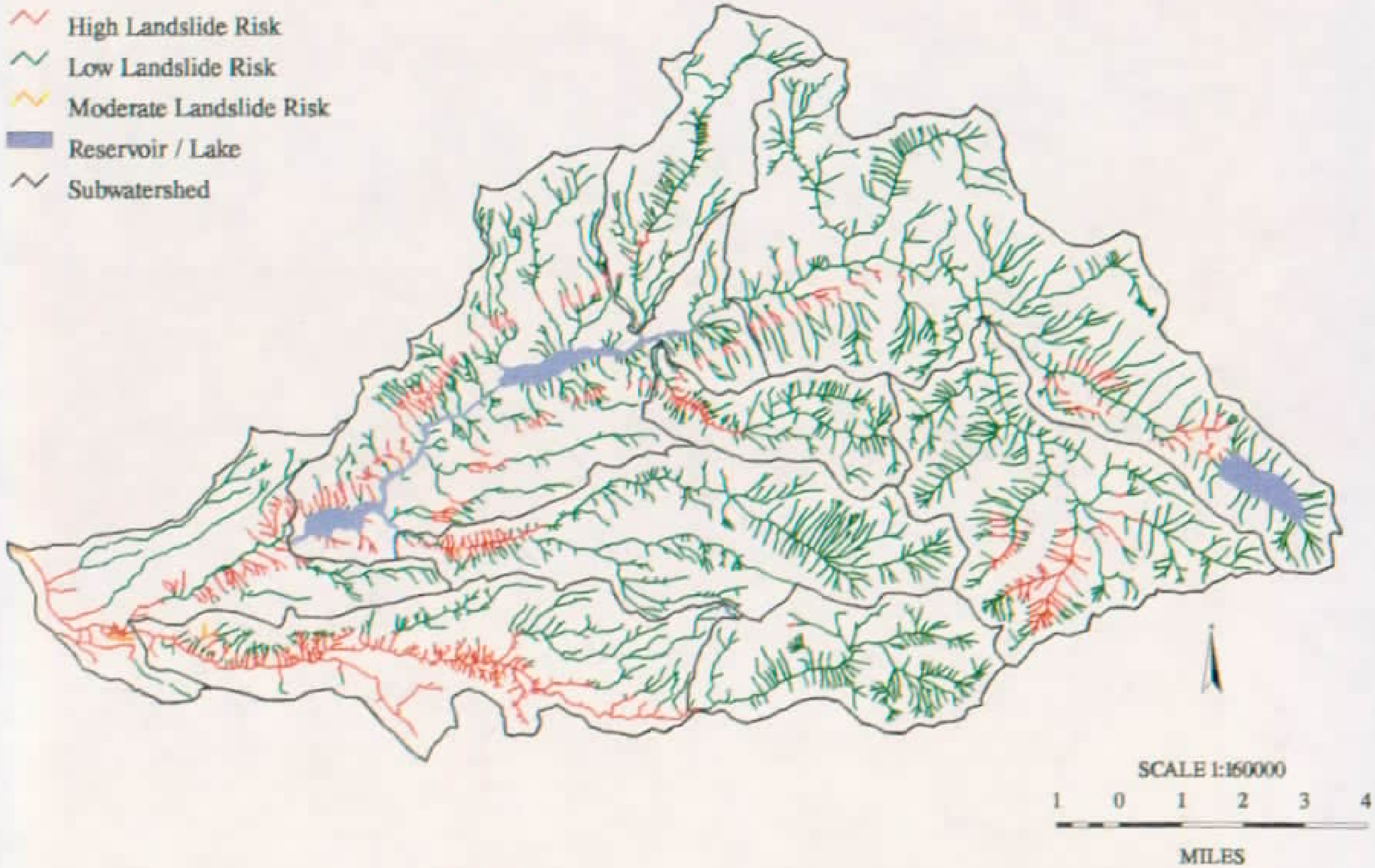
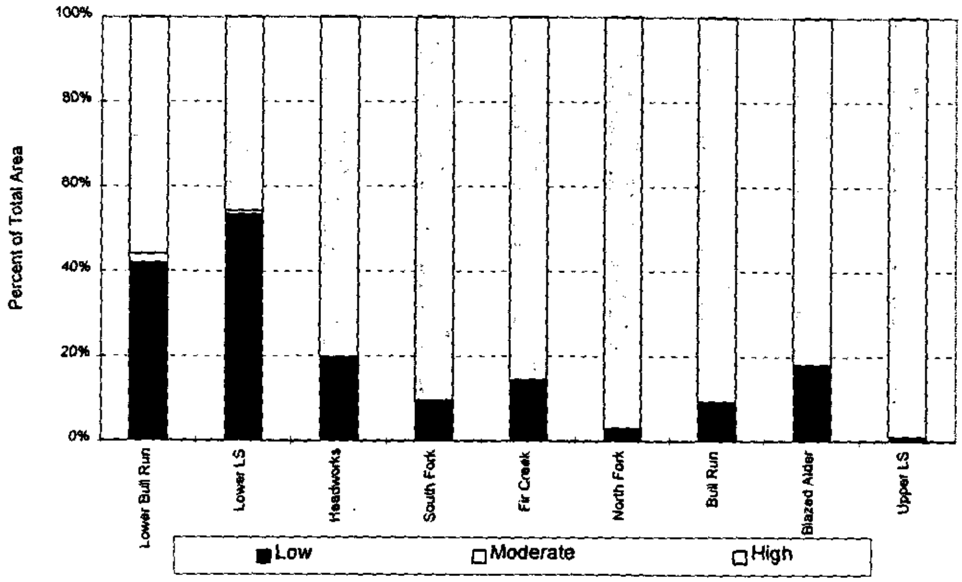


Chart 4-1 -- Stream Stability



As outlined in Figure 4-5 and Chart 4-1, the majority of the unstable stream channels are located within the watershed's lower portion. Specifically, these occur in the Lower Bull Run and Lower Little Sandy subwatersheds, with major inclusions in the lower portions of the South Fork of the Bull Run River, Cedar Creek, Fir Creek, and Hickman Creek. Additionally, it appears many of the small tributaries that drain into Reservoir 1 are also unstable channels.

It should be noted that even a small area of unstable channel can have major water quality impacts. The North Fork Subwatershed has relatively little area rated as low stability (3%). A 1972 dam-break flood caused a large debris flow into the North Fork Bull Run River. This debris flow eroded an area of unstable stream channel and caused a persistent turbidity problem in the reservoirs.

Depositional Areas

Areas of unstable stream channels with the potential to generate sediment through streambank and streambed erosion have been identified. Any sediment generated in these areas has the potential to be routed downstream to depositional stream reaches, and to thereby affect water quality and aquatic habitat.

Although stored fine-grained sediment is uncommon in the watershed's channels, some streamside deposits do exist. Alluvial flood plains and terraces exist in the wide, relatively low-gradient valley bottoms that have formed in the Bull Run Watershed by lateral erosion of relatively weak geologic formations.

For example, erodible alluvial deposits are present adjacent to small stream channels that empty into the northern portion of the upper reservoir: Five-mile Creek, Bear Creek, Deer Creek, and Cougar Creek. Cedar Creek, lower South Fork Bull Run River, and the lower segment of Fir Creek also have relatively wide valley bottoms with erodible deposits. Sediment that has been deposited during high velocity streamflows into the Bull Run Watershed lacks fine particles that may linger in suspension in reservoirs. (This sediment typically consists of sand, gravel, cobbles, and boulders.)

Weathering and soil genesis on old deposits gradually leads to accumulation of finer particles. As these deposits erode during exceptional storms, the potential severity of downstream water-quality problems increases (LaHusen, 94).

Depositional stream reaches are defined as areas with less than 2% channel gradient. Depositional stream reaches below areas of unstable stream channels are identified in Figure 4-6.

Figure 4-6 -- Potential Sediment Source Areas and Depositional Reaches

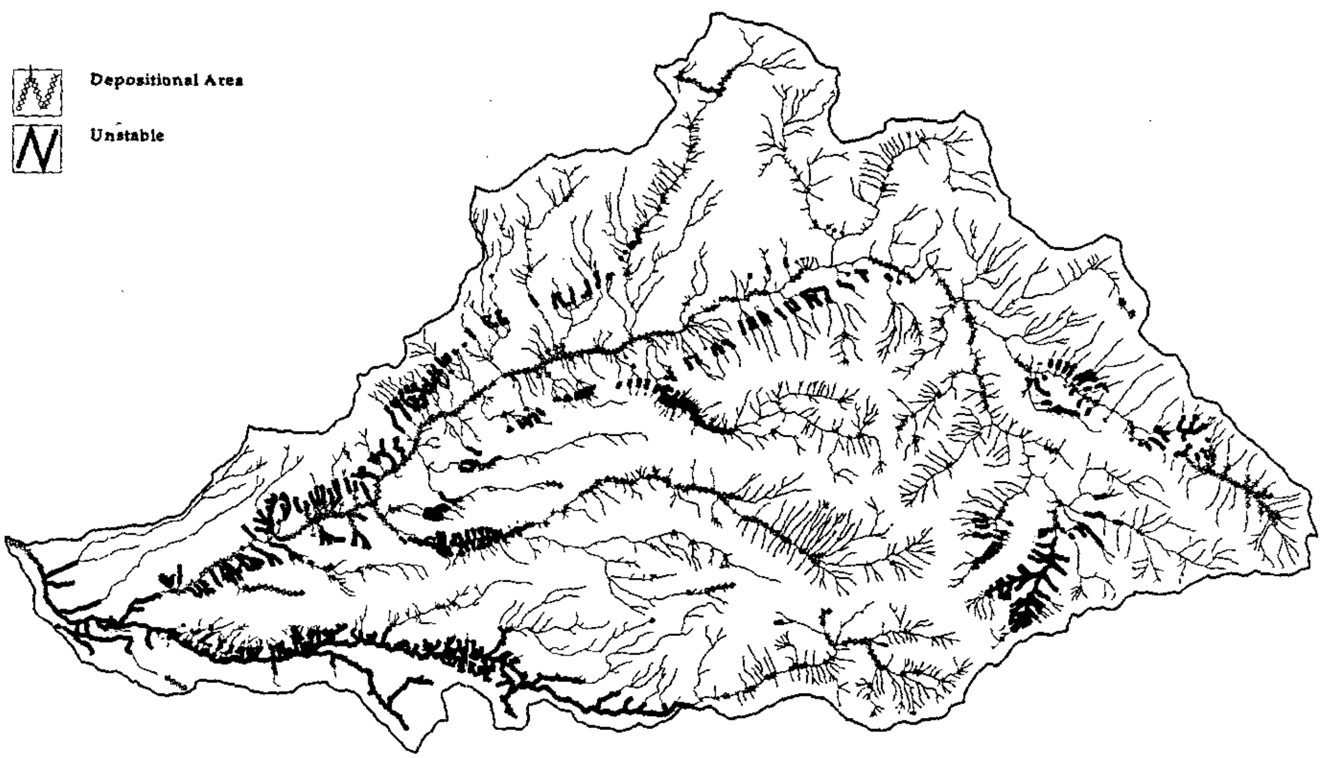


Figure 4-6 identifies major depositional areas below unstable stream reaches at the reservoirs and lower Bull Run River near the PGE powerhouse. (This situation represents potential implications for water quality and anadromous fish habitat -- discussed in this chapter's hydrology and fisheries sections.)

Conclusions Stream Geomorphology

- Much of the total length of Bull Run Watershed stream channels are incised into massive and competent flows of andesite and basalt. Accordingly, episodes of streamside mass wasting will most likely be limited to sections of stream channel within the Rhododendron Formation (LaHusen, 1994).

- Once unstable channels within the Rhodedendron formation are disturbed accelerated erosion of unconsolidated and unprotected streambanks can persist for prolonged periods (Lahusen, 1994).

Soils

"We know more about the movement of celestial bodies than about the soil underfoot."

Leonardo Da Vinci

"The history of every nation is eventually written in the way in which it cares for its soil."

President Franklin D. Roosevelt

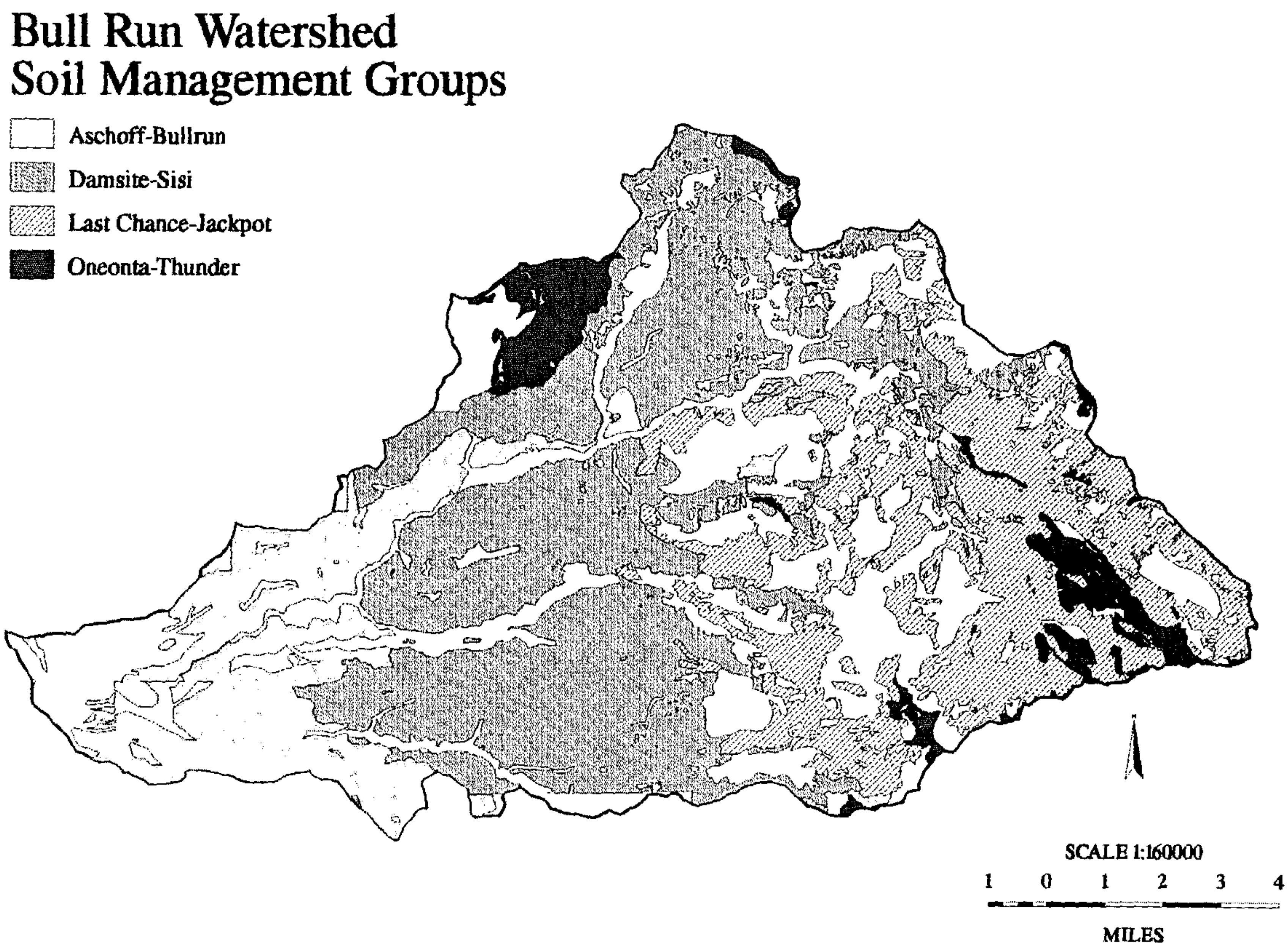
Soils in the Bull Run Watershed are influenced in part by the geologic conditions described in this chapter's previous section. In addition, topography, climate, vegetation and organic matter, and time combine to shape the soils and their development within the watershed. Soils are forming in alluvium, residuum and colluvium from volcanic rocks and glacial deposits. Deposits of volcanic ash and loess are present in the upper soil layers throughout the Bull Run Watershed.

Soil Management Groups

Thirty-five different soil types are mapped within the Watershed Analysis area. Of these, 11 soil types describe more than 80 percent of the area (Figure 4-7 -- Soil Management Groups of the Bull Run Watershed). These soil types have been grouped here by their common features and capabilities for management:

Bull Run - Aschoff

The Bull Run silt loam and the Aschoff stony loam soils are medium textured, well-drained soils forming in residuum and colluvium from basalt, andesite and volcanic breccias. They are located in the westernmost portion of the watershed at elevations up to 2000 feet within the Western Hemlock Zone. The Bull Run and Aschoff soils are found primarily on gentle sloping (5-30%), broad valley bottoms, sideslopes, and ridges. Some Bull Run soils are mapped on steeper slopes in the canyons of the South Fork and mainstem Bull Run rivers.


Bull Run Watershed
Soil Management Groups
Aschoff-Bullrun
Damsite-Sisi
Last Chance-Jackpot
Oneonta-Thunder
SCALE 1:160000
1 0 1 2 3 4
MILES

As their names imply, Bull Run silt loams differ somewhat from the Aschoff stony loams. The Aschoff soils are stony throughout with moderately deep organic horizons. The Bull Run soils lack coarse fragments and have thin organic horizons, possibly reflecting a more recent fire history.

Aschoff - Bull Run soils are very productive and comprise 13 percent of the watershed area.

Damsite - Sisi

The Damsite gravely loam and Sisi stony loam soils are medium textured, well-drained, productive soils forming in residuum and colluvium from Columbia River Basalts and Rhododendron Formation. They are located in the middle of the watershed, from 1000-4000 feet, and overlap the Western Hemlock and Pacific Silver Fir zones. The Damsite and Sisi soils are found primarily on broad, gentle slopes, (5-30%) bordered by steeper (30-80%) sideslopes.

On both the Damsite gravely loams and Sisi stony loams, coarse fragments comprise up to 40-70% of the soil volume. Damsite and Sisi soils have moderately thick to thick organic horizons (2.5-4 inches) above a well-developed topsoil.

Included within the Damsite - Sisi management group is the Headworks silt loam. Headworks soils are medium textured soils derived from loess and are found on slopes 5-30%. Headworks soils contain no stones or gravel, and have a moderately thick organic horizon above a moderately well developed topsoil.

The Damsite gravely loams, Sisi stony loams and Headworks silt loams are very productive soils and account for approximately 30 percent of the watershed area.

Last Chance - Jackpot

The Last Chance stony loam and Jackpot gravely silt loam soils are moderately well to well-drained, medium textured soils. The majority of these soils are forming in residuum and colluvium from basalts and andesites, while some areas have been altered by alpine glaciation. The Last Chance and Jackpot soils are found on mountain upslopes, sideslopes, and canyons ranging from 5-80% gradient. Last Chance and Jackpot soils are located in the eastern half of the watershed at elevations of 1000-4000 feet. Last Chance and Jackpot soils are predominantly found in the Pacific Silver Fir Zone. Some of the Jackpot soils also occur in the upper portions of the Western Hemlock Zone.

Last Chance stony loam and Jackpot silt loam soils are gravely or stony throughout the profile, containing 40-80% coarse fragments. Last Chance soils have moderately thick organic horizons (up to two-inch depth), and have root and water restrictions at 38 inches. Both soils are variable in productivity.

Last Chance and Jackpot soils comprise 16 percent and 4 percent of the watershed area respectively.

Oneonta - Thunder

The Oneonta gravely loam and Thunder angular cobbly loam soils are moderately well to well-drained, medium textured soils. These soils are forming in residuum and colluvium from basalts and andesites. The Oneonta and Thunder soils are found on gentle (generally 0-30%) upper slope positions along the watershed's north and southeast boundaries from 2000-4000 feet. Oneonta - Thunder soils overlap the Pacific Silver Fir Zone.

Oneonta gravely loams contain up to 50 percent gravels or stones and the mineral soil is covered by a thick (up to four- inch) organic horizon. Thunder angular cobbly loams contain 50-80% angular cobbles and the mineral soil is also overlain by a thick organic horizon. Oneonta and Thunder soils are shallow to fractured bedrock. Rock outcrop and rubble lands are found intermingled with these soils.

Oneonta - Thunder soils have low productivity and comprise 5 percent of the watershed area.

Talapus

Talapus gravely silt loams are moderately well-drained, medium-textured soils. They are forming in colluvium and residuum from basalt, andesite and breccias which have been altered by alpine glaciation in some areas. Talapus soils are found in the central portion of the watershed on mountain sideslopes and ridgetops at elevations of 2000-4000 feet. These soils overlap the Pacific Silver Fir Zone.

Talapus gravely silt loams contain 40-80% gravels or stones and are shallow to massive bedrock. The well-developed topsoil is covered by a moderately thick organic horizon. Small wetlands and rubble land are found within this soil map unit.

Talapus soil are moderately productive and occupy 7 percent of the watershed area.

Glacial and Rubble Lands

Glacial and rubble lands are interspersed throughout the watershed's mid and upper elevations. These lands are lacking soil development and are dominated by rock fragments.

Glacial and rubble lands comprise nearly 8 percent of the watershed area.

Other Soils

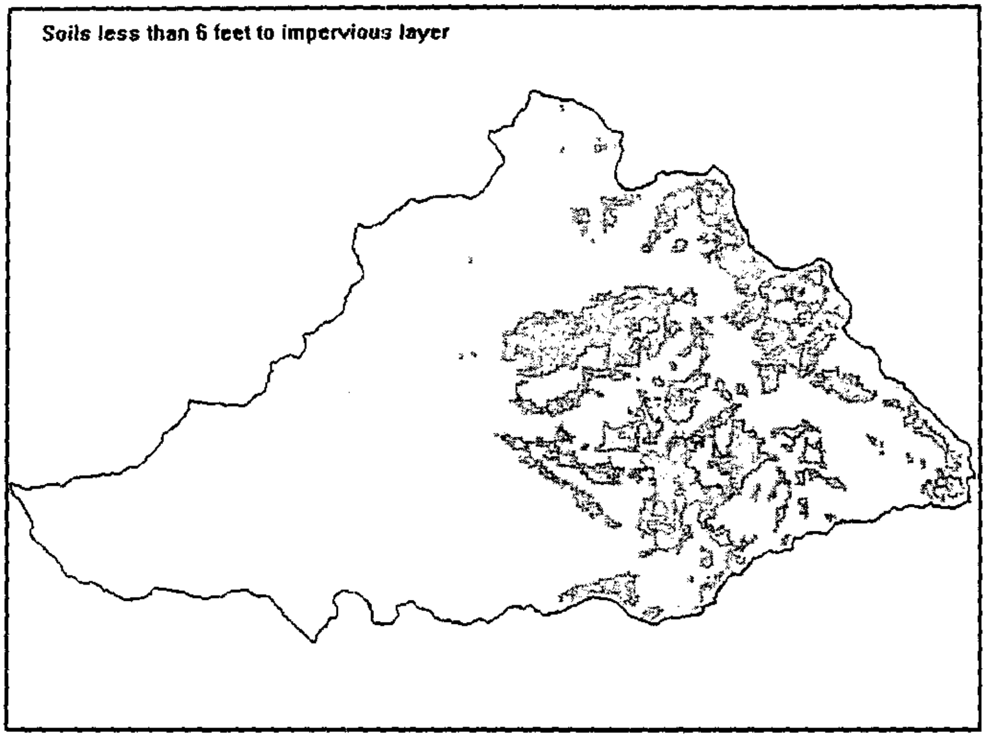
The following soils and land types are mapped within the planning area. They represent approximately 15 percent of the watershed area. More information about these soils is available in the Clackamas County Soil Survey the Multnomah County Soil Survey or the Bull Run-Little Sandy Soil Survey.

- Aslpaugh clay loam
- Basalt and Andesite rock outcrop
- Dabney loamy sand
- Delena silt loam
- Dystrochrepts, very steep
- Enola gravely silt loam
- Goodfellow gravely silt loam
- Headworks silt loam
- Hickman very gravely loam
- Hiyu gravely silt loam
- Humaquepts
- Jimbo loam, cool
- Klickitat stony loam
- Klickitat-Kinney complex
- Loamy alluvial land
- Made land
- Marsh
- Molalla cobbly loam
- Newberg fine sandy loam
- Salem silt loam
- Tuff and Breccia outcrop
- Wet loamy alluvial land
- Zygore gravely loam

Soil Attributes

Because topsoil layers in the watershed exhibit moderately well-developed structure, infiltration of surface water is rapid. Surface water infiltration rates contribute to low surface erosion potentials for many of the watershed's soils. Soils developing in glacial till in the upper valleys of Cedar Creek, Mainstem Bull Run River, and Blazed Alder Creek, exhibit perched water tables during periods of heavy winter rain. Figure 4-8 illustrates soils which may exhibit these perched water tables. With the exception of those soils forming in glacial till and steep stream adjacent slopes, soil profiles offer rooting depths greater than 40 inches.

Figure 4-8 -- Soils With Impervious Layers



Large accumulations of soil organic matter are common on soils forming in the central portion of the watershed (see Figure 4-9). Above 3000 feet, lower temperatures contribute to slower organic matter decomposition rates. Soil fertility declines in response to lower rates of nitrogen turnover associated with slower organic decomposition rates. On low sites, soil organic matter may contain up to one-half of the on-site nitrogen.

On higher sites (generally below 3000 feet), organic horizon development may be attributed to high biomass accumulation and the time elapsed since forest floor disturbance (usually fire). On high sites in the Bull Run, up to one-third of the total nitrogen may be stored in the forest floor.

Figure 4-9 – Soil Organic Horizon Depths

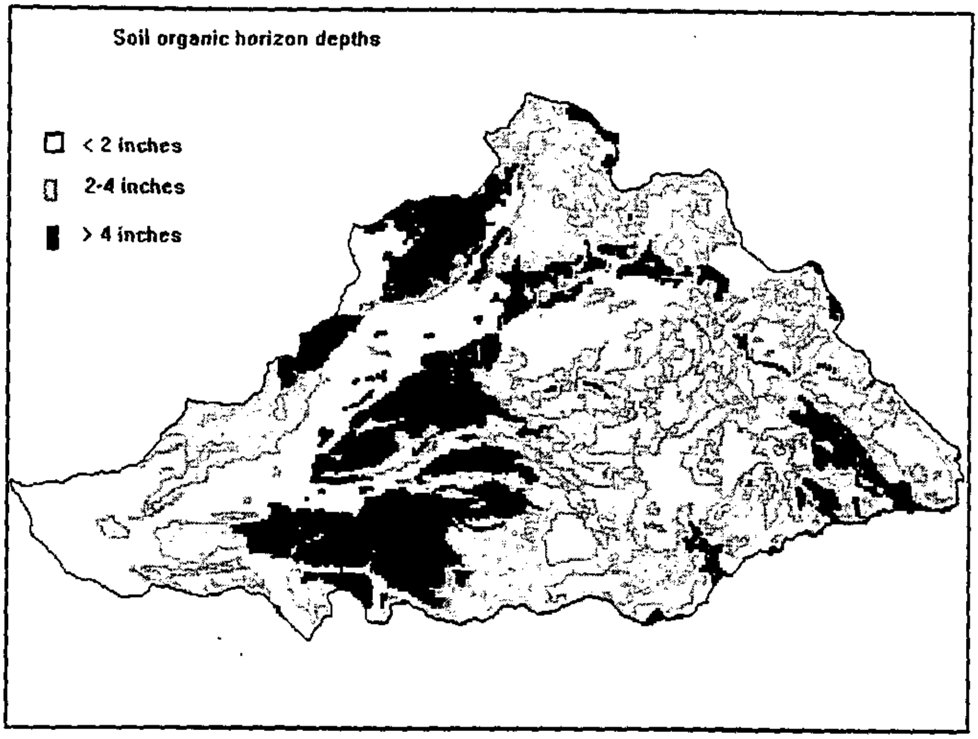


Table 4-9 summarizes properties of common soils in the Bull Run Watershed. It contains additional details of soil attributes and soil interpretations appropriate for planning within the watershed. Additional information on soil properties is available in electronic files and in *The Bull Run-Sandy Area Soil Survey* (Stephens, 1966).

Table 4-9 Properties of Common Soils in the Bull Run Watershed

Soil Name	Map Symbol	Acres	% Rock Fragments	Depth of Organic Horizon	Impervious w/in 6ft?	Surface Erosion Rating	Subsoil Erosion Rating	Compaction Hazard	Windthrow Hazard
Aschoff stony silt loam, 5-30 slopes	47G	3,394	40-70	2	N	SLIGHT	LOW	MOD.	SLIGHT
Aschoff stony silt loam, 30-60% slopes	47M	916	40-70	2	N	MOD.	LOW	MOD.	SLIGHT
Aschoff stony silt loam, 60-80% slopes	47V	42	40-70	2	N	SEVERE			
Aschoff cobbly loam, 30-60% slopes	5E (Clack.)	857		2	N	MOD.			SLIGHT
		5,209							
Bull Run silt loam		77	none	1					
Bull Run variant silt loam, 0-12% slopes	10C (Clack.)	44	none	1					
Bull Run silt loam, 3-8% slopes	5B (Mult.)	395	none	1					
Bull Run silt loam, 15-30% slopes	5D (Mult.)	1,939	none	1					
Bull Run silt loam, 5-30% slopes	37G	3,095	none	1	N	SLIGHT	HIGH	SEVERE	SLIGHT
Bull Run silt loam, 30-60% slopes	37M	361	none	1	N	MOD.	HIGH	SEVERE	SLIGHT
Bull Run silt loam, 60-90% slopes	37V	230	none	1	N	MOD.	HIGH	SEVERE	SLIGHT
		6,140							
Damsite gravelly loam 5-30% slopes	48G	8,949	40-80	4	N	SLIGHT	LOW	MOD.	SLIGHT
Damsite gravelly loam, 30-60% slopes	48M	4,036	40-80	4	N	MOD.	LOW	MOD.	SLIGHT
Damsite gravelly loam, 60-80% slopes	48V	469	40-80	4	N	SEVERE	LOW	MOD.	SLIGHT
		13,454							
Sisi stony loam, 5-30% slopes	42G	7,126	40-70	2.5	N	SLIGHT	LOW	MOD.	SLIGHT
Sisi stony loam, 30-60% slopes	42M	3,243	40-70	2.5	N	MOD.	LOW	MOD.	SLIGHT
Sisi stony loam, 60-80% slopes	42V	2,621	40-70	2.5	N	SEVERE	LOW	MOD.	MOD.
		12,989							
Last chance stony loam, 5-30% slopes	43G	7,086	50-80	2	N	SLIGHT	LOW	MOD.	SLIGHT
Last chance stony loam, 30-60%	43Ma	4,970	50-80	2	N	MOD.	LOW	MOD.	SLIGHT
Last chance stony loam, 60-80% slopes	43V	2,337	50-80	2	N	SEVERE	LOW	MOD.	SEVERE

Soil Name	Map Symbol	Acres	% Rock Fragments	Depth of Organic Horizon	Impervious w/in 6ft?	Surface Erosion Rating	Subsoil Erosion Rating	Compaction Hazard	Windthrow Hazard
		14,393							
Jackpot gravelly silt loam, 30-60% slopes	44Ma	1,522	40-75	1.5	Y	SEVERE	HIGH	SEVERE	SEVERE
Jackpot gravelly silt loam, 5-30% slopes	44G	2,398	40-75	1.5	Y	MOD.	HIGH	SEVERE	SEVERE
		3,920							
Oneonta gravelly loam, 0-30% slopes	52G	1,724	10-50	4	N	SLIGHT	LOW	MOD.	SLIGHT
Oneonta gravelly loam, 30-60% slopes	52M	72	10-50	4	N	MOD.	LOW	MOD.	MOD.
Oneonta gravelly loam, 60-80% slopes	52V	282	10-50	4	N	SEVERE	LOW	MOD.	MOD.
		2,077							
Thunder angular cobbly loam, 0-30% slopes	53G	1,153	50-80	5	N	SLIGHT	LOW	MOD.	MOD.
Thunder angular cobbly loam, 30-60% slopes	53M	496	50-80	5	N	MOD.	LOW	MOD.	MOD.
Thunder angular cobbly loam, 60-90% slopes	53V	701	50-80	5	N	SEVERE	LOW	MOD.	MOD.
		2,351							
Talapus gravelly loam, 5-30% slopes	45G	3,302	40-80	1.5	Y	SLIGHT	MOD.	SEVERE	SEVERE
Talapus gravelly loam, 30-60% slopes	45M	1,457	40-80	1.5	Y	MOD.	MOD.	SEVERE	SEVERE
Talapus gravelly loam, 60-80% slopes	45V	1,423	40-80	1.5	Y	SEVERE	MOD.	SEVERE	SEVERE
Talapus gravelly loam, 60-80% dissected	45Va	454	40-80	1.5	Y	SEVERE	MOD.	SEVERE	SEVERE
		6,637							
Glacially plucked land, 0-30% slopes	40G	193			V	SLIGHT	VARIABLE	SLIGHT-HIGH	
Glacially plucked land, 30-60% slopes	40M	736			V	MOD.	VARIABLE	SLIGHT-HIGH	
Glacial plucked land, 60%-vertical	40V	3,174			V	MOD.	VARIABLE	SLIGHT-HIGH	
		4,103							
Rubbleland	60G	32			N		LOW	SLIGHT	
Rubbleland, 10-60% slopes	60M	627			N		LOW	SLIGHT	
Rubbleland, 60-100% slopes	60V	2,248			N		LOW	SLIGHT	
		2907							

Conclusions: Soils

- The Aschoff-Bull Run and Damsite-Sisi soils are deep, medium textured and contribute to high site productivity within the watershed. The Aschoff-Bull Run and Damsite-Sisi soil groups comprise approximately 43% of the total watershed area.

- Soil properties of the Aschoff - Bull Run and Damsite - Sisi soil groups contribute to rapid infiltration of precipitation and snowmelt as well as high soil moisture storage. As a result, soils in the watershed have low surface erosion hazards when undisturbed.

- Soils in the eastern portion of the watershed, are more variable in productivity and runoff rates. Shallow, rocky soils or soils with an impervious layer near the surface may be more prone to windthrow. Disturbance of soils with a perched water table can alter subsurface hydrology and create concerns for road maintenance and runoff.

- Glacial and rubble lands and rock outcrops are interspersed throughout the upper elevations of the watershed, comprise nearly 10% of the watershed area and create diverse above and below ground habitats.

Disturbance from Fire

Fire and wind have been the major disturbance regimes affecting ecological values within the Bull Run Watershed. Individual fire events in the watershed have been documented from as many as 750 years ago (Krusemark et al, 1996).

Fire History

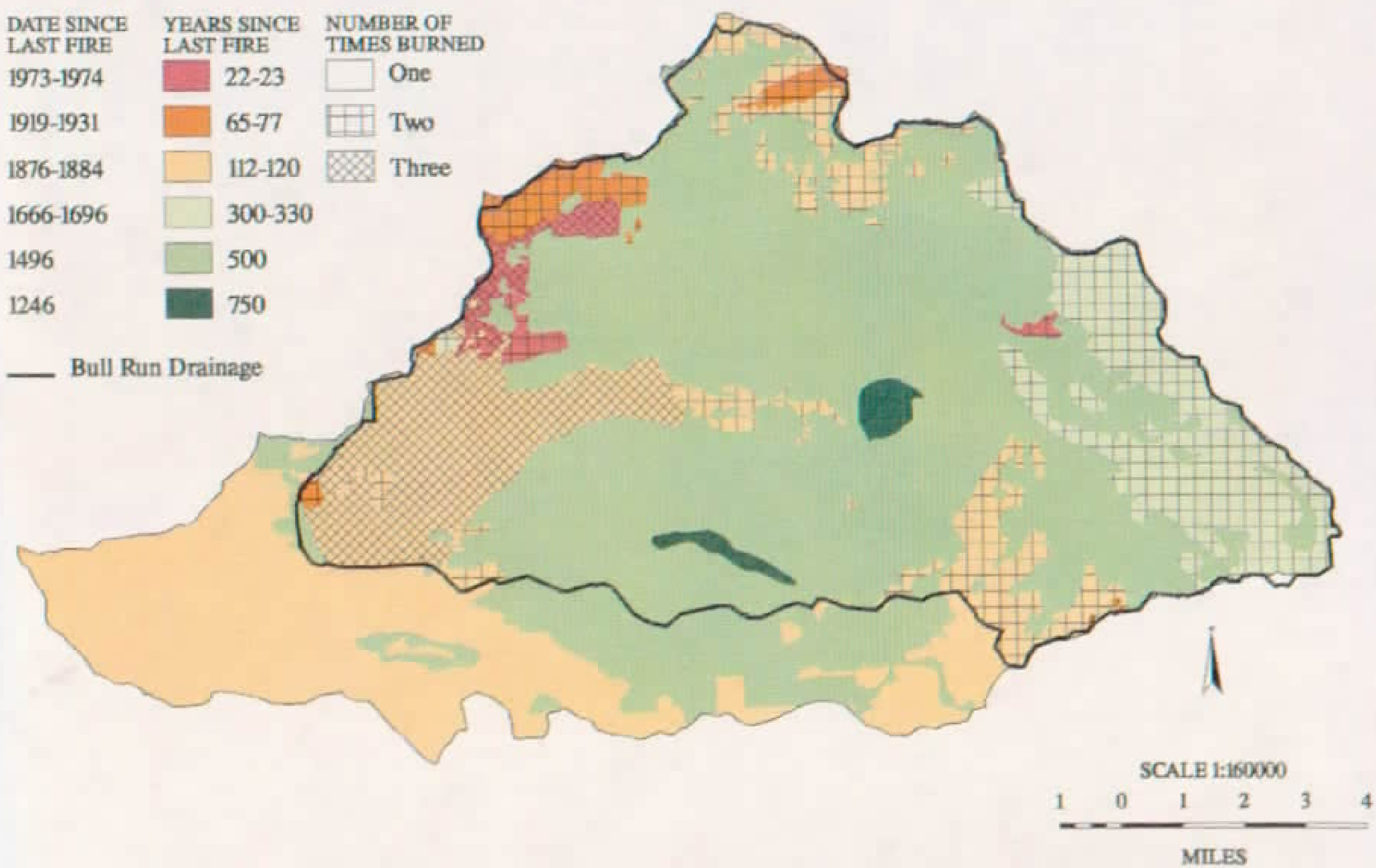
In 1993 a fire history study was initiated by the City of Portland and Forest Service as part of a larger project investigating natural disturbance processes within the Bull Run Watershed (Krusemark et al, 1996). This joint study, however, focused solely on the city's municipal water supply drainage portion of the watershed. Forest stands were delineated on aerial photos. Extensive field sampling of tree age, particularly Douglas-fir, provided stand-age information to help reconstruct past fire events. Temporal distances between stand-age classes were used to help establish fire return intervals. The dominance of different age classes also helped to determine fire regimes.

Two remnant stands (of mixed Douglas-fir, Pacific silver fir, Alaska yellow cedar, and western hemlock) located within the watershed date back 750 years to a large fire event circa 1243 A.D. Because of overlapping fires that occurred after this, the exact extent of this historic event cannot be determined. The next major fire event in the Bull Run Watershed occurred 500 years ago (in 1493). This event burned virtually the entire watershed, with the exception of the two remnant 750-year-old stands.

After the 1493 event, sporadic fires burned throughout the watershed every 150-200 years, sometimes reaching 6,000 to 7,000 acres in size. Between 1873 and 1881, much of the watershed's western lowland and southern portions burned. These fires may have represented the northern extent of much larger fire events that originated south of the Bull Run Watershed. Exact cause of these fires has not been determined. During this current century, no watershed fires have exceeded 1000 acres.

A composite fire history diagram (Figure 4-10) displays: areas burned by stand-replacing fire events, years since the most recent fire, and areas that have burned more than once in the past 750 years. Information pertaining to the area inside the municipal water supply drainage is from Krusemark et al. Information on the portion of the watershed located outside the water supply drainage is based on interpretations from current aerial photos and forest cover survey data from 1948 and 1914.

Bull Run Watershed Composite Fire History



Although difficult to corroborate, one hypothesis for the large expanse of area burned during 1493 and other years is that, rather than one single fire, this burning resulted from a combination of multiple fire starts sparked from passing lightning storms. These multiple starts may have smoldered for several weeks or more until an east wind event caused the fires to flare-up and burn together into one large fire. (Krusemark, et al., 1996)

By studying the burn patterns of past fires, it appears that fires within the Bull Run Watershed had elongated, east-west orientated shapes. Excluding topographic influences (which tend to be less important as the fire's size increases), the most important factor influencing fire is wind. Typically, west winds here are associated with cool, moist marine air from the ocean and coastal mountain ranges, while east winds are the dry dominant ones. Therefore, the most likely fire scenario here is for fires to spread from east to west. (Krusemark, et al., 1996)

The east winds in the Bull Run area occur more frequently in exposed places between 250-1000m elevation than at lower elevations (Cramer 1957), which might help to explain why fires entering the Bull Run tend to dissipate once they have entered the watershed. Furthermore, the watershed appears to be influenced by fires originating from outside the watershed, with less fire activity generated from fires starting in the watershed (Krusemark et al, 1996). However, not all fires appear to have entered the watershed from outside such as the Camp Creek Fire of 1870.

Current Fire Documentation

Available Mt. Hood National Forest historical fire occurrence records consist of: documented fires from 1908-1930 in the *Mt. Hood N.F. Fire Atlas*, fire lookout panoramic photos from 1930-1934, and fire history maps that date back to the 1870s. The 1979 *Final Environmental Impact Statement for the Bull Run Land Management Plan*, and the 1992 *Fire Management Plan for the Bull Run Watershed* also contain fire information dating from 1930-1959. In 1960, the Mt. Hood National Forest started documenting fire records for wildfires.

An examination of these reference sources reveal a total of 110 fires occurred in the Bull Run Watershed so far this century -- 66 from 1908-1959, and 44 from 1960-1995. Of these most recent 44 fires, four were 200 acres or greater in size. The largest, the 1971 Linket Fire, burned 960 acres. The most recent, the 1976 Log Creek Fire, burned 209 acres. The largest proportion of fires, however, have been less than an acre.

Of the 66 fires during 1908-1959, 11% were caused from human activity (slash/brush fires, equipment, campfires, smoking), 33% from lightning, and 55% were from unknown causes. Of the 44 fires during 1960-1995, 48% were caused by human activity (slash/brush fires, equipment, campfires, smoking), and a similar percentage, 43%, were caused from lightning.

Chart 4-2 Percent of Fires by Cause (1960-1995)

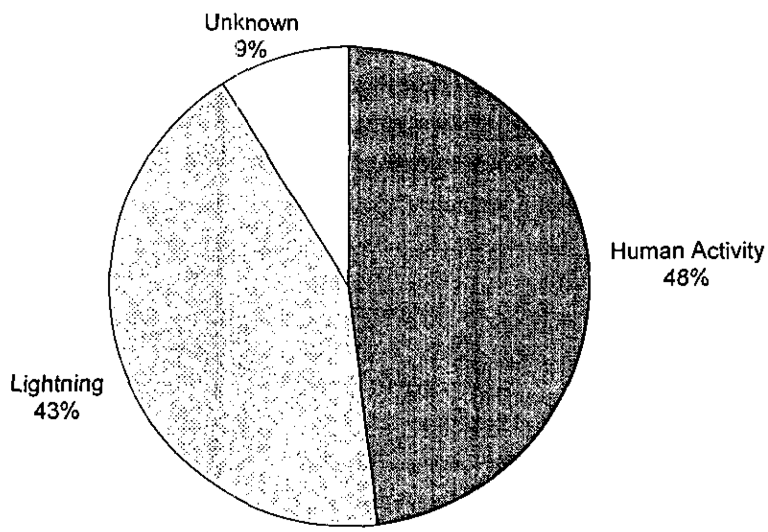
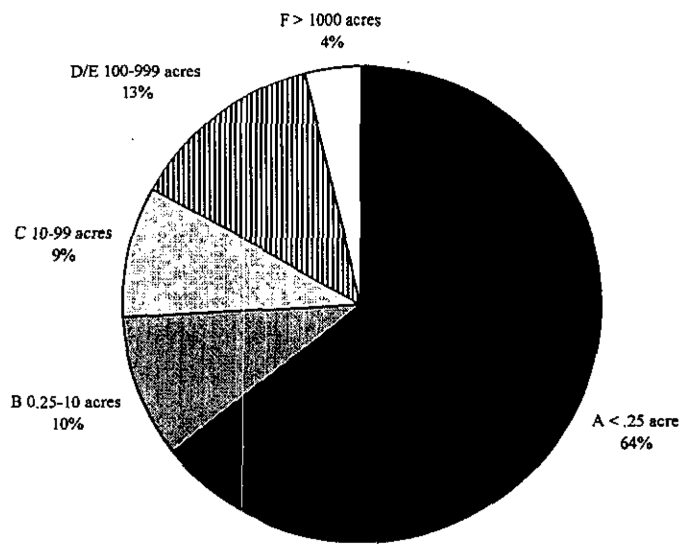


Chart 4-3 Percent of Fires by Size Class (1960-1995)



The aggregation of existing fire data also confirms that the summer months of June through October provide the most fire-ignition starts. September and October, which historically have the greatest percentage of east wind events, account for the preponderance of large fires.

Natural Fire Rotation

Fire frequency was calculated for the Bull Run Watershed physical drainage by Krusemark, et. al. using the Natural Fire Rotation (NFR) method. This method, which uses age class data and assumptions about reconstructing past fire events, estimates that every 350 years, the total area burned within the physical drainage will be 68,000 acres. Due to its drier sites, NFR for the watershed area outside the physical drainage is estimated to be shorter, between 250-300 years.

Fire Severity Regimes

Across the Pacific Northwest, the frequency, intensity, and extent of fires differ considerably. These differences are categorized into three broad categories of "high" "moderate" and "low" severity as described by the frequency, intensity, and environmental gradients of temperature and moisture.

Water Supply Drainage

The fire regime for the Bull Run Watershed's water supply's physical drainage is dominated by a "high" severity fire regime, characterized by infrequent fires of generally high intensity stand replacement events (Krusemark, et al, 1996).

These "high" severity fire regimes are characterized by: infrequent severe crown or surface fires that cause high tree mortality; or stand replacement fires that typically result in total stand mortality and moderate to high loss of the duff-litter layer. Unlike "moderate" fire severity regimes, the landscape following "high" severity fire regimes are usually dominated by a lack of residual (remnant) trees that will ultimately regenerate into an even-aged stand. These fires are generally associated with: drought years, east wind weather events which lower humidity, and an ignition source such as lightning. Fires are often of short duration, but of high intensity and severity.

Areas Outside the Water Supply Drainage

Watershed areas outside the water supply's physical drainage more closely reflect a "moderate" fire regime.

These fire regimes are more difficult to characterize because individual fires often show a wide range of effects, from some mortality to the intermediate and overstory vegetation, and light to moderate loss to the duff-litter layer -- to light underburns with no loss to the intermediate vegetation, or light loss to the duff-litter layer. Under "moderate" fire regimes, fires occur in areas with typically long, dry summers and can be from weeks to months in duration. Periods of intense fire behavior are mixed with periods of moderate and low-intensity fire behavior.

"Low" fire regime characteristics are more common to the drier forest types east of the Cascades. Low and moderate severity fire effects, however, have been documented in the Bull Run Watershed's riparian areas around the margins of high-severity burns (Krusemark, et. al., 1986).

Fire Ecology Groups

In 1994, a group of fire specialists developed the draft report *Fire Ecology of the Mid-Columbia* (Evers et al., 1994), which summarized current available fire ecology and management information for the mid-Columbia area of Oregon and Washington, including the Mt. Hood National Forest. Fire ecology groups were based on plant associations and species' response to fire, as well as these species' roles during succession. Occurrence and extent of the fire groups was determined by field sample data of plant associations. These fire ecology groups can also be used to describe and predict fire's potential impact on an ecosystem.

Fire Ecology Groups of the Bull Run Watershed

One dominant and two minor fire ecology groups are represented within the Bull Run Watershed. Fire Group 8 encompasses approximately 83 percent of the watershed, with scattered inclusions of fire groups 6 and 9 comprising the remaining 17 percent.

Fire Group 8

Fire Group 8 includes the watershed's moist and wet western hemlock and Pacific silver fir plant associations. Very wet sites -- indicated by devil's club or skunk cabbage -- tend to halt or greatly slow the spread of surface fires during most years. Deep duff and large logs are typical of this group, resulting in "low" to "moderate" wildfire hazard -- depending on weather conditions and canopy gaps.

Within Fire Group 8 lands:

- Prolonged drought (of at least three years) dries the forest floor enough to allow fires to ignite and spread.
- Smoldering combustion and creeping rates-of-spread are most common until dry east winds fan the flames into a much higher intensity fire.
- Fire frequency in similar habitat types average 200+ years.
- Average fire return intervals in sites with devil's club and skunk cabbage may easily exceed 300 years.
- The highest fire danger occurs from August through October.
- Little or no hazard exists from natural fuel accumulations until stands reach mature or overmature status, or some other natural event such as wildfire or windthrow occurs.
- Fire exclusion may have had minor effects on the typical fire behavior and fire size.
- To avoid soil damage and seedbank scarification caused by prolonged smoldering, burning for hazard reduction should occur when duff moisture is relatively high.
- Heavy equipment can cause compaction and erosion problems when used for either fuel treatment or wildfire suppression.
- Many sites can withstand "moderate" to "low" severity burning quite readily with little or no effect expected on long-term productivity. "High" severity burning, however, may emit too much nitrogen to maintain site productivity.
- The relatively high decomposition rates typical of these plant associations suggest that non-burning fuel treatment methods may adequately address the higher hazards associated with logging slash.

Fire Group 9

Fire Group 9 consists of dry western hemlock plant associations from 2000 to 2700 feet in the watershed's south to southwest slopes. Drier conditions in the understory in late summer provides live fuel in the form of cured grasses and shrubs with fine twigs. In more open canopies, tree crowns can reach closer to the ground, providing a ladder for fire to reach the canopy. Fuel loadings in this fire group are highly variable, depending on individual stand and site conditions. Generally, this fire group does not contain duff as deep as Fire Group 8. Large logs, however, are common and most Fire Group 9 sites dry out sufficiently. They typically contain enough fine fuels to carry fires in late August.

Within Fire Group 9 lands:

- Fire frequency communities average between 25-150 years, depending on specific location.
- In the absence of east winds, topography and rockiness tend to control fire size and shape. However, this fire group is also surrounded by the more moist Fire Group 8, which could also influence behavior.
- In the presence of east winds, low to moderate rates-of-spread and fireline intensities dominate fire behavior. During most years, this fire group tends to carry a higher risk of fire than Group 8.

Fire Group 6

Fire Group 6 is found on cool sites on upper slopes and ridgetops above 2600 feet, primarily scattered along the watershed's eastside. According to Krusemark, et. al. (1996), many of the watershed's smaller fire events were concentrated in these rim environments – possibly due to the greater likelihood of lightning.

Current evidence suggests that Fire Group 6 experiences high-intensity stand-replacing fires almost exclusively. With the exception of periods with prolonged drought, the understory in this Fire Group does not support fire. Fire exclusion probably has not altered the typical fuel loading and fire behavior. The heavy shrub loading still serves as a heat sink, preventing the start and spread of most fires during average burning conditions.

Within Fire Group 6 lands:

- Little or no wildfire hazard exists from natural fuel accumulation, except in stands at or near the climax state.
- Fire protection may be critical during extreme burning conditions, particularly around active timber sales and in northern spotted owl habitat.
- Because soils tend to be nutrient poor, slash treatment methods should remove as little organic matter as possible to maintain site productivity.
- Conifer establishment occurs very slowly or not at all.
- Slash protects the area from frost and reduces the expansion of aggressive forbs.

Fire Risk and Hazard

Hazard and Risk are important wildfire prevention concepts. Wildfire loss can be reduced by one of two strategies: eliminate or reduce the sources of ignition (risk management); or remove or modify the fuel to reduce its flammability and burning intensity (hazard management).

Risk

Risk (such as lightning, campfires, smoking) is the agent that causes wildfires. Because it is virtually impossible to eliminate all risk, some level of risk must always be accepted. The acceptable level of risk should be determined by the existing level of fuel hazard and values to be protected.

The probability of lightning is relatively low in the Bull Run when comparing regional lightning probabilities. Human ignition events, because of restricted access in the watershed, are also more limited than other watersheds.

Human ignitions are more likely to start outside the watershed than inside. Those that start to the west are unlikely to move far inside the watershed. Fires originating along the Highway 26 corridor along the Columbia River (northeast of the Bull Run) or along Highway 26 (southeast of the Bull Run) appear to have significant potential in late summer to fall to spread westerly into the Bull Run Watershed under east wind conditions. The 1991 Falls fire is a good example of this type of fire, although it was contained before it entered the watershed. (Agee,

1996) In general, risk is higher outside the watershed due to recreational, industrial, and private use, which increases the risk of human ignitions.

Hazard

Where values are high and risk cannot be sufficiently reduced, an alternative may be to reduce the fuel hazard. "Hazard" is a rating assigned to a fuel complex that reflects its susceptibility to: ignition, the fire behavior and severity it would support, and the suppression difficulty it represents. Hazard reduction can be planned to decrease wildfire incidence and severity, lessen rate of spread and intensity, and make extinguishing fire easier and less costly.

Hazard will vary over time since disturbance. Potential **surface fire** behavior, as modeled in the Olympic Mountains by Agee and Huff, 1987, is highest in early succession stands, decreases in mid succession stands, and increases slowly in multi-layered old growth forests. In these west Cascade forests, however, **crown fire** potential is another important type of fire that needs to be considered and is not easily modeled or understood (Agee, 1996).

Christensen and Pickford, 1991, showed that after several years untreated windthrow slash in the Bull Run had fine fuel loads similar to older windthrown stands (up to 80 years old). The Bull Run has a low fire risk and relatively rapid natural fire reduction in fire hazard, therefore decreasing the need for fuel treatments.

If a fire in the Bull Run is a large east wind driven event, it is likely to move until the weather changes and therefore is largely fuel independent. Buffers of primarily conifer forest do not provide increased protection for these large scale fire events. In addition, buffer zones are not fully effective against spot fires started by firebrands and carried by wind. Winds can loft firebrands many miles, making almost any buffer zone width vulnerable. (Agee 1996.)

Still, stand level treatments such as: removing or breaking up the continuity of fine fuels near high risk areas; removing fuels in strategic areas to augment natural barriers; and keeping stands healthy and vigorous, could be considered to reduce hazard. These treatments could be considered in strategic locations, but are not intended over wide areas of the landscape.

Current Fire Management Objectives

Fire and fuels management direction vary by land allocation. The overall fire suppression direction for National Forest lands, in order of priority, is to protect: 1. life, 2. property, and 3. natural resources. Note: The Federal Wildland Fire Management Policy and Program, (USDA & USDI), states that: "Protection priorities are (1) life and (2) property or natural resources based on relative risk, commensurate with suppression costs." However, as of the print date for this watershed analysis, this policy has not been officially implemented.

In addition, fire management objectives for the Bull Run Watershed Management Unit are: reduce the probability of catastrophic wildfire by reducing wildfire risk; protect the Management Unit from wildfire; promptly extinguish all wildfires.

The Bull Run Final Environmental Impact Statement (1979) clearly establishes that the 10-acre fire control policy will remain in effect for the Bull Run Watershed Management Unit. Objective of this 10-acre control policy is to plan for and implement suppression actions that control all wildfires at 10 acres or less.

Watershed Portion Outside the Management Unit

Fire management objectives for Bull Run Watershed areas outside the Management Unit are based on the *Mt. Hood National Forest Appropriate Suppression Response* (ASR) guide. The ASR guide bases suppression action on expected suppression costs, public safety, and resource values at risk. Every ignition declared a wildfire requires a timely suppression response with appropriate forces. Appropriate suppression response to a wildfire may range from direct attack and control, to more indirect methods of confinement and containment.

Confinement strategy would be used to limit fire spread within a predetermined area through the use of natural or pre-constructed barriers, or environmental conditions. Containment strategy would be to surround a fire and any spot fires with the necessary control lines (which can reasonably be expected to check the fire's spread under prevailing and predicted conditions).

Additional fire management direction for the Bull Run Watershed can be found in the *Bull Run Planning Unit Final Environmental Statement* (1979), the *Bull Run Fire Management Plan* (June 1992), *Mt. Hood National Forest ASR guide*, and the *Mt. Hood Forest Plan*.

Current Fire Protection Infrastructure

The Bull Run Watershed's fire protection infrastructure consists of: detection, water sources, helispots, prevention signs, and patrols. District/zone resources available for detection and initial attack suppression are Patrol 408 (a 200-gallon model 45 engine), and the Hickman Butte Lookout. In a high fire danger situation when extra fire detection patrols are required, the Forest also has access to fixed or rotor wing aerial detection. However, available funding affects the ability to meet these on an annual basis.

Airtankers are also available for retardant suppression support from the Redmond Air Center and the Troutdale Air Tanker Base. In addition, the Zigzag Interagency Hotshot Crew, based at the nearby Zigzag Ranger Station, is potentially available. A 100-person fire equipment cache is also available at the Troutdale Air Tanker Base.

Patrol 408 traverses the watershed seven days a week from June 1 through October 15. Additional fire suppression support, available at the Zigzag Ranger Station: Patrol 407 (200-gallon model 45 engine), Engine 402 (1,000-gallon model 80 engine), and Watertender 404 (3,000 gallon watertender). (Additional Mt. Hood National Forest resources available for initial attack support are identified in the *Mt. Hood National Forest Appropriate Suppression Response* [ASR] guide.)

In addition, one Remote Automated Weather Station (RAWS) is located in the Bull Run Watershed that monitors fire weather 24 hours per day on a year-round basis. (Four others are located elsewhere on the Forest.) Once per hour, these stations record and store weather readings (wind speed direction, air temperature, precipitation, fuel moisture-temperature, relative humidity, and soil moisture-temperature). Every three hours, this data is transmitted via satellite to a Boise, Idaho base station to be used for fire behavior calculations in pre-suppression and suppression efforts.

Conclusions: Disturbance from Fire

- In general, much of the watershed consists of older forest unburned for centuries, a fair amount of younger forest in the western portion of the watershed initiated by 19th century fires, and little significant natural fire activity in the 20th century. The Bull Run appears to burn infrequently and contains a large proportion of old-growth forest as a result.

- Past large fires may actually have resulted from multiple fire starts from passing lightning storms that smoldered for several weeks or more until an east wind event caused the fires to flare-up and burn together into one large fire. This would be an unlikely scenario today given adequate suppression forces.

- The most likely fire scenario is for fires to spread from east to west, with dry, dominant east winds that typically occur in September and October.

- The Bull Run area's 350-year overall natural fire rotation is quite long. The physical drainage is dominated by a "high" severity fire regime, characterized by infrequent fires of generally high intensity, and stand replacement events with moderate to high loss of the duff and litter layers. The Little Sandy Watershed more closely reflects a "moderate" fire regime which can show a wide range of effects.

- Many of the watershed's smaller fire events were concentrated in the rim environments, possibly due to the greater likelihood of lightning.

- The probability of lightning is relatively low in the Bull Run. Human ignition events, because of restricted access in the watershed, are also more limited than other watersheds. Ignitions are more likely to start from outside the watershed than inside.

- Large, east wind-driven fire events are largely fuel independent and are likely to continue spreading until the weather changes. The 1991 Falls Fire is a good example of this type of fire.

- Overall, the Bull Run has a history of stand replacing fires. Risk is low, yet a fire or multiple fires under the right weather conditions and an east wind event could result in a large, stand replacement fire. The best, cost effective suppression strategy is to maintain early detection and early suppression efforts with sufficient road infrastructure for access.

Disturbance From Wind

Natural disturbances such as windthrow, i.e., the wind-related uprooting of trees, are integral components of the forest succession process. Windthrow creates woody debris, mixes forest soils, and alters forest composition and structure. At the landscape level, the process of windthrow can be influenced by landforms and vegetation patterns, and recent evidence indicates that windthrow patterns are sensitive to patterns of forest fragmentation. At a smaller scale, factors such as root decay or a particularly shallow rooting system can predispose trees to windthrow.

The majority of this section is summarized from the Draft Report on "Windthrow in the Bull Run watershed, Oregon: Analyses of spatial patterns, temporal patterns and estimated future risk" by Diana S. Sinton, Julia A. Jones, and Frederick S. Swanson, June 1996. This report is part of the disturbance study cooperative research agreement between the Pacific Northwest Research Station and Oregon State University. Further citations may be found within the source report.

Since the final disturbance study report has not been submitted to the City of Portland and the Mt. Hood N.F., watershed analysis review comments from Julia Jones and colleagues Diana Sinton and Fred Swanson have been incorporated into this document.

The disturbance study of the Bull Run Watershed examines the effects of broad-scale ecological and landscape patterns on the process of windthrow. It includes only the water supply drainage of the Bull Run Watershed and does not include the Little Sandy Watershed.

Windthrow History

High winds associated with storms are common in the Pacific Northwest and especially in the vicinity of the Columbia River Gorge. Most windthrow in the western half of the Gorge has been associated with winds coming from the east, especially during winter storms.

In the disturbance study, windthrow patterns were reconstructed over a 100-year period by using a combination of aerial photography and field work. Windthrow of Douglas-fir often releases shade-tolerant understory species such as Pacific silver fir and western hemlock. Identification of stands dominated by these species was used to identify sites that may have had windthrow at an earlier date. The most obvious indicator of windthrow in a stand was the presence of uprooted trees, lying in the same general direction and at approximately the same state of decay (in contrast to root disease pockets where trees are jackstrawed).

The results of this work indicated at least five distinct windthrow events during the pre-logging period (prior to 1958 when logging began). The most extensive pre-logging windthrow occurred in 1931 and was located in the southern and central portions of the watershed. The 1931 storm blew down approximately 2% of the forested area.

In the last twenty five years, and after logging had begun in the watershed, two wind storms in the area generated considerable windthrow in the Bull Run. Following each of these storms, salvage logging was performed to remove the windthrown trees, as they represented a potential threat for insect or disease infestations or wildfires. In January 1973, an east-wind storm crossed the basin and blew down approximately 3% of the watershed, mainly in the eastern, Otter Creek area. A second easterly storm in December 1983 blew down approximately 7% of the watershed in the central and eastern parts of the watershed and was in the same general area as the windthrow from the 1973 storm.

The storm events of April 1931, January 1973 and December 1983 were roughly comparable in terms of wind speed and direction, based on available data from the Portland area. In the three storm events, winds were from the north, northeast or east directions. Winds gusting up to 90 m.p.h. were estimated for the 1983 storm. Furthermore, the 1973 and 1983 storms were characterized by cold, sub-freezing temperatures.

Relationship to Ecological and Landscape Patterns

In the disturbance study, the spatial arrangement of windthrow patches from the 1931, 1973 and 1983 storms was compared to landscape patterns of aspect, elevation, slope, soil type, vegetation cover type and openings in the forest canopy.

Landscape Pattern

The landscape patterns of windthrow from the three storms are remarkably dissimilar in their geographic distribution. Several factors may explain these pattern differences, including: 1) the interaction of slightly different wind trajectories in each storm with the local and broader-scale topography; 2) forest stand conditions at the time of each storm; 3) the sub-freezing temperatures of the 1973 and 1983 storms; and 4) the existence of new, clearcut edges prior to each of the 1973 and 1983 events.

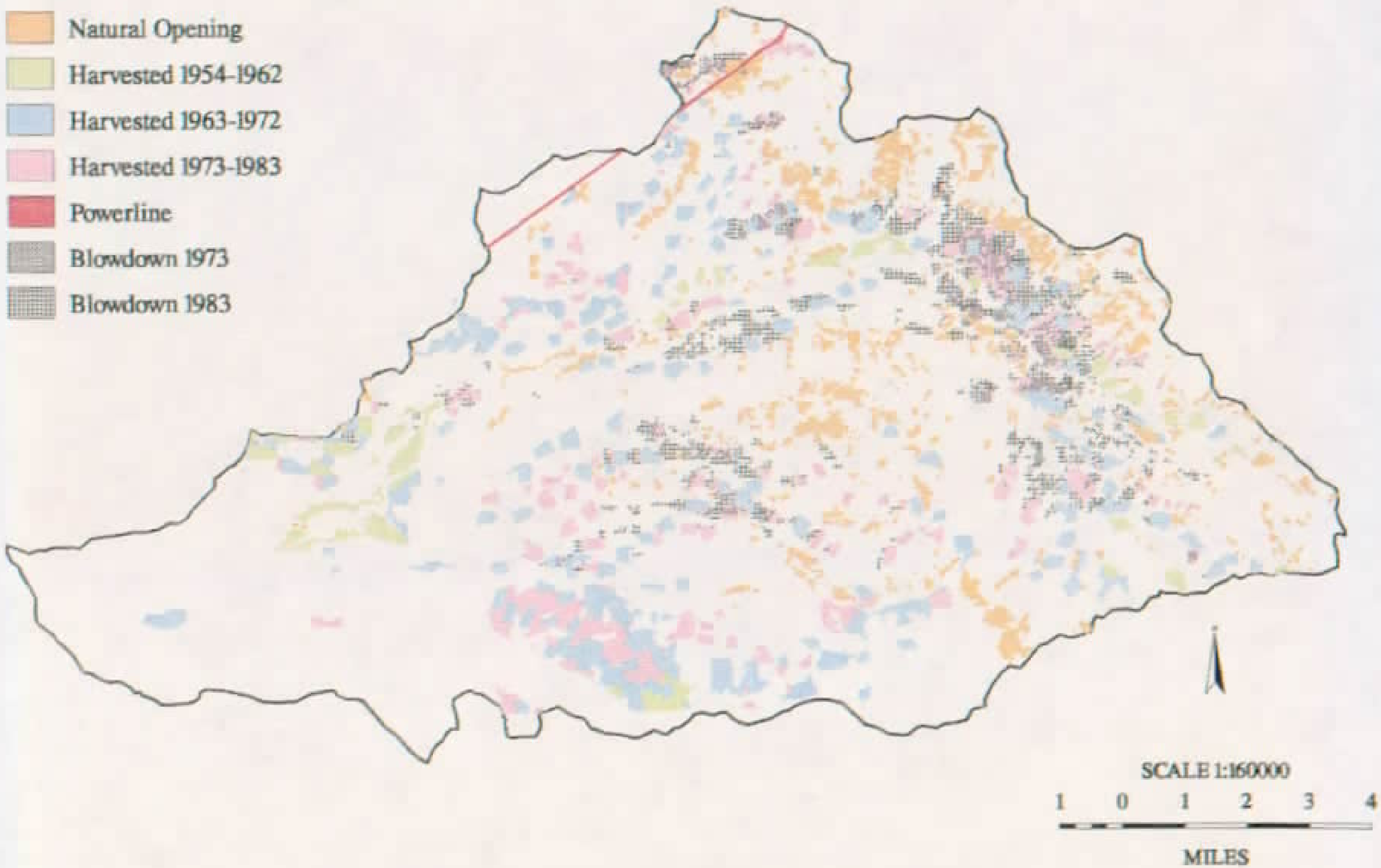
In all three storms, windthrow was frequently found adjacent to openings in the forest canopy (within 150 meters of edges). Approximately one-third of the windthrow in 1931, 1973 and 1983 occurred near natural openings such as talus slopes and meadows. Although none of the windthrow in the pre-logging 1931 storm was associated with created openings (clearcut edges), 56% of the windthrow in the 1973 storm and 77% of the windthrow in the 1983 storm was associated with created openings. This disturbance study finding is consistent with the Forest Service Environmental Impact Statement for the salvage of the 1983 windthrow which stated "About 74% of the 1983 blowdown occurred adjacent to openings and the degree of exposure to the damaging winds is a major factor influencing windthrow hazard" (USDA Forest Service, 1988).

Trees at the edges of natural openings are presumed to have a greater inherent "windfirmness" than trees located elsewhere, as they have grown under chronic wind exposure and tend to have wind-pruned canopies and a stable rooting system. Under extreme wind conditions these factors may prove inadequate to protect the tree from windthrow, as was likely the case with the 1973 and 1983 storms.

Trees located at the edges of created openings, such as clearcuts, are susceptible to being windthrown because they are newly exposed to winds, having previously been protected from direct wind exposure by surrounding canopy trees. Clearcut edges, however, gradually lose their vulnerability to windthrow over time as revegetation occurs within the cut, the distinctive height differences between forest and opening gradually diminishes, and any particularly weak or vulnerable trees at the edge of the adjacent stand are windthrown during mild to moderate storm events. In addition, natural pruning of limbs and tops during milder storm events increases wind tolerance of trees at the edges of adjacent stands.

Clearcut edge density increased steadily between the 1950s and the 1980s, a landscape feature that has strongly influenced windthrow patterns. However, while the 1983 windthrow commonly occurred near the edges of 1973 salvage clearcuts, those salvage clearcuts themselves were the result of both edge- and non-edge related 1973 windthrow. Locations with seemingly direct links between clearcut-edge related 1973 windthrow and subsequent clearcut edge-related 1983 windthrow, based on aerial photo and map interpretation, are evident only in certain portions of the watershed, such as the Otter Creek area, where other topographic or soil variables contributed to windthrow as well. Figure 4-11 -- Blowdown and Harvest 1954-1983, shows the spatial arrangement of blowdown and harvest units.

Bull Run Watershed
Blowdown and Harvest 1954-1983



Topographic Factors

Topographic exposure to winds from a northeasterly storm would directly expose the northern, northeastern, and eastern aspects of the watershed, and this explains the predominantly northeast facing location of the 1931 windthrow. After removing clearcut-related windthrow from the 1973 and 1983 patterns, the remaining windthrow also exhibited higher than expected values on directly exposed, northeastern aspects.

Windthrow can also affect the lee side of a ridge and therefore northeasterly winds would create a lee effect on southwestern aspects, where much of the 1973 and 1983 windthrow was found. The high amount of 1973 windthrow found on lee aspects at mid-elevations may be attributed to both a lee slope, turbulent wind effect and the concentration of clearcuts in those locations.

Soils and Climate

A high proportion of windthrow in 1973 and 1983 occurred on "severe" windthrow hazard soils, where perched water tables may restrict tree rooting. Yet the majority of the windthrow during all three storm events occurred on "slight" hazard areas, the assigned classification for the majority of the soils in the watershed. This result is counter-intuitive and suggests there may be inherent flaws in the soil hazard mapping designations. Also, the Bull Run Soil Survey (USDA Forest Service 1964) states that "extremely high and gusty wind conditions" may render the soil hazard classification inadequate for prediction of windthrow.

A contributing mechanism to windthrow susceptibility in the 1973 and 1983 storms may have been temperature. Both storms were characterized by maximum daytime temperatures below the freezing point. Trees that were stiffened by cold may have functioned as levers, foregoing their natural ability to bend with the wind. Instead they may have uprooted en masse, particularly in areas where shallow soils and perched water tables had already compromised the stabilizing effects of root systems.

Vegetation Factors

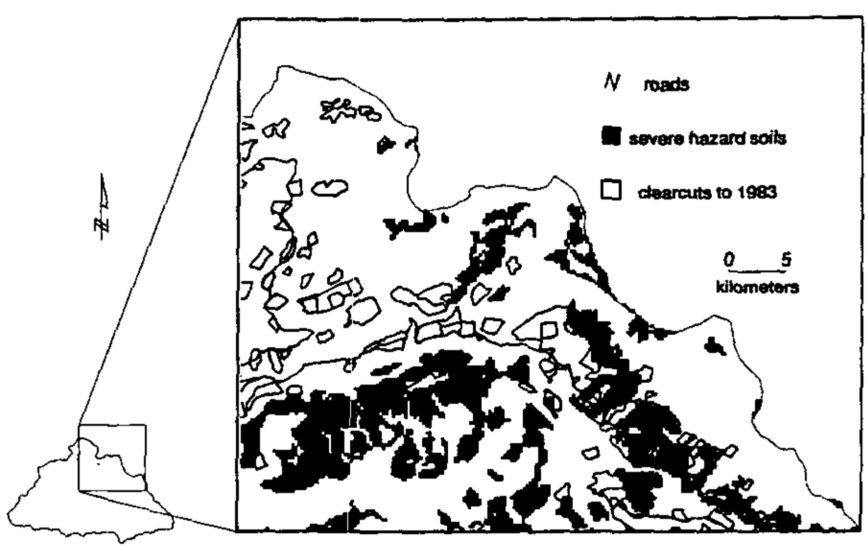
Forest composition and age affect windfirmness. Old-growth conifer forest, defined as stands greater than 200 years old, was the predominant cover type affected in all three storms. The majority of windthrow from the 1931 storm affected old-growth (58%), but younger conifer stands also were affected. There was little or no windthrow associated with other cover-types. In 1983, only half the forested area (53%) was classified as old growth, but the old-growth forest experienced 90% of the windthrow.

On a species basis, Douglas-fir is considered more windfirm than either western hemlock or Pacific silver fir. Yet Douglas-fir trees achieve greater height than the other species, and in the Bull Run Watershed, Douglas-fir was the most frequently windthrown tree found from storms since the 1890s. In old-growth forests where a mixed-age and multi-story canopy is typical, the relative height of a tree may be more important than its rooting characteristics in evaluating its susceptibility to windthrow.

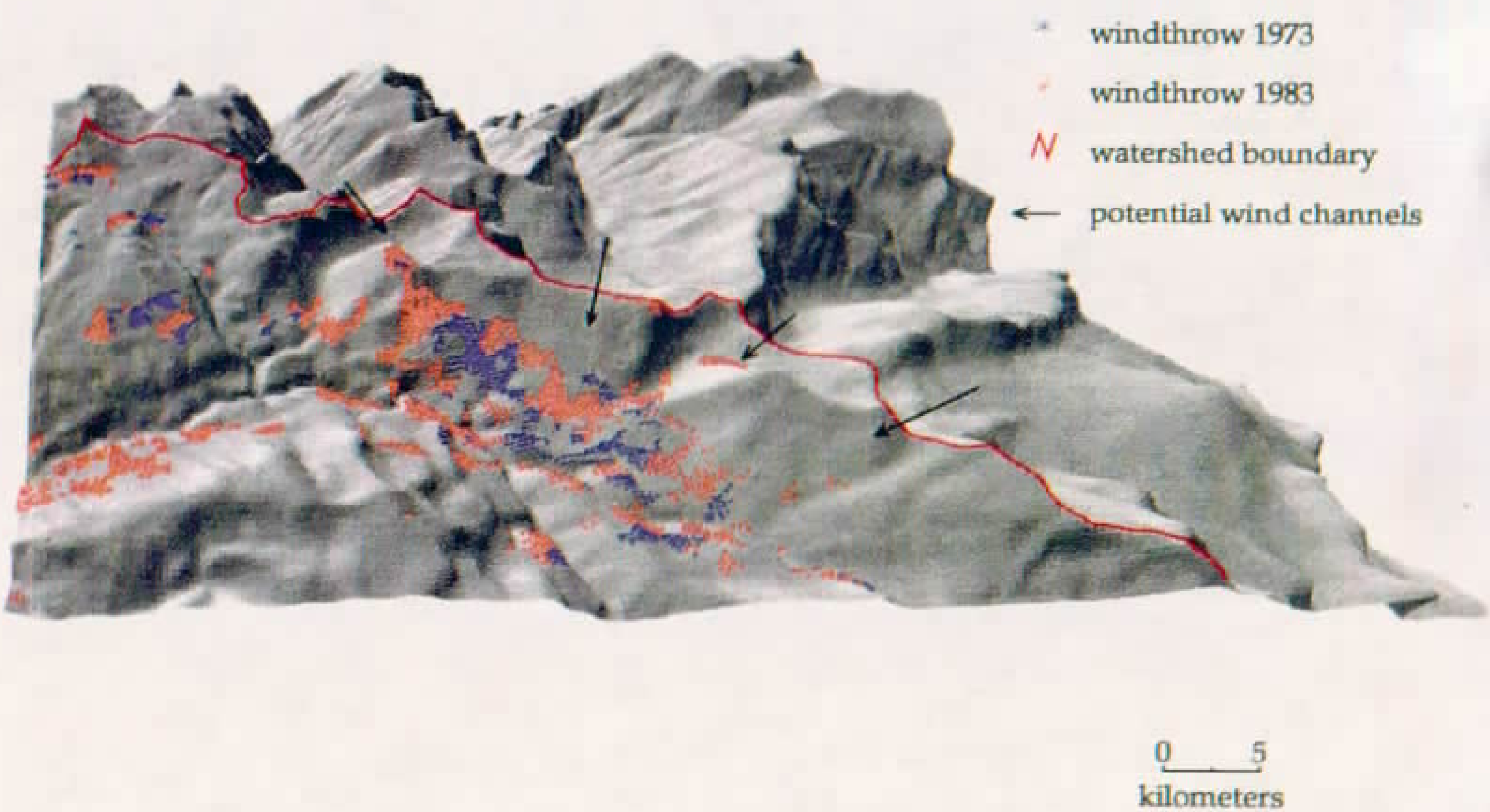
Northeast Quadrant

Several ecological variables occur in the northeastern quadrant of the Bull Run Watershed that appear to have predisposed the area to extensive windthrow. Winds from the north and east can be funneled through topographic channels to the area as displayed in Figure 4-12 -- Topographic View, NE Quadrant. Much of the windthrow occurs not at the ridgeline itself but further down the lee slope, below natural talus slopes, suggesting that the turbulent lee effect of wind over a ridge line may have been critical. Inherent characteristics of the area, notably shallow, poorly drained soils and large natural openings, may have interacted with clearcut edges to produce the dramatic windthrow patterns in 1973 and 1983. On southwestern slopes in this area, forests downwind of a recent clearcut edge were as much as five times more likely to have experienced windthrow in 1983 than other forested areas.

Northeast Quadrant of the Bull Run Watershed



Northeastern quadrant of the Bull Run watershed, topographic view looking northeasterly.



Conclusions: Windthrow Disturbance

- Storms created windthrow in the Bull Run Watershed throughout the 20th century, and undoubtedly before. On a broad, geographic scale, easterly winds channeled down the Columbia River Gorge funnel directly into the watershed, exposing trees both on the windward (north and northeast facing) and lee (south and southwest facing) slopes.

- Extensive windthrow in the Bull Run is relatively uncommon. Since 1890 only two events (January 1973 and December 1983) have generated windthrow covering more than 2% of the water supply drainage.

- Persistently wet soils, resulting from perched water tables, created local zones of high windthrow risk, although the existing soil windthrow-hazard maps may inadequately represent those zones.

- Cold, sub-freezing temperatures of the 1973 and 1983 storms may have contributed to the susceptibility of the forest to windthrow.

- Old-growth conifer forest was the predominant cover type affected in all three storms. Douglas-fir was the most frequently windthrown tree found from storms since the 1890s. Even though Douglas-fir is more windfirm than other conifers, the relative height of the tree may be more important than its rooting characteristics in evaluating its susceptibility to windthrow.

- Windthrow was frequently found adjacent to openings in the forest canopy, both from natural openings such as talus slopes and meadows and from clearcut edges.

- Clearcutting in the late 1950s through the 1970s created many new edges along which trees were highly likely to be windthrown, and salvage logging of windthrown trees from 1973 and 1983 storms created additional susceptible forest edges. Storms since the mid-1980s have not generated significant windthrow, and trees at created opening edges may have begun to lose their vulnerability. However, the significant windthrow associated with natural openings suggests that clearcut edges much older than ten years may remain significantly more vulnerable than interior forest.

- The reconstruction of windthrow patterns over the last 100 years in the Bull Run Watershed has shown that the windthrow disturbance regime is characterized by a range of event frequencies, sizes, and magnitudes. The patterns have been related to both landscape features, such as landforms, and canopy openings. However, the windthrow patterns as well as the disturbance regime itself will vary over time as many of the contributing factors are dynamic in nature.

Windthrow Risk

In the disturbance study, windthrow risk in the Bull Run was estimated by using spatial, hazard variables such as hillslope position, aspect, and knowledge of shallow soil locations, in conjunction with temporal, exposure variables such as the age or height of vegetation and the age of clearcut edges. Exposure based on topography may remain constant given a certain wind direction. However, vegetation characteristics, such as the height of trees and the presence of openings in the forest canopy, can change over a relatively short period of time.

An additional factor to be considered with regard to exposure is the probability of the occurrence of winds of a certain magnitude. Storms causing the most recent windthrow in the Bull Run Watershed have had at least two days duration in the winter months, with high-velocity, east winds and sub-freezing temperatures. A model using Portland Airport climatic data yielded low predictive success and predicting windthrow generating storms may be difficult to achieve.

Maps of future windthrow risk generated for the Bull Run were designed to describe relative probabilities of windthrow, rather than represent actual predicted locations of future windthrow. Locations with relatively low, medium, and high risk for windthrow, based on 1995 vegetation conditions and a northeast storm event were mapped as well as risk probabilities for the years 2010 and 2075. In each case, the greatest proportion of the watershed was designated as having moderate windthrow risk.

The current and future windthrow risk maps produced in the disturbance study for the Bull Run are largely reflective of the vegetation patterns for each time period. High hazard ratings occur predominantly where old-growth conifer forest is exposed to north and northeast wind conditions. Medium windthrow hazard is assigned to the western, low-elevation area, but this area has experienced very little of the mapped windthrow. Low hazard ratings occur in young plantations, and along the Bull Run River in the western portion of the watershed.

The Draft Windthrow Report states "The areas most likely to experience windthrow during the next decade or so include forested locations near ephemeral openings, such as recent clearcuts in the Bull Run. The spatial arrangement of clearcuts influenced windthrow during storms in 1973 and 1983, although there were also wind storms in 1989 and 1996 that did not generate windthrow along cutting lines. As a conservative measure, areas within a 150-m buffer of younger clearcuts remain classified as having a high risk potential for windthrow under current conditions. In contrast, these high risk sites near ephemeral edges are likely to have been mitigated by the year 2010, and the arrangement of "high risk" windthrow zones is then projected to reflect more inherent topographical risk: ridges and upper slopes on aspects directly exposed to winds from the northeast and east. By the year 2075, younger conifer stands will have reached a stage of increased windthrow risk, and the patterns of windthrow risk varies again. In a "shifting mosaic" of landscape patterns, future windthrow patterns may more closely resemble those that occurred prior to timber harvesting, once trees at clearcut edges lose their particular vulnerability to being windthrown."

The Draft Windthrow Report also describes overall windthrow risk in the Bull Run. "The most general way to evaluate windthrow risk in the Bull Run is to consider the area of forest that is available to be windthrown at any particular time. Fires, clearcutting, and windthrow have reduced the amount of (late successional) forest in the Bull Run by over 40% since the 1870s, while the total amount of newly created edges may have peaked. With continued fire suppression and a cessation of logging activities, the current younger forest stands will age, resulting in an increasingly older and taller forest across the landscape. Under these assumptions, the windthrow risk is currently at a low point, and will increase over the next several decades as more forest becomes vulnerable to windthrow."

Watershed analysis review comments received from Associate Professor Julia Jones and colleagues describe a different interpretation of clearcut edge susceptibility than the draft windthrow report. The review comments state "we consider that the evidence for a reduction in windthrow susceptibility of edges based on their age is not convincing. In 1983, the edges which were ten years old and appeared more windfirm may have been in portions of the basin which received overall much less windthrow." In addition, "Since we lack good, long-term climatic records from the Bull Run area, we cannot assume that many of the clearcut edges have been fully "tested" by a potential windthrow-generating storm event." And that "the significant windthrow associated with perennial, (natural), edges much older than ten years may remain significantly more vulnerable than interior forest".

While the watershed analysis team agrees that edges may remain significantly more vulnerable than interior forest, the team also agrees with the concept of edges decreasing their susceptibility to windthrow over time. This is based on our understanding of the process by which trees increase windfirmness described previously in this section under Landscape Pattern. Therefore, the concept of reduced clearcut edge susceptibility over time is carried forward into the conclusion section.

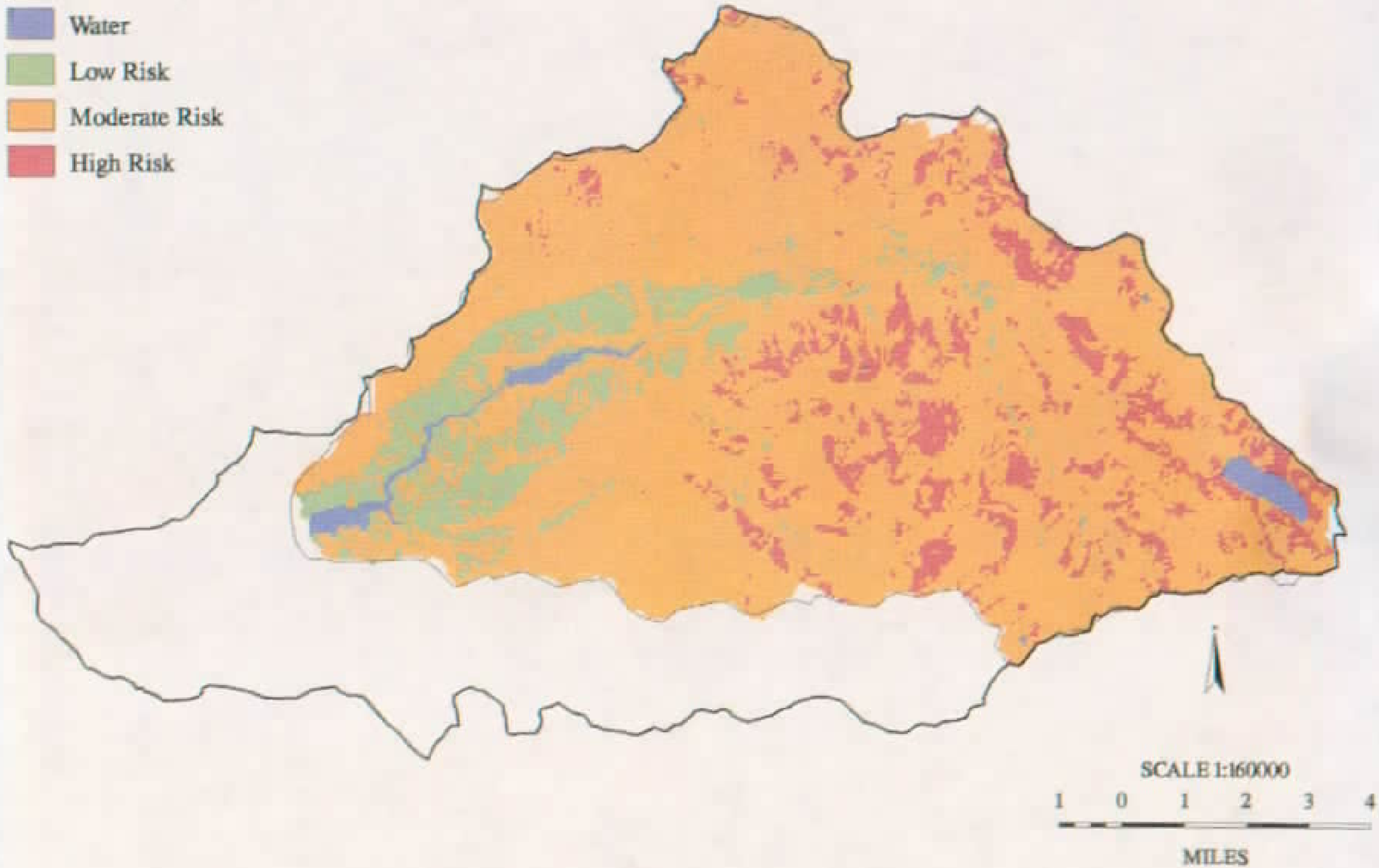
Inherent Blowdown Risk

Vegetation characteristics and their interactions with landform features (aspect, soils) were strongly statistically associated with windthrow for the storms of 1973 and 1983. The distribution of natural and created edges, as well as changing heights of vegetation stands, were critical determinants of windthrow in the Bull Run disturbance study.

The watershed analysis team also wanted to look at a landform based assessment of windthrow risk. If vegetation were equal, what might the inherent risk be? While variables to windthrow risk such as the height of trees and created openings are transitory, certain contributing factors do not change much over time, such as topographic exposure to an east wind or the existence of shallow, moisture-laden soils. For these reasons, ***the watershed analysis team prepared a map displaying inherent blowdown risk (Figure 4-13 – Inherent Blowdown Risk). This map uses the same topographic and soils data from the disturbance study, yet does not include vegetation characteristics, thereby displaying a landform based assessment of windthrow risk***. This map visually displays a "portion" of the windthrow risk equation, but does not take into account vegetation interactions.

The map displays low windthrow risk in the main east-west oriented drainage, following the Bull Run River. The majority of the watershed is rated as moderate risk of windthrow with scattered high risk areas in the eastern and south central portions of the watershed.

Bull Run Watershed
Inherent Blowdown Risk



Conclusions: Windthrow Risk

- The pattern and timing of vegetation succession interacts with the return interval of windthrow generating storm events in determining the likelihood of windthrow at any given location and time.

- Current and future windthrow risk are largely reflective of the vegetation patterns, i.e. old-growth stands are more susceptible, whereas young plantations are the least susceptible.

- The areas most likely to experience windthrow during the next decade or so include forested locations near created openings, and old-growth stands exposed to northeast storm events. In a "shifting mosaic" of landscape patterns, future windthrow patterns may more closely resemble those that occurred prior to timber harvesting, once trees at clearcut edges increase their windfirmness.

- As current younger forest stands age, windthrow risk will increase over the next several decades as more forest becomes older and taller and therefore more vulnerable to windthrow.

- Inherent, landform based assessment of windthrow risk, without vegetation characteristics, suggests a moderate risk of windthrow over the majority of the watershed, with scattered high risk areas in the eastern and south central portions, and low risk in the main east-west drainage of the Bull Run River.

Disturbance From Insects and Pathogens

Insects and pathogens are important agents of change and serve a vital role in ecosystem function (Wickman 1992). They cause tree mortality, which in turn affects an area's natural succession and its diversity of plant communities. They also create many of the dead trees that provide important habitat and food sources for a wide variety of wildlife species.

Nutrient cycling and production of downed woody material are two important ecological processes influenced by insects and pathogens which contribute to the long-term productivity of forest ecosystems (Wickman, 1992). Conversely, trees affected by insects and disease may also create safety hazards near populated sites, and may produce less timber volume. Furthermore, large amounts of mortality can severely damage: high-value sites, timber stands, and important old-growth habitat.

Insects and diseases may cause localized, small-scale disturbances throughout the landscape, or, during epidemics, may cause large scale disturbances.

Aerial Insect Detection Surveys

Results of aerial insect detection surveys were available for 1969 through 1995. (These data were for the Columbia Gorge Ranger District, which includes the Bull Run Watershed.) Aerial sketch-mapping surveys are an effective way to rapidly estimate insect activity over large areas. These surveys provide information on the insect activity's current status, and are useful in examining insect activity trends over large areas (Keith Sprengel, Westside Insect & Disease Technical Center, Pers. Comm.).

Aerial survey data indicate four insect species with notable activity in or near the Bull Run Watershed since 1969: balsam woolly adelgid, Douglas-fir beetle, western spruce budworm, and hemlock sawfly.

Balsam Woolly Adelgid ***(Adelges piceae)***

SURVEY YEAR	INTENSITY	CURRENT YR. ACRES
1969	H	5,320
1969	L	1,160
1969	M	880
1970	L	6,260
1971	L	1370
1971	M	130
1972	L	450
1973	L	320
1973	M	200
1974	L	120
1975	L	470

Intensity codes:

H = Many dead trees, or area heavily affected.
M = More than a few scattered trees. (Subjective measure between light and heavy.)
L = A few scattered trees.

The balsam woolly adelgid, a European species now widely established in North America, can be highly destructive to Pacific silver fir, subalpine fir, and grand fir. Introduced into North America circa 1900 in eastern Canada, by 1930 significant damage to grand fir had been noted in the Willamette Valley. By 1957, an estimated 600,000 forested acres in Oregon and Washington were infested, causing mortality to trees with an estimated volume of 1.5 billion board feet.

Previously known as the balsam woolly aphid, the balsam woolly adelgid feeds on the stem, branches, and twigs. During feeding, it injects a salivary substance into the tree which causes calluses and gall-like formations on the twigs and branches. Bole infestations usually kill the tree in a few years. Branch and twig infestations weaken the tree over many years.

Several thousand acres of the Bull Run Watershed were affected by the balsam woolly adelgid from at least 1969 through 1971. (It is most probable that high levels of infestations also occurred prior to 1969.) From 1971-75, low to moderate levels of activity occurred in the watershed on a few hundred acres per year. After 1975, no activity was observed from these aerial surveys.

Balsam woolly adelgid infestations in the Bull Run Watershed were most likely related to the larger infestations that occurred in the Northwest in the 1950s. After establishment and moving toward equilibrium with predators and parasites, its populations have declined. Even so, the balsam woolly adelgid may still pose a threat to the watershed's true firs. The most severe outbreaks in the Northwest occur at the lower end of the host species' elevational ranges – 1,500 to 3,000 feet for Pacific silver fir. Therefore, these stands may be the most susceptible in the watershed. Because the balsam woolly adelgid is an introduced species, its effects are outside the range of historic conditions.

Douglas-Fir Beetle
(Dendroctonus pseudotsugae)

SURVEY YEAR	CURRENT YR ACRES
1970	50
1971	260
1972	700
1973	440
1976	20
1979	250
1986	470
1987	870
1988	52
1989	142
1991	58
1992	932
1993	229
1994	164
1995	10

(No intensity codes are used for Douglas-fir beetle.)

The Douglas-fir beetle is indigenous to North America's Douglas-fir forests. In wet areas, such as west of the Cascade Crest and the Oregon Coast Range, this beetle maintains its low-level populations by infesting trees weakened by root disease or other stress factors and in scattered windfall. Laminated root disease serves as a significant predisposing agent, helping maintain resident populations of Douglas-fir beetle.

After a significant disturbance event, beetle populations will increase in downed and damaged Douglas-fir until -- in subsequent years -- they will attack and kill healthy standing trees. Then, if significant amounts of windthrow do not occur, these outbreaks will typically last only three years -- as the beetles attack and kill successively fewer trees each year (Hostetler, April, 1996).

The Douglas-fir beetle produces one generation per year. In most westside locations, adults emerge, fly to and infest new host trees during March through May. Although a shorter flight may occur later in the summer, only this spring flight provides the potential to infest significant numbers of standing green trees. This infestation potential is manifested the second spring, after occurrence of significant disturbance events.

The more recent the felled material, the more attractive it is (Jantz and Rudinsky 1966; Johnson 1963; Lejeune, McMullen, and Atkins 1961). When attracted to a felled tree, some beetles land on and bore into nearby standing trees. If the beetles are not expelled by an excessive pitch flow, they will gain entrance and release more attractant. When large numbers of beetles infest a living tree, even a healthy one can be killed (Johnson and Pettinger 1961). **During years of high beetle populations, trees most likely to be killed are those near recently felled or damaged trees.** These trees provide the initial attractant compounds for the beetles (Johnson and Belluschi 1969). However, the probability of live trees being attacked and killed the first spring after a major disturbance is quite low.

Factors that increase Douglas-fir beetle populations include large numbers of windthrown trees, felled trees, logging slash, and other diseased and weakened trees. The critical threshold of felled trees that will generate bark beetle populations sufficient to attack living trees is unknown. Experience in westside forests, however, indicates that when the number of windthrown trees reaches or exceeds three per acre, Douglas-fir beetle populations will increase to levels the following season that could lead to the attack and mortality of green Douglas-fir. Furthermore, west of the Cascade Crest, Douglas-fir beetle generally infest trees greater than 12-inches in diameter at breast height (DBH). If all trees in a stand are smaller than this, the probability of Douglas-fir beetle-caused tree mortality is low (Hostetler, April 1996).

Douglas-fir beetle may infest small as well as large patches -- or scattered -- windthrow. Infested downed trees covered by partial to full-shade will produce more beetles than trees fully exposed to the sun. Thus, a downed tree in a scattered, shaded blowdown situation will produce more beetles in the subsequent generation than a similar size tree within a large patch of blowdown exposed to higher levels of solar radiation (Hostetler, April 1996).

Douglas-fir beetles can also fly to and infest trees several miles from where they first emerge. Therefore, if large beetle populations are generated in downed trees, infestations and mortality may occur in surrounding areas -- several miles from these downed trees.

From 1970-75, aerial surveys have consistently detected Douglas-fir beetle within the Bull Run Watershed. Typical annual acreage detected during this time span ranged from 10 to 932 acres.

Observations made in 1986 revealed that -- in a few areas -- Douglas-fir beetles caused individual tree mortality. For the most part, this activity occurred in trees heavily damaged or stressed by the 1983 windstorm in and adjacent to the blowdown areas. **The areas of light to moderate amounts of blowdown proved more susceptible to beetle attacks than in areas where most or all trees were downed.**

1986 observations also indicated an increase in beetle attacks from 1983-86 (after the 1983 major blowdown event). The extent and degree of insect attacks, however, was light and later declined. Past observations have illustrated that the Douglas-fir beetle has not proved to be a major problem within the Bull Run Watershed (Bull Run Blowdown FEIS, 1986).

It is unclear why beetle populations failed to increase to higher levels after the 1983 blowdown event. Possibly, the weather provided favorable moisture conditions, keeping live trees vigorous and less susceptible to beetle attacks. Such weather conditions may have also slowed developments of broods -- decreasing beetle survival. Perhaps populations were very low to begin with.

The large patches of blowdown (from the 1983 event) may have also been exposed to high levels of solar radiation (less favorable to beetle production). Beetle populations did decrease after 1986, which is consistent with the premise: with no additional windthrow, Douglas-fir mortality from Douglas-fir beetle attack generally subsides to background levels by the fourth year.

Although only small Douglas-fir beetle outbreaks have occurred within the Bull Run Watershed in the past, large outbreaks could still occur here in the future. Successive windthrow events, including scattered windthrow of more than three trees per acre, could contribute to population increases and adjacent green tree mortality. Stands of weakened or diseased Douglas-fir, greater than 12 inches DBH and adjacent to downed trees with shading, would be most susceptible to beetle attack.

Western Spruce Budworm *(Choristoneura occidentalis)*

SURVEY YEAR	INTENSITY	CURRENT YR. ACRES
1984	M	2,080
1985	L	1,590
1986	L	11,810
1986	L	1,830
1987	L	1,920
1993	1	238
1993	2	365
1994	1	1,282
1994	2	429

Intensity codes:

(Note: two different coding systems have been used for spruce budworm, the system was revamped in recent years to more accurately assess the effects of defoliation by western spruce budworm).

H = Current year defoliation visible from air -- with some mortality likely
M = Current year defoliation visible from air -- with some bare tops visible
L = Current year defoliation visible from the air

1 = Defoliation visible from the air -- (>=30% defoliation)
2 = Defoliation with some bare tops visible -- (very little gray, still much green foliage)
3 = Defoliation with many bare tops visible -- (some gray color with some foliage in host trees visible)
4 = Defoliation with bare crowns -- (very gray in color, no visible green foliage in trees)

In recent decades, especially east of the Cascade Mountains, the western spruce budworm has been a major defoliator in Oregon and Washington. East of the Cascades, changes in vegetative conditions have favored spruce budworm populations.

Budworm larvae feed during late spring and early summer on the current year's buds and foliage. Effects of defoliation include: decreased growth, top killing, tree deformity, and, sometimes entire tree mortality. Four to five years of successive, intense defoliation can result in the complete defoliation of individual trees.

While budworm epidemics often occur over extensive areas, significant amounts of budworm-caused tree mortality generally occur in just 10-20% of outbreak areas. Douglas-fir beetle populations sometimes increase in these same defoliated stands and cause additional mortality of stressed trees.

Recent dendrochronology studies have documented the occurrence of numerous western spruce budworm outbreaks over the past three centuries. These long-term reconstructions provide a historical reference on the range of natural variability. Compilations of the numbers of trees with outbreaks within the Mt. Hood National Forest reveal a strong pattern of repeated outbreaks over the past several centuries (Swetnam and Wickman et al, 1994). Outbreaks occurred approximately twice each century with an average duration of twelve to fourteen years per outbreak.

From 1984-94, light to moderate budworm activity occurred within the Columbia Gorge Ranger District which includes the Bull Run Watershed. The largest recorded activity area was 11,810 acres of light intensity in 1986.

The 1984, 1985, and 1986 surveys also refer to the western blackheaded budworm. While a mixture of both the western spruce budworm and blackheaded budworms likely occurred, a blackheaded budworm outbreak was never detected inside the Bull Run Watershed. This budworm activity occurred during the time of the much more extensive and damaging outbreaks of western spruce budworm east of the Cascades and throughout eastern Oregon.

Budworm activity has been mapped for Oregon and Washington from 1947 to 1979 (USDA 1980). Although budworm was detected in the watershed during this time period, there were no recorded outbreaks (epidemics). It is likely that the westside climatic conditions, coupled with the health and structure of the vegetative conditions in the Bull Run Watershed, keep budworm activity minimal -- and most likely within the range of historic conditions.

Hemlock sawfly ***(Neodiprion tsugae)***

SURVEY YEAR	INTENSITY	CURRENT YR. ACRES
1993	H	674
1993	L	27
1993	M	1,008

Intensity codes:

H = Described as a sea of red or a major lack of foliage.
M = Subjective measure of current year defoliation, intensity between light and heavy.
L = >= 25% defoliation

The hemlock sawfly, a native species, is an important defoliator of western hemlock in the coastal forests of Oregon, Washington, British Columbia, and Alaska. Larval feeding is in the late spring and early summer. Generally, several insect parasites presumably help keep this sawfly under control.

Light to heavy hemlock defoliation was noted on limited acres in the Bull Run Watershed in 1993. No further activity has been observed, which suggests populations are not increasing.

Laminated Root Disease ***(Phellinus weirii)***

Laminated root disease, caused by the fungus *Phellinus weirii (P. weirii)*, is widespread throughout the northwest's forested areas. *P. weirii*, like many tree root pathogens, is believed to have co-evolved with its hosts. Thus, it is a natural -- and perhaps even necessary -- part of many forest ecosystems (Thies and Sturrock, 1995).

Primary host-species for laminated root disease are Douglas-fir, western hemlock, and true firs. Tolerant and resistant species include lodgepole pine, western white pine, and western red cedar. Hardwoods are considered immune.

In westside Douglas-fir types, the average amount of total area infected with laminated root disease is 20 to 25%. Laminated root disease spreads when roots of a susceptible tree grow into contact with infested stumps or roots left from a previous stand and are colonized by *P. weirii.* The rate-of-spread is about one foot per year, out from the edges of the infected area, called a root disease center.

The majority of the Bull Run Watershed is composed of highly susceptible or intermediately susceptible host species for P. weirii. Known laminated root disease pockets exist in the Bull Run Watershed's lower portion. In fact, this disease, as well as other root diseases, are most likely scattered throughout the watershed at low levels. Based on host type and estimated levels of infection in the watershed, the percentage of trees infected with P. weirii are expected to increase, yet remain within the range of historic conditions.

Vegetation

This section provides an overview of four key elements of vegetation: **Potential Vegetation**, **Structure**, **Seral Stage**, and **Landscape Pattern**. It outlines how these key elements are expressed -- currently and historically -- within the landscape of the Bull Run Watershed.

Potential Vegetation

When vegetation is undisturbed for long periods of time, it tends to stabilize with a predictable species composition. Potential Vegetation is vegetation which develops on a site and, in the absence of disturbance, is capable of self-perpetuation. It reflects the underlying site qualities, including climate. The Potential Vegetation concept reflects the endpoint of natural successional processes. To describe vegetation based on its potential provides an opportunity to readily understand and communicate environmental gradients, including limitations and opportunities, inherent to the site.

Potential Vegetation can be stratified broadly within "forest zones," and defined more specifically by groupings called "plant associations." Whereas Stand Structure, Seral Stage, and Landscape Pattern can vary widely over time and space, the site's Potential Vegetation (forest zone and plant association) remains relatively stable. Climatic shifts which often take many centuries, or catastrophic events such as volcanic eruptions that change a site's physical character, may permanently alter or shift Potential Vegetation.

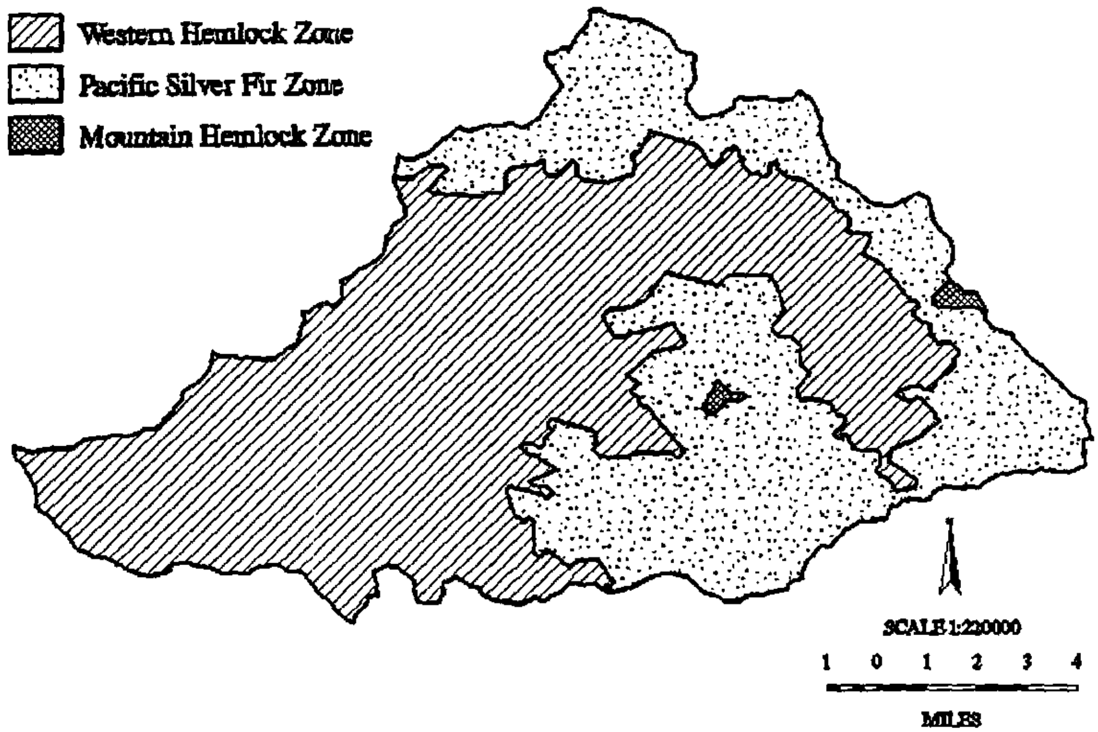
Forest Zones

The Western Hemlock Zone covers 60% of the Bull Run Watershed, while the Pacific Silver Fir Zone covers 40%. The Mountain Hemlock Zone occurs in less than 1% of the watershed.

Forest zones are of interest because they generally represent major large-scale climatic differences within a region. They are defined based on the dominant tree species that would eventually dominate an area in a long-term absence of disturbance.

The Bull Run Watershed is dominated by two forest zones, with minor occurrences of a third. Figure 4-14 displays the locations of these forest zones.

Figure 4-14 -- Forest Zones of the Bull Run Watershed



Western Hemlock Zone

The Western Hemlock Zone is that area in which western hemlock is the major tree species that will replace itself over time. It occurs on warm, moist sites relative to other forest zones and tends to be the most productive in terms of rapid and large tree growth. Douglas-fir and western redcedar are also common species within this zone. Even though Douglas-fir is shade-intolerant, it is very long-lived (750 years+) and thus, dominates many of the stands in the Western Hemlock Zone (Halverson et al. 1986).

The Western Hemlock Zone occupies lower elevations of the watershed, forming a crescent-shaped band that extends up the main fork of the Bull Run River and its adjacent slopes. It dominates the watershed's western portions. Inside the watershed, the average elevation of this zone is 1880 feet. (The elevational range of this zone in the watershed extends from approximately 300 to 3400 feet.)

Pacific Silver Fir Zone

The Pacific Silver Fir Zone represents the area where Pacific silver fir is the major tree species that will replace itself over time. Within this zone, temperatures tend to be cooler than within the Western Hemlock Zone. Summer frost in upper elevations is common, particularly on gentle topography. This zone represents an area in which periodic warm winter rains may cause rain-on-snow events.

Douglas-fir is also prevalent in this zone, but not as common as in the Western Hemlock Zone. Even though forests are typically dominated by Douglas-fir and noble fir following large fires, these species are eventually replaced by Pacific silver fir.

The Pacific Silver Fir Zone's tree layer is often quite diverse. It commonly includes: noble fir, western white pine, mountain hemlock, western hemlock, and western redcedar (Hemstrom et al. 1982). Trees are slower-growing in this zone and are commonly smaller than within the Western Hemlock Zone.

The Pacific Silver Fir Zone is concentrated to the Bull Run Watershed's north and eastern edges, as well as in the vicinity of Big Bend Mountain. In general, it occurs on higher and harsher sites than does the Western Hemlock Zone. Average elevation of this zone within the watershed is 3237 feet, which is lower than where the Pacific Silver Fir Zone is commonly found across the Mt. Hood National Forest. Based on field samples, the elevational range of the Silver Fir Zone within the watershed is 2100 to 4400 feet.

Mountain Hemlock Zone

The Mountain Hemlock Zone occurs above the Pacific Silver Fir Zone in harsher climatic conditions. Snowpacks prevail much of the year and frost can occur during the growing season. Biological processes are slow and result in fragile ecosystems. Trees grow slowly and attain smaller sizes in this zone.

Within the Bull Run Watershed, the Mountain Hemlock Zone is uncommon. It occurs on approximately 1% of the watershed in two upper elevational areas: one and a half miles south of Big Bend Mountain, and just south of Buck Peak.

Within the watershed, average elevation of the Mountain Hemlock Zone is 4052 feet.

Plant Associations

More than two thirds of the Bull Run Watershed is comprised of highly productive moist or wet site plant associations.

Plant associations are groupings of plant species which re-occur on the landscape within particular environmental tolerances. They are a relatively stable grouping of plant species that, over time, come into equilibrium with the physical, chemical and biological environment on a given site.

Plant associations, classified and described for the Bull Run Watershed, provide a means to infer a great deal about a site's characteristics (Halverson et al.1986; Hemstrom et al. 1982). More than 280 well-distributed field samples (plots) of plant association information have been documented for the Bull Run Watershed. These provide insights to habitat potential, fire regime, management limitations and opportunities, and other important landscape and ecosystem components.

Plant Association and Management Guides applicable to the watershed, including keys, descriptions, environment indications, and management limitations and opportunities, are available through the Mount Hood National Forest Supervisor's Office (Halverson et al. 1986; Hemstrom et al. 1982, Diaz and Mellen 1996). Evers et al. (1995) provides fire ecology group information that relates plant associations to fire regime including management implications (briefly outlined in this chapter's Fire section).

Table 4-10 – Plant Associations of the Bull Run Watershed

The following paragraphs and associated tables provide an overview of the plant associations known to occur within the Bull Run Watershed. Similar plant associations are grouped. Number of plots is included as a qualitative view of relative dominance of the different associations. Plant associations provide the basis to determine fire ecology group, also included in tables. (In the following tables: WH = western hemlock; PSF = Pacific silver fir; MH = mountain hemlock.)

Moist Site Plant Associations

Plant associations found on productive soils and moist sites dominate the Bull Run Watershed. Sites with these associations, rich in herbaceous species, are ideal for rapid and large-tree growth.

The dominance and far-reaching eastern extent of the highly productive western hemlock/swordfern/oxalis plant association is unique to this watershed. Its broad occurrence within the watershed is most likely influenced by the east-west orientation of the watershed's principle drainages – allowing penetration of warm, moist marine storms deep into the watershed's interior.

Plant Association	Fire Group	# of Plots
WH / Swordfern - Oxalis	*Eight*	*71*
WH / Alaska huckleberry / Oxalis	*Eight*	*24*
WH / Alaska huckleberry / Bunchberry	*Eight*	*2*
WH / Vanilla-leaf	*Eight*	*2*
PSF / Alaska huckleberry / Bunchberry	*Eight*	*40*
PSF / Oxalis	*Eight*	*17*
PSF / Foamflower	*Eight*	*2*
PSF / Vine maple / Foamflower	*Eight*	*2*

Wet Site Plant Associations

The wet site plant associations, frequent within the Bull Run Watershed, are extemely productive. These sites are dominated by devil's club or skunk cabbage, and are typically indicators of riparian conditions, intermittent flows or impeded drainage (year-round saturated soils). These wet site associations, combined with the moist site associations listed above, account for 69% of the sampled sites within the Bull Run Watershed.

Plant Association	Fire Group	# of Plots
WH / Devil's club / Oxalis	*Eight*	*12*
WH / Alaska huckleberry - Devil's club	*Eight*	*8*
WH / Skunk-cabbage	*Eight*	*1*
PSF / Devil's club	*Eight*	*12*

Dry/Warm Site Plant Associations

While present in the watershed, relatively dry sites are limited to midslopes on south or west aspects within the lower portions of the Bull Run, South Fork and Little Sandy drainages. These dry to mesic sites are identified by the dominance of broadleaf evergreen shrubs, and may be low in nitrogen.

Plant Association	Fire Group	# of Plots
WH / Dwarf Oregongrape - Salal	*Nine*	*21*
WH / Dwarf Oregongrape / Swordfern	*Nine*	*3*
WH / Dwarf Oregongrape	*Nine*	*2*
WH / Alaska huckleberry - Salal	*Eight*	*5*
WH / Swordfern	*Eight*	*5*
PSF / Alaska huckleberry - Salal	*Eight*	*8*
PSF / Rhododendron - A.huckleberry / Foamflower	*Eight*	*5*
PSF - WH / Rhododendron - Salal	*Eight*	*2*
PSF / Rhododendron - Dwarf Oregongrape	*Eight*	*2*

Cold/Dry Site Plant Associations

The following plant associations indicate sites in the watershed that are effectively cold and dry and may be deficient in nitrogen. These sites are located within the watershed's mid to upper elevations on steep, rocky ridgetops and upper slopes.

Plant Association	Fire Group	# of Plots
WH / Rhododendron / Beargrass	*Six*	*5*
WH / Big huckleberry / Beargrass	*Six*	*1*
PSF / Rhododendron / Beargrass	*Six*	*5*
PSF / Big huckleberry / Beargrass	*Six*	*3*
MH / Rhododendron	*Six*	*2*

Cold/Moist Site Plant Associations

Cold-moist to cold-wet sites within the watershed's upper elevations are indicated by the following plant associations:

Plant Association	Fire Group	# of Plots
PSF / Big huckleberry / Beadlilly	*Eight*	*7*
PSF / Cascade's azalea / Beargrass	*Six*	*3*
PSF / Fool's huckleberry	*Six*	*2*
MH / Cascade's azalea	*Six*	*2*

Conclusions: Potential Vegetation

- The Western Hemlock Zone covers 60% of the Bull Run Watershed, while the Pacific Silver Fir Zone covers 40%. The Mountain Hemlock Zone is uncommon at less than 1%.
- The Western Hemlock Zone dominates the western portions of the watershed and forms a crescent-shaped band that extends up the main fork of the Bull Run River and its adjacent slopes.
- The Pacific Silver Fir Zone on average, occurs at lower elevations than commonly found across the Mt. Hood National Forest.
- More than two thirds of the Bull Run Watershed is comprised of highly productive moist or wet site plant associations.
- The dominance and far-reaching eastern extent of the highly productive western hemlock/swordfern/oxalis plant association is unique to this watershed. Its occurrence is influenced by the east-west orientation of the watershed's principle drainages that allow penetration of warm, moist marine storms deep into the watershed's interior.
- Site specific information on plant association distribution and plot location can be found in the Analysis File and Bull Run Databases.

Structure

Forest vegetation can be categorized by both physical structure (tree size and canopy closure) and seral (or successional) stage. Both are often key determinants of habitat for various species of plants and animals and both affect a variety of landscape processes.

The Integrated Satellite Vegetation Database (ISAT, USDA 1993) was used as a base for extracting current forest stand structure information. ISAT data is derived through a process that scans a 1989 satellite pixel classification to produce the best representation of vegetation types -- based on canopy cover, size structure, and species groups.

ISAT data was available for most of the watershed. To complete the data coverage, a small area in the watershed's western end was interpreted into broad ISAT categories from 1995 aerial photos. The entire coverage was then updated for timber harvest that occurred between 1989 and 1995. ISAT structure classes were grouped into categories that best approximate those in the Mt. Hood National Forest's wildlife habitat relationship database. This database uses the widely-recognized wildlife habitat classes based on tree size and canopy closure from Hall et al. (1985).

Detailed documentation that describes how the various data from the sources mentioned above were grouped into Structure Class and Seral Stage as used in this analysis can be found in the Bull Run Watershed "Analysis File". A basic description of criteria used is presented below for structure and in the next section for seral stage.

Structure Classes

Structure classifications are based on tree size and canopy closure. Two levels of structural categories were used in this analysis:

1. Coarse splits into ***Open, Small Conifer,*** and ***Large Conifer.***
2. Finer breaks based primarily on canopy closure within these three classes.

The Bull Run Watershed currently consists of the following structure classes: 50% Small Conifer, 33% Large Conifer, 15% Open, and 2% non-vegetated.

Open:. Areas of potential forest that currently function as openings. The watershed's Open stands have resulted primarily from recent timber harvest, windthrow events and timber salvage. A minor amount of acreage in the Open category can be attributed to fire. The Open structure class includes:
(Note: dbh = diameter at breast height -- 4 1/2 feet)

- Grass/forb/shrub (GFS): Dominated by early-seral vegetation and tree seedlings with less than 40% total tree canopy cover. (4258 acres.)
- Open Sapling/Pole (OSP): sapling and pole size trees dominate (<9" dbh) and canopy cover is 70% or less. Shrubs may be well established. (8976 acres.)

Small Conifer: Stands that have tree canopy closure over 40% and are dominated by tree sizes between 9-21" dbh, or sapling/pole stands over 70% closure. Small conifer stands in the watershed include mid-seral stands originating from past stand-replacement fires, old stands on poor sites (primarily Pacific Silver Fir Zone), and old plantations on productive sites.

Old-growth stands that exist at higher elevations may contain smaller tree sizes than those in the lower elevation Douglas-fir dominated stands, however, they too provide important ecological functions as described under the Large stucture class. Small conifer stands include:

- Closed Sapling Pole (CSP): trees up to 9" dbh dominate the stand; canopy closure is greater than 70%. Early-seral understory vegetation is sparse due to dense canopy. (1848 acres.)
- Open Small Conifer (OSC): trees 9-21" dbh dominate the stand; canopy closure is 70% or less. These stands are found primarily in the Pacific Silver Fir Zone and often include special habitats of rock/talus. (7351 acres.)
- Closed Small Conifer (CSC): trees 9-21" dbh dominate the stand; canopy cover is over 70%. A variety of stands are represented -- from dense young single-story stands with little understory vegetation to old stands with multiple canopy layers. At 35,039 acres, this structure type is the most widespread in the watershed.

Large Conifer: Stands that have tree canopy closure of 40% or more and are dominated by trees greater than 21" in diameter. Large conifer stands in the Bull Run Watershed tend to be quite old (most are more than 500 years in age) and have developed old-growth characteristics such as large live trees, standing dead trees, multiple layered canopies, and large down logs.

These old forests of Large conifers provide habitat for old-growth related species of plants and animals. Some old-growth species such as certain species of lichens may take hundreds of years to colonize a site.

Scattered old-growth patches in areas that have little of this stand structure are important for maintaining local populations of species that are poor dispersers by providing a source to repopulate future or adjacent stands.

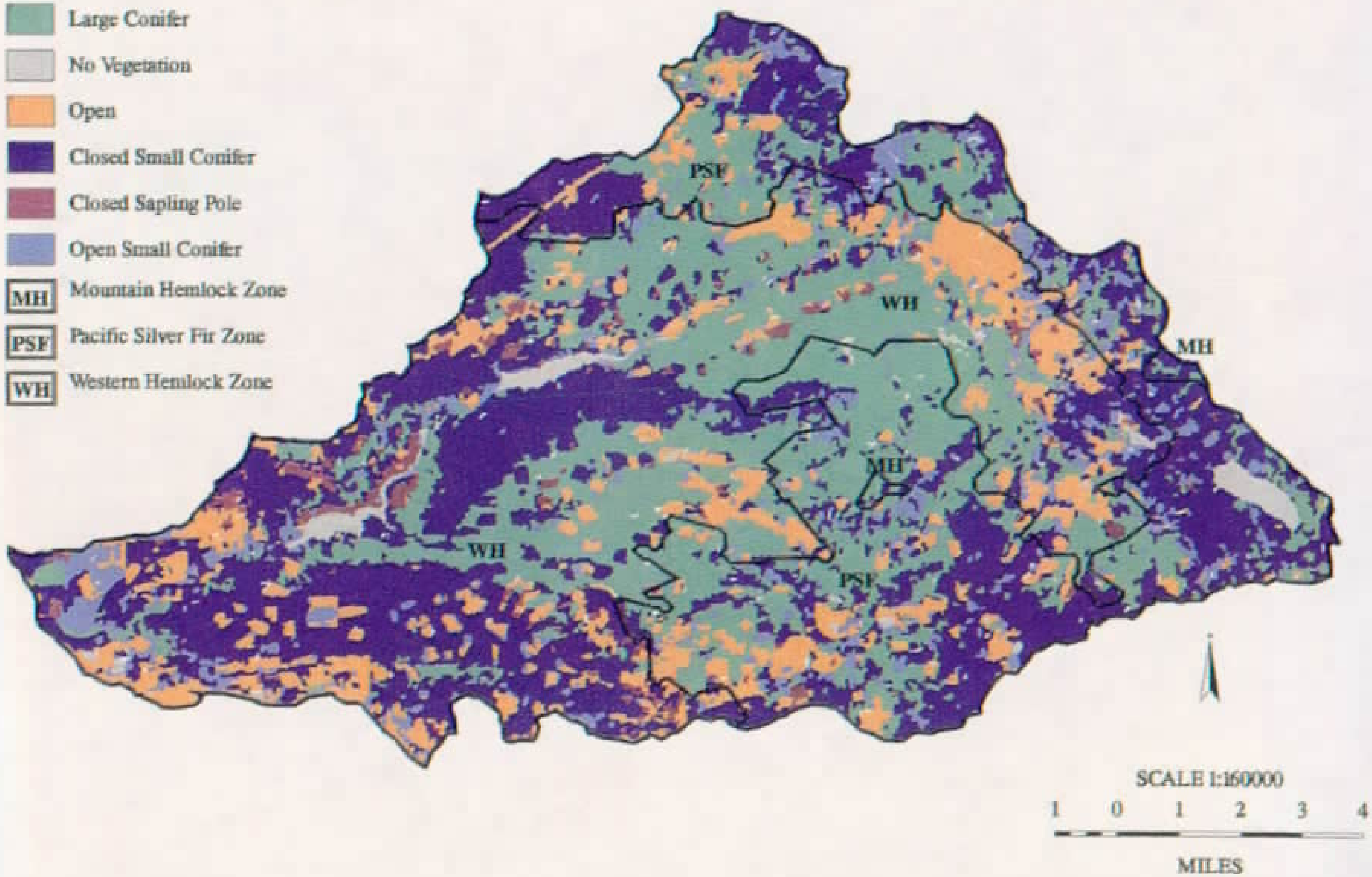
The Large class may also include mature stands beginning to develop characteristics of old-growth. Large conifer stands are predominantly found in the highly productive, moist plant associations and include:

- Open Large Conifer (OLC): trees over 21" dbh dominate the stand, and canopy cover is 50% or less. (781 acres.)
- Closed Large Conifer (CLC): trees over 21" dbh dominate the stand and canopy cover is over 50%. This structure type is common in the watershed, representing 28,741 acres.

Large Conifer stands in the Bull Run Watershed tend to be quite old. Most are over 500 years in age and have well developed old-growth characteristics.

Figure 4-15 – Current Stand Structure, displays the spatial arrangement of stand structures across the watershed. *(The sub-categories of Large and of the Open class are not broken out for display purposes)*

Bull Run Watershed
Current Stand Structure



Historic Stand Structure and Trends

Information from 1940 county forest cover surveys (USDA 1944) provides stand structure information prior to most timber management activities and recent windthrow events. Data were only available for Federal lands (93% of the watershed). Circa 1948, the Bull Run Watershed included: 6% Open, 32% Small Conifer, and 61% Large Conifer. Approximately 1% of the watershed's area was attributed to rock or water.

Table 4-11 -- Stand Structure: 1948 v.s. 1996

Amounts expressed as percent of watershed*

Structure Class	1948	1996
Large	61	36
Small	32	48
Open	6	14
Non Veg.	1	2

*(*comparison based on Federal lands only)*

The most notable change from 1948 to present is the decrease in the amount of Large Conifer stands from approximately 61% down to 36% of the watershed.

Reasons for the stand structure differences presented in Table 4-11, in order of magnitude, include:

1. *Timber management:* Primarily regeneration harvest that converted mostly Large Conifer stands to Open structure, some of which has subsequently grown into Small conifer stands.
2. *Windthrow/salvage:* Windthrow (specifically 1973 and 1983 events) combined with subsequent timber salvage operations, converted stands primarily comprised of Large Conifer to Open.
3. *Growth:* The most noticeable change is in managed Open structure stands created through timber harvest (within this time period) that have subsequently grown out of Open into the lower end of the Small Conifer class.

4. *Different data sources:* Although some inconsistencies between the 1948 and 1996 data sets were readily rectified, minor differences still exist.

5. *Reservoir construction:* Reservoir #2 was constructed as well as small reservoir projects during this time period, resulting in the conversion of some Large Conifer to Non Vegetated.

6. *Fires:* Few stand-replacing fires occurred during this period (86 acres). This converted stands from Large or Small conifer to Open.

Even within a high severity fire regime as found in the Bull Run Watershed, some snags, downed trees, large remnant trees and forest patches were left after stand-replacing fires. These components of the preceding stand provided structural diversity within the newly created openings that was carried into the new stands that followed.

Many of the existing early-seral stands in the watershed, however, were created following timber management activities and lack the structural components left behind by natural fire. (Harvest activities since the late 1980's, however, tended to leave more structural components behind. Current Northwest Forest Plan standards and guidelines require even higher levels of these structural components to be retained after harvest, ROD p. C-39 to C-44.)

For the most part, landscape level effects from decreased stand structure in this watershed are minimized as harvest units are dispersed among late-seral forests rich in structural diversity. Altered conditions and ecological processes, however, may exist in subwatersheds that are low in late-seral forests and dominated by aggregated harvest units (Lower Little Sandy, Lower Bull Run, Headworks, and Otter Creek area of Bull Run).

Altered conditions and ecological processes that result from decresed stand structure may exist in subwatersheds that are both low in late-seral forests and dominated by aggregated harvest units.

Conclusions: Stand Structure

- The Bull Run Watershed currently consists of the following structure classes: 50% Small Conifer, 33% Large Conifer, 15% Open, and 2% non-vegetated.
- Large Conifer stands in the Bull Run Watershed tend to be quite old -- most over 500 years in age -- and have well developed old-growth characteristics.
- Some stands of Small Conifer at upper elevations are actually quite old (300 - 500 years). These stands are classed as late-seral forest *(next section).*
- The amount of Large Conifer Stands has decreased since 1948 in the watershed primarily as a result of timber management activities, windthrow, timber salvage, and reservoir projects.
- Altered conditions and ecological processes may exist in four subwatersheds that are low in late-seral forest and dominated by aggregated harvest units. (Lower Little Sandy, Lower Bull Run, Headworks, Otter Creek area)

Seral Stage

Old stands serve ecological roles that young stands of similar tree size may not. For this reason, seral stage was analyzed separately from physical stand structure. Seral stage serves as an important ecological driver within the watershed that affects a variety of ecosystem functions, including: hydrologic function, wildlife species use, nutrient cycling, production of snags and woody debris, and disturbance processes (fire, windthrow and landslides, among others). Current Seral Stage for this analyses was determined using *both* stand structure *and* forest zone data. Forest zone helps to account for differing productivity potentials.

Three categories of forest Seral Stage were utilized in this analysis. These classifications were also used when assessing Northwest Forest Plan standards and guidelines that refer to seral or successional stages:

1. **Early-seral:** Areas of potential forest that currently function as openings. Stands are dominated by shrubs, forbs, grasses and/or tree seedlings or

scattered tree saplings. Early-seral stands are essentially all stands classed as Open structure including grass/forb/shrub through open/sapling/pole classes.

2. **Mid-seral:** Trees are well established in these stands and dominate the vegetation. Includes closed sapling pole structure class and all stands dominated by trees 9-21" dbh in Western Hemlock Zone (may have some trees over 21"), and stands dominated by trees 9-21" dbh in the Pacific Silver Fir or Mountain Hemlock zones that do not have a component of trees over 21" dbh.

3. **Late-seral:** Late-seral forests are those forest seral stages that include mature and old-growth age classes. Includes all stands classified as Large conifer (over 21" dbh) in all zones. Includes Small conifer stands in the Pacific Silver Fir or Mountain Hemlock Zone with multiple canopies that include at least some trees over 21" dbh.

Currently, late-seral forests occupy 45% of the Bull Run Watershed's land area. Late-seral forests within the watershed tend to be quite old, with some approximately 300-years-old. Most are more than 500-years-old. Mid-seral forests account for 38% – 15% are early-seral, and 2% is non-vegetated (rock/water).

ROD 15% Late-Successional Guideline

In this watershed analysis document, the terms late-successional and late-seral are used with the same meaning. Standards and guidelines from the Northwest Forest Plan state that landscape areas where little late-successional forest persists should be managed to retain late-successional patches.

This standard and guideline will be applied in fifth field watersheds with 15% or less late-successional forest on federal lands (ROD p. C-44). The Bull Run Watershed as defined in this analysis *(a fifth field watershed)* is well above this criteria with 49% late-seral forest ***on federal lands.***

If the Little Sandy subwatersheds are excluded, the amount is 53%. If the Little Sandy is viewed as a separate watershed, it too is above the 15% standard and guideline at 28%. Amounts in the Little Sandy subwatersheds, however, are currently poorly distributed and highly fragmented. There is a fair amount of mid-seral forest of nearly 120-years-old that is in transition to late-seral forest (initiated from 1873 fires) in the Lower Little Sandy Subwatershed.

Most of the late-seral forest in the watershed occurs on "reserve lands". Currently 47% of federal lands in the watershed support late-seral forests that are protected by reserve lands. Reserve lands for this purpose include Administratively Withdrawn, Riparian Reserves and Late Successional Reserves. Table 4-12 displays how the amounts of late-seral forest are distributed on federal lands.

Table 4-12 -- Late-Seral Amounts on Federal Lands

Amounts are grouped by reserve and matrix allocations

Federal Land Area	Total Acres by Area	Acres of Late-Seral	Percent of Late-Seral
Reserve Lands	71,998	37,250	**47%**
Other Lands	7,168	1,462	**2%**
All Federal Lands	**79,166**	**38,712**	**49%**

(Note: If the Little Sandy is examined independently, it too has over 15% of the federal lands in reserve lands with late-seral forest (17%).

Figure 4-16 -- Seral Stage Amounts by Subwatersheds

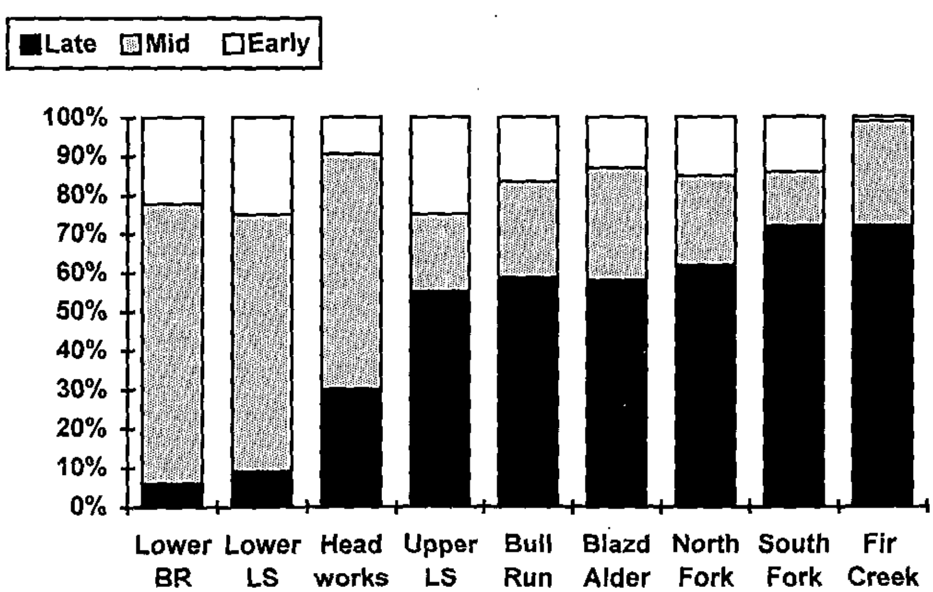


Figure 4-16 -- Seral Stage Amounts by Subwatersheds, displays the proportions of each subwatershed within the three seral stages. Three subwatersheds, Lower Bull

Run, Lower Little Sandy and Headworks are quite low in the amount of late-seral forest and have only isolated patches of old-growth.

Seral Stage – Range of Natural Variability (RNV)

Ecosystems are not static. They vary over both time and space. Successional processes, coupled with a range of disturbance regimes, account for much of this natural variability. Rather than emphasizing any single point in time, the range of natural variability (RNV) concept recognizes the dynamic nature of ecosystems and helps us understand what these parameters may be.

These parameters provide an indication on what may or may not be sustainable within an ecosystem, as well as the ecosystem's resiliency. When an ecosystem condition or process is pushed outside this range, that condition/process and those depending upon it might not be sustained naturally. This range can provide "a picture" of what condition a particular species or population may have evolved under or adapted to over time.

Exploring the range of natural variability helps inform assessments of possible consequences of deviation, and choose appropriate courses of action.

Applying the range of natural variation (RNV) to Seral Stage in the Bull Run Watershed provides an ecosystem reference from which to assess current conditions and future trends. One source for helping define what natural ranges may have been for Seral Stage within this watershed was an examination of the area's fire history by Krusemark et al. (1996).

This study provides spatial data on stand ages over the past 500 years. Thus, it provides a unique opportunity to look at not just one, but *several* points in time. By using the stand age information and mapped fire polygons, the Analysis Team reconstructed seral stage amounts and distribution on the landscape by "ungrowing" stands back to different periods of time. Three representative time periods were chosen from this data (1700, 1805, 1900).

In addition, the 1948 forest cover survey data were also used to establish a fourth time reference. This data provided a relatively recent view of the landscape prior to most timber management periods. This snapshot in time, as well as the current (1996) condition, was based primarily on stand structure rather than age.

Together, these four Seral Stage snapshots in time provide valuable insights into: the range of natural variability, the distribution of the three seral stages through time, and a reference from which to evaluate current conditions. Additional assumptions used in this analysis of seral stage through time are presented in the analysis file. Figure 4-17 through Figure 4-21 display the amount and distribution of the various forest seral stages through time.

Figure 4-17 -- Seral Stage and Distribution in 1700

Figure 4-18 -- Seral Stage and Distribution in 1805

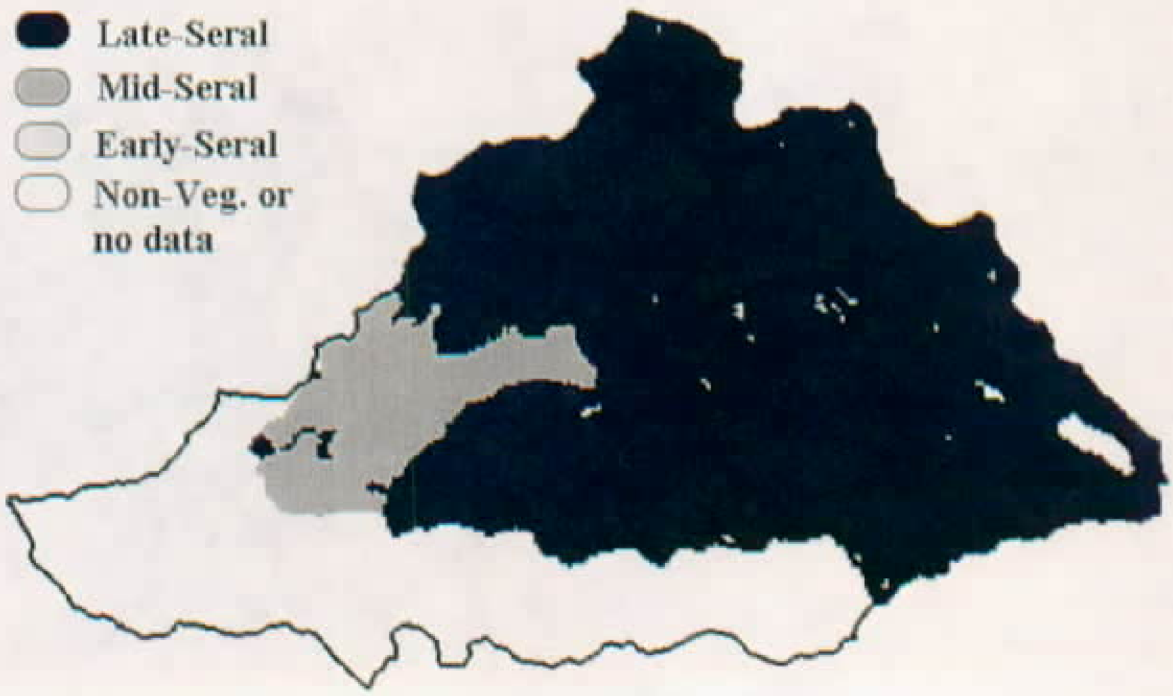


Figure 4-19 -- Seral Stage and Distribution in 1900

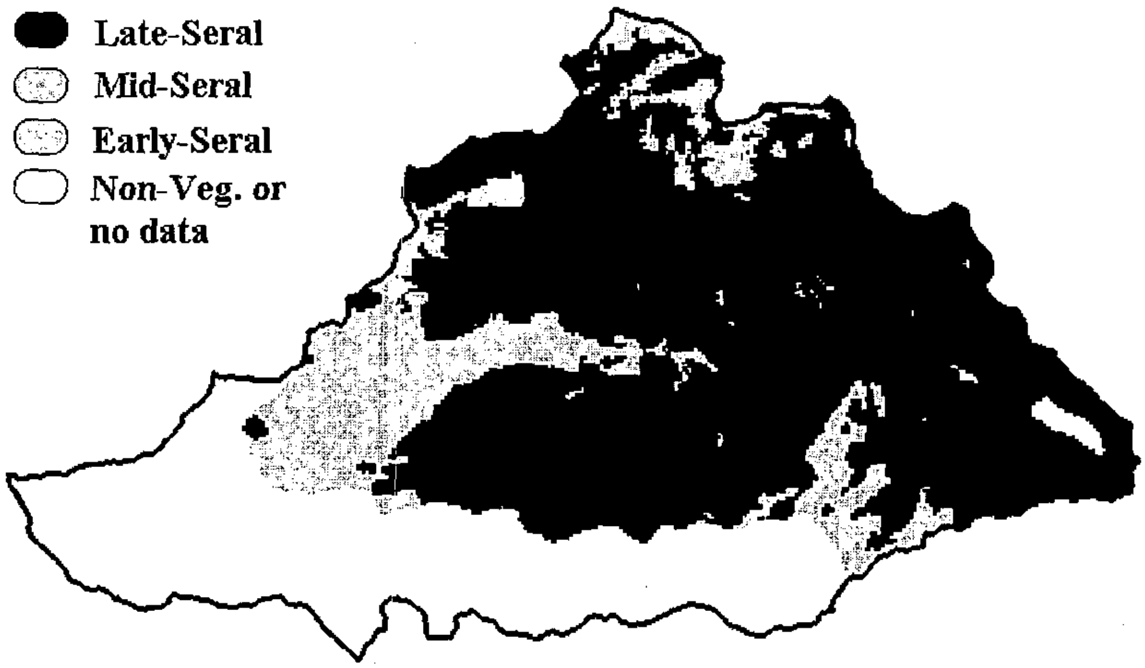


Figure 4-20 -- Seral Stage and Distribution in 1948

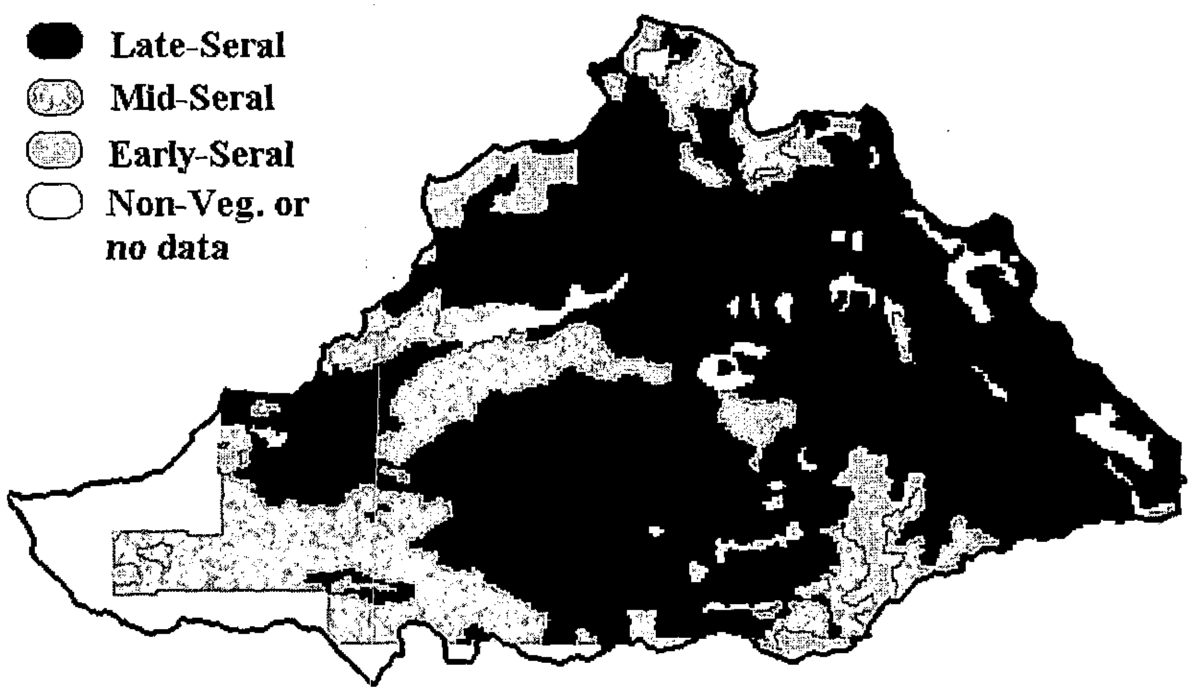


Figure 4-21 -- Seral Stage and Distribution in 1996

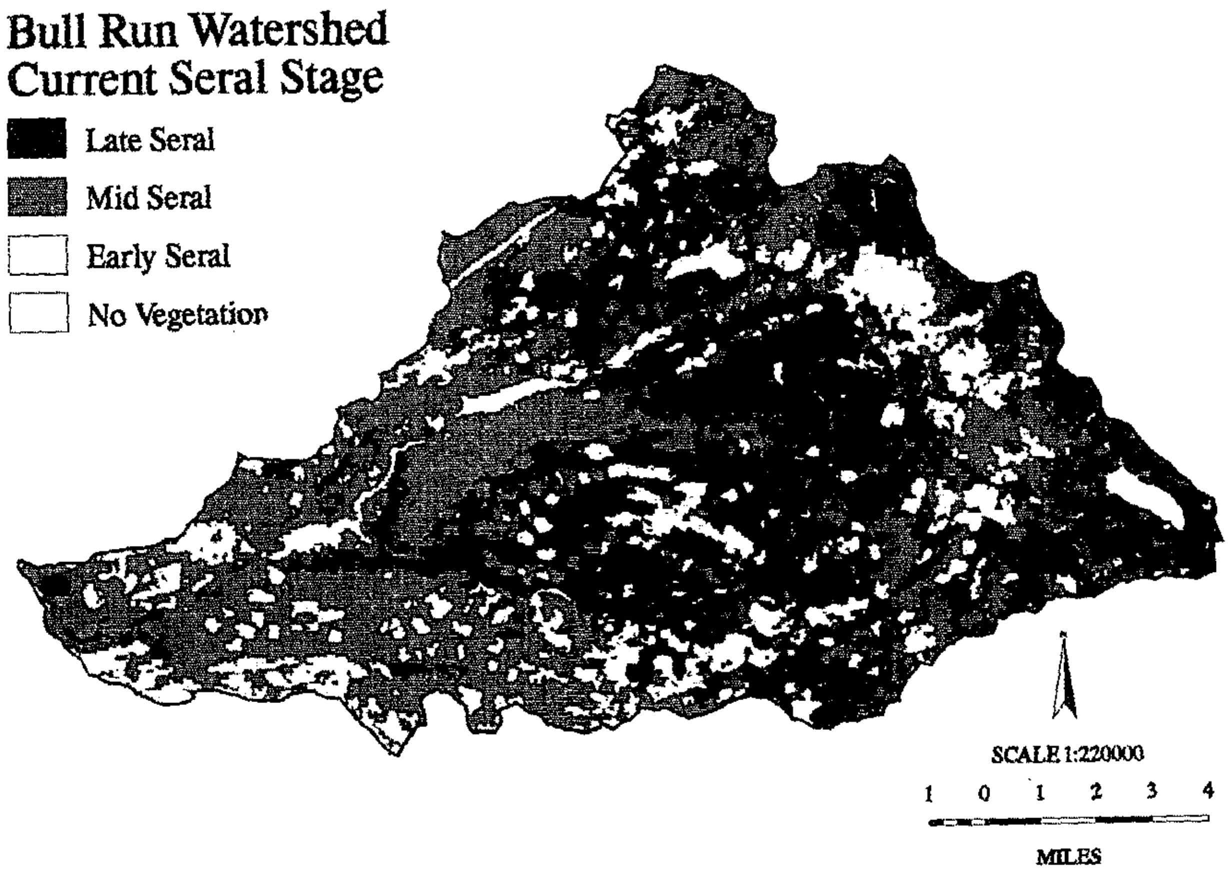
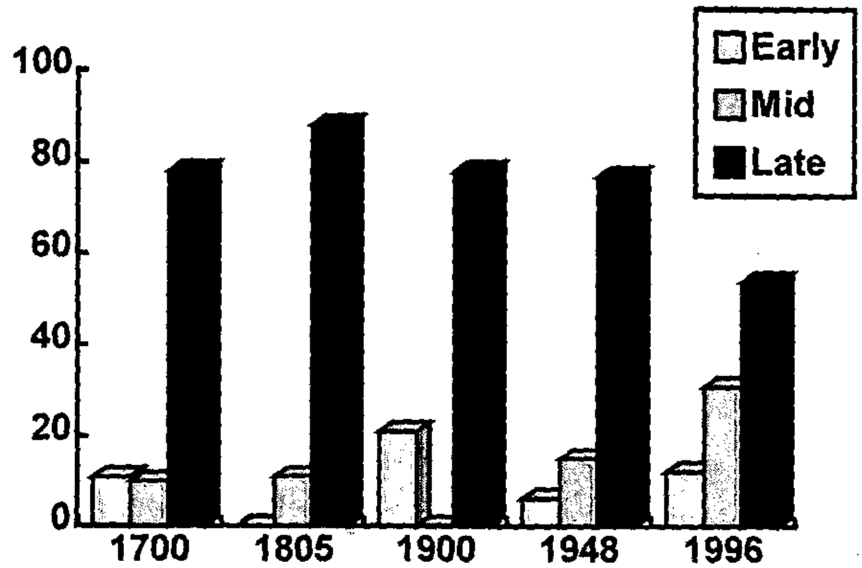


Figure 4-22 -- Seral Stages Through Time, displays the percentage of the landscape within the water supply drainage (65,356 ac) within the three seral stages at four previous points in time as compared to 1996. The four time periods of 1700, 1805, 1900, and 1948 were used to construct the range of natural variability (RNV) for the watershed.

Figure 4-22 – Seral Stages Through Time

(percent of water supply drainage)



The comparisons over time and Range of Natural Variation (RNV) are based solely on the Bull Run Watershed's municipal water supply drainage (65,356 acres) -- even though additional information is displayed on the above illustrations in

Seral Stage – Watershed Scale Trends

The amount of late-seral forest is currently below the Range of Natural Variability, with most of the deviation occuring in the Western Hemlock Zone.

Table 4-13 displays the RNV for the three Seral Stages compared to the 1996 existing condition for the Bull Run Watershed (water supply drainage only).

Table 4-13 -- Seral Stage: RNV vs. Current Condition

Bull Run Watershed

By percent of total area (water supply drainage)

Zone	Seral Stage	RNV %	Current %
WH	Late	74-81	42
PSF	Late	72-98	69
Total	**Late**	**77-88**	**54**
WH	Mid	0-15	39
PSF	Mid	0-18	22
Total	**Mid**	**0-15**	**31**
WH	Early	0-25	16
PSF	Early	0-15	7
Total	**Early**	**0-21**	**12**

Note: Based on the assumptions used, for brief periods (up to 50 years) during the mid-1600s and mid-1800s, the amount of late-seral forest approached 100% of the watershed. Between 1493 and 1613, the amount of late-seral may have been below 10% following a large fire event in 1493. Stands missed by the 1493 event, however, show lack of fire for 250 years prior to that. Both extremes noted were not included in the ranges reported in Table 4-13.

It is important not to extract too much detail from such comparisons, but rather to focus on obvious trends or amount of deviation and implications to ecological function. The portion of the watershed that was examined has experienced until recently, a constant, substantial percentage (77-88% and occasionally higher) of late-seral forests over the past 350 years. The natural ranges of late-seral forest for both the Western Hemlock Zone (74-84%), and the Pacific Silver Fir Zone (72-98%), were high and quite similar. Likewise, the range of early-seral forest over time was also similar -- 0-25% in the Western Hemlock Zone, compared to the Pacific Silver Fir Zone's 0-15%.

The total amount of late-seral forest is currently outside (below) the range established over this time period. Without the influence of timber harvest, windthrow, salvage, and reservoir construction projects over the last 50 years, the current amount (given the same fire history) would be 74% -- a percentage rather consistent to amounts over the past 350 years.

As outlined in Table 4-13, the greatest deviation occurs within the Western Hemlock Zone, the area in which most harvest activities as well as the last large fire event (1873) have occurred. Within this zone, the amount of mid-seral forest is currently outside (above) the established range. Amounts of mid-seral forest beyond that initiated by past fire events are largely due to re-growth within older harvest units. Within the watershed's western portion, additional stands from the large 1873 fires are presently in transition from mid-seral to late-seral. The total amount of early-seral forest present on the landscape is within the established range.

Seral Stage -- Watershed Context and Basin Scale Trends

Approximately one half of the late-seral forests present in the Sandy River Basin are located within the Bull Run Watershed.

The Bull Run Watershed and four other watersheds comprise the Sandy River Basin. Data from the *1993 Regional Ecological Assessment Project* (USDA, 1993), presents Seral Stage conditions at the basin level. RNV and existing conditions were developed for the Sandy Basin for early and late-seral stage by forest zone.

Table 4-14 -- Seral Stage: RNV vs. Current Condition, Sandy Basin

(by percent of total area within Forest boundary)

Zone	Seral Stage	RNV %	Current %
WH	Late	47-59	27
PSF	Late	38-55	35
WH	Early	8-28	12
PSF	Early	9-35	13

According to the Regional Ecological Assessment Project (REAP) analysis, the Sandy Basin is currently below the RNV for late-seral forests in both Western Hemlock and Pacific Silver Fir zones. Additionally, the basin is at the low end of RNV for early-seral.

REAP information, coupled with information from Watershed Analysis, provides a context to the Bull Run Watershed's overall role in the Sandy Basin. Table 4-15 displays the percentage of total late-seral acreage (by forest zone) distributed among the basin's five watersheds.

Table 4-15 -- Distribution of Late-Seral Forests in the Sandy Basin

Percent of basin total by watershed, grouped by zone

(amounts based on lands within Forest boundary)

Zone	Bull Run	Zigzag	Salmon	Sandy	Gorge Tribs	Sandy Basin
WH	51	3	17	10	19	31736 ac
PSF	53	3	27	9	8	43540 ac

At present, approximately half of the basin's late successional forests are located in the Bull Run Watershed. Given the high amount of late-seral forest over the past 350 years, in the watershed, the Bull Run Watershed may have accounted for a large proportion of the late-seral forests within the Sandy River Basin through time.

Conclusions: Seral Stage

- Seral stage is defined by using both stand structure data (*tree size and forest canopy closure*) and productivity data (*forest zone*).
- Seral stage is synonymous with successional stage throughout this analysis.
- Late-seral forests are above the ROD retention standard of 15%, with 49% currently present on Federal lands, most all of which is within reserve lands.
- Late-seral forests in the Bull Run Watershed tend to be very old. Most are over 500-years-old.
- The amount of late-seral forest is currently below the Range of Natural Variability (RNV), with most of the deviation occuring in the Western Hemlock Zone.

- Without the effects of timber harvest, windthrow, timber salvage, and reservoir construction that occurred during the past 50 years, the amount of late-seral forest would be nearly within the RNV.
- Over the past 350 years the watershed has contained a rather constant and high amount of late-seral forest (77-88% of the watershed).
- In addition to late-seral forest, western portions of the watershed contain a fair amount of older mid-seral forest (80-120 years old) that is in transition to late-seral forest.
- Three subwatersheds are quite low in the amount of late-seral forest (5-30%) and have only isolated patches of old-growth (Lower Bull Run, Lower Little Sandy and Headworks).
- Approximately one half of the late-seral forests present in the Sandy River Basin are located within the Bull Run Watershed.
- The Bull Run Watershed may have accounted for a large proportion of the late-seral forests within the Sandy River Basin through time.

Landscape Pattern

Landscape pattern is a critical determinant of landscape scale ecological processes. Most forests in the Bull Run Watershed have been initiated by stand-replacing fires that range back 750 years ago (Krusemark et al. 1996). These large, infrequent events influenced species composition and stand structure, and, in turn, the landscape pattern. Pattern characteristics include patch size, shape, amount of edge/interior habitat, and degree of fragmentation or connectivity.

Landscape pattern affects ecological function. According to Chen et al. (1990), late-seral forests next to clearcuts may have reduced humidity, increased wind velocity, and increased summer temperatures up to 600 feet into the forest. Soil temperature and moisture content may be affected up to 400 feet from the edge. Any species that relies on microhabitats found in interior forest patches may have problems with edge habitat.(Chen et al. 1990) High amounts of edge may also allow for invasion by edge predators and introduced species (Simberloff et al. 1992).

Interior habitat is defined in this analysis as late-seral stands that are at least 500 feet from created openings whereas that portion within 500 feet functions as edge. Created openings include those created by human activities such as timber harvest or natural disturbance events such as lightning fires. Openings for this purpose generally will be early-seral forest patches and exclude stable natural openings such as wetlands or rock patches.

Large blocks of interior habitat within or partially within the Bull Run Watershed include two over 5000 acres, three between 2500-5000 acres, one between 1000-2500 acres, and three between 600-1000 acres.

The landscape of the Bull Run Watershed is dominated by mid to late-seral, closed canopy forests. This forest is interspersed with natural and created openings in varying degrees over time (both permanent and successional). As illustrated in through and in the Composite Fire History map in this chapter's Fire Section, landscape patterns prior to the 20th century generally consisted of large unfragmented, irregularly-shaped patches. Forest cover of mid to late-seral stands dominated the landscape in large unbroken areas.

A large-scale landscape analysis of the Mt. Hood National Forest (PULSE, 1994) included a classification of landscape patterns. The Sandy Basin as a whole currently includes extensive areas of unfragmented forest (some late, but most within mid-seral conditions); perforated old forest; and some smaller areas of local fragmentation or aggregated openings. The Bull Run Watershed is dominated by the Perforated class with some areas of Fragmented and Aggregated Openings.

***Perforated* -- (approximately 60% of watershed)**

Closed canopy forest comprises 70-80% of total landscape within this class and is perforated by uniformly dispersed harvest units of up to 60 acres. Forest connectivity is still high, although the amount of interior habitat is reduced from that of an unfragmented condition. This condition is common from east to west across the watershed's central portion.

***Fragmented* -- (approximately 10% of watershed))**

Closed canopy forest comprises approximately 60-70% of this landscape, with the remainder occurring in open patches or plantations created through timber harvest. Harvest units tend to be uniform in size, less than 60 acres, with high contrast edges. Harvest units are fairly evenly dispersed within the forest. Forest connectivity may begin to be significantly impaired when the amount of forest reaches 60% or less. The area around North Fork Bull Run River fits this description.

Aggregated Openings -- **(approximately 30% of watershed)**

Closed Canopy forest is less than 50% of this landscape. Open patches, created primarily by human activities, dominate the structure and function of the landscape. Openings begin to coalesce into areas larger than 60 acres. Forest connectivity is severely reduced or absent, as is interior habitat. This condition is prevalent in the central portion of the Little Sandy Watershed, the upper portion of the Bull Run River (Otter Creek area), and along the eastern edge of the Bull Run Watershed.

The Bull Run Watershed is bordered to the north by an extensive area of unfragmented lands in the Columbia River Gorge National Scenic Area. Late Successional Reserves surround the watershed to the northwest, north and east and for the most part contain unfragmented forest. In contrast, the watershed is bordered to the south by an extensive area of aggregated openings within the U.S. Highway 26 Corridor.

Conclusions: Landscape Pattern

- Landscape patterns are generally altered from the RNV, with patchy high contrast patterns common instead of large irregular patches.
- Dispersed timber harvest units have caused many portions of late-seral forests to function as edge.
- At the landscape scale, forest connectivity is quite good across much of the watershed. Large blocks (in excess of 600 acres) of late-seral forest are common and often connected or within close proximity to other large contiguous blocks of late-seral forest.

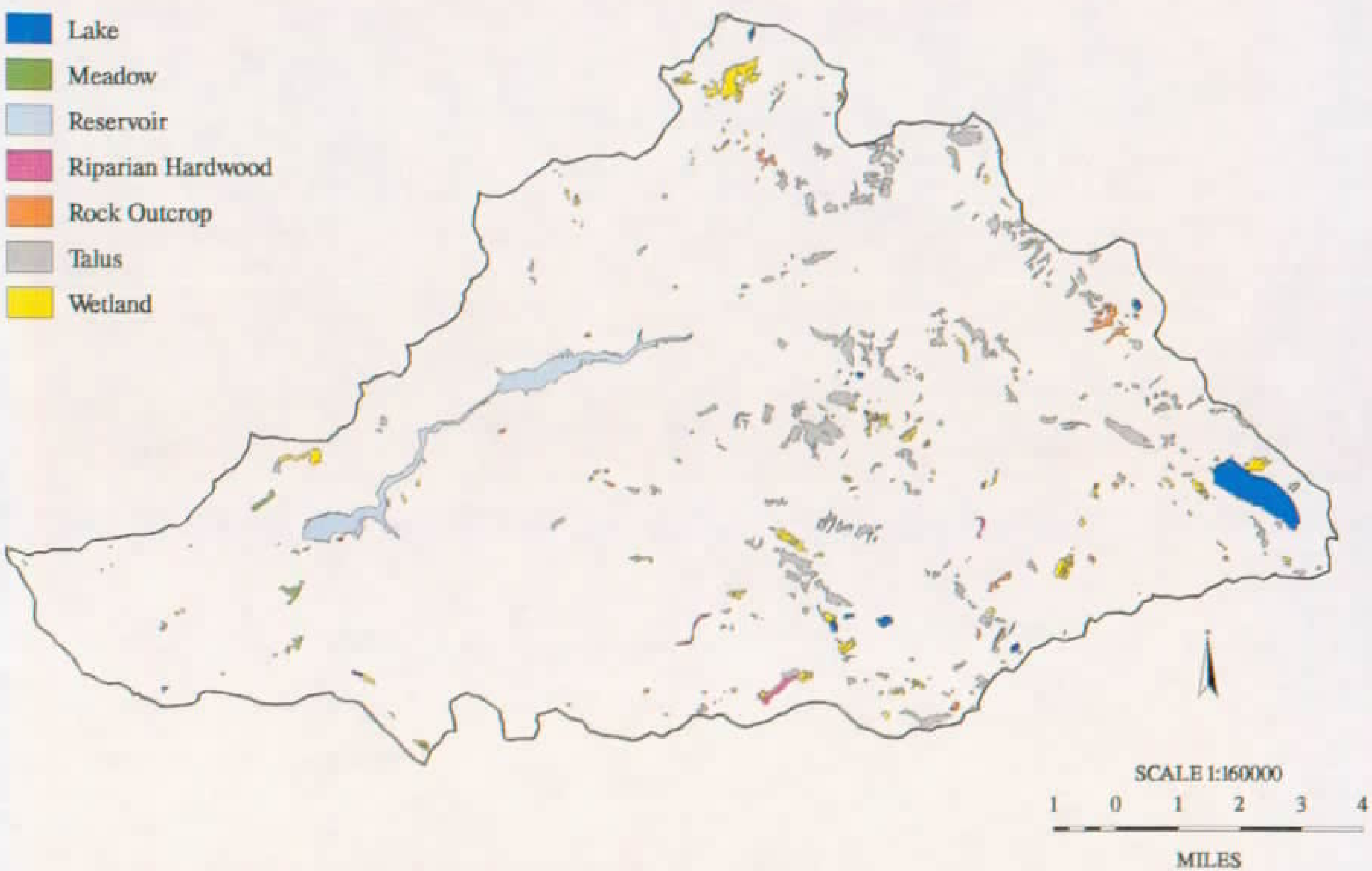
Special Habitats

The Bull Run Watershed includes approximately 3,000 acres of special habitats (unique areas with limited distribution). Table 4-16 -- Special Habitats and Species of Concern lists habitat types, approximate acres, and the associated "species of concern" who use these habitats. The Special Habitat Map (Figure 4-23) shows the distribution of these habitats across the watershed. A brief discussion of each habitat follows. (Additional discussions of individual species are included in this chapter's botany, wildlife, and fisheries subsections.)

Table 4-16 -- Special Habitats and Species of Concern

SPECIAL HABITAT	ACRES	ASSOCIATED SPECIES
Talus	1929	survey and manage lichens
Rock	208	Howell's daisy, long-bearded hawkweed, Columbia lewisia, peregrine falcon
Wetland	850	pale sedge, Indian rice, bog clubmoss, scheuchzeria, Strickland's taushia, lesser bladderwort, adder's tongue, stiff clubmoss, wild cranberry, sweet gale, red-legged frog, Cope's giant salamander
Lakes	536	common loon, bald eagle
Reservoirs	877	common loon, bald eagle
Meadow	94	

Bull Run Watershed Special Habitats



Talus slopes: comprise the most common special habitat in the watershed (1929 acres). These piles of boulders and rocks can be vegetated or unvegetated, wet or dry. Picas and other small mammals use these spaces as homes and cover. Some plants such as parsley fern, selaginella, and sedums are also associated with talus. Talus slopes can often be covered with a layer of desiccation-tolerant lichens and bryophytes. Moist, shaded talus provides potential habitat for the sensitive Larch Mountain salamander.

Rock habitat: includes large rock outcrops and cliffs. While cliffs may provide some nesting sites for peregrine falcons, higher quality sites are available for this species in the nearby Columbia River Gorge. Howell's daisy, a sensitive plant confined almost entirely to Columbia River Gorge rock outcrops, occurs on basalt outcrops in the Bull Run Watershed's Blazed Alder drainage. More basalt habitat is available for this flower and other rare Gorge flowers within the watershed. (See geology map, **Figure 4-1**). Some Northwest Forest Plan "survey and manage" lichen species specific to forested rock outcrops have the potential to occur within this watershed (ROD, pg C-57; Boyll 1996).

Wetlands: Various types of wetlands are scattered throughout the Bull Run Watershed, including wet meadows dominated by sedges and herbs, and both shrubby and forested wetlands. The National Wetlands Inventory Map (available for viewing at the Zigzag Ranger Station) was used as a base layer to create this portion of the Special Habitat Map.

Wetlands are generally recognized as important areas of biological diversity.

A 1981 survey of 25 wetlands located 195 plant species, approximately half of the plant diversity then documented in the watershed (Siddall, 1981). Ten known species of rare plants and two rare wildlife species inhabit the watershed's wetlands.

Unique aspects of the watershed's wetlands include a large number of sphagnum bogs (Siddall, 1982), as well as relatively little human visitation. Reservoir construction activities, however, have altered two of the watershed's larger wetland complexes from their historic condition.

Latourelle Prairie, a 151-acre wetland located in the watershed's northern tip, was dammed in 1959 to become Boody Lake. In a 1967 photo, approximately one-third of the wetland appears flooded. Approximately 55 acres of wetland habitat were eliminated. The dam is now a culvert; and a 1977 photo taken after a series of spillway failures and impoundment fluctuations shows water levels back to pre-dam levels. The historical distribution of the sensitive plant Indian rice in Latourelle Prairie may have been decreased by the flooding. (See Regional Forester's Sensitive Species section in this chapter.) Impacts on other plants and wildlife is not known.

In addition to approximately 18 years of unnatural water levels, additional disturbances have included: a powerline corridor intruding through the wetland's northwest corner, and clearcut harvest units partially bordering its northwest and eastern edges. Despite these disturbances, Latourelle Prairie appears to be in good health. When pre-dam 1958 and 1995 photos are compared, its physical shape and distribution of water appear similar. In addition, elk herds still forage here and Indian rice has been located in the previously flooded area.

Goodfellow Lakes (three individual lakes) are located north of the watershed's southern boundary near North Mountain and the headwaters of the Little Sandy River. A large wetland is located at the western-most lake's north end. In 1970 the Forest Service analyzed a City of Portland proposal to modify the west and middle Goodfellow lakes for water storage. By 1972, all three lakes and the wetland were surrounded by clearcuts and the western-most lake drained to facilitate dam construction. Aerial photos from 1972 and 1974 show the west lake totally dry in summer.

The program was halted after it became apparent that the water storage project's benefits would be far less than the project's costs. Sometime after 1974 the elevation at the west lake's outflow was restored. Lake levels in a 1977 photo appear normal. Like Latourelle Prairie, the physical integrity of Goodfellow Lakes appears similar today (1996) to a 1948 photo -- the trees are simply smaller. Impacts to local plants and wildlife from the loss of old-growth forest around the lakes is not known.

Dry meadows: are an uncommon habitat in western Cascade temperate rainforest. These meadows are created and maintained by disturbance and soil characteristics. They often occur on steep slopes and usually exhibit an abundance of wildflowers. The meadow below Preacher's Peak overlooking Bull Run Lake is a model example of a dry meadow.

Conclusions: Special Habitats

- Talus is the most common special habitat in the watershed.
- Wetlands represent the most biologically significant special habitat in the watershed. Close to one-half of the vascular plant species documented in the watershed in 1981 were associated with wetlands. Ten rare plants and two rare amphibians live in wetlands.
- Two large wetlands, Latourelle Prairie and Goodfellow Lakes, have been effected by reservoir projects. Despite disturbances, Latourelle Prairie appears to be in good health. The physical integrity of Goodfellow Lakes appears to have recovered, but impacts to local plants and wildlife are not known.

Botany

". . . The Bull Run Watershed harbors some botanical treasures in our state."

David H. Wagner
Director and Curator
University of Oregon Herbarium, 1982

Plant Biodiversity

Undisturbed old-growth forests, abundant wetlands, and other special habitats in the Bull Run Watershed provide homes for a diverse flora. In 1982, 412 plant taxa were documented in the "Checklist of Bull Run Plant Species" (Kierstead, 1982). Three species were new additions to the Oregon flora that year and several others were noted as more common to the north.

Seventy-seven species (60 percent) of vascular plants listed as closely associated with old-growth forest in the Northwest Forest Plan are found in the watershed.

Potentially 800 different vascular plants may be present in the watershed, of which 133 (17 percent) would not be native to the Pacific Northwest (SCCA Database, 1994). Due to the paucity of information on fungi, lichens, and bryophytes, there are no species estimates for these groups.

The following is a discussion of the ecology and status of important plant species of concern, including: Regional Forester's Sensitive Species, Survey and Manage Species, Mt. Hood Inventory Species, and noxious weeds.

The Bull Run Watershed is home to 26 Sensitive, Survey and Manage, and Inventory Species -- more species than either the Salmon (19), Zigzag (15) or Upper Sandy (14) watersheds.

Threatened and Endangered Plant Species

No federally listed threatened or endangered plant species are known or expected within the Bull Run Watershed.

Regional Forester's Sensitive Plant Species

Twenty sensitive plant species are either documented or suspected to occur in the Bull Run Watershed (see Table 4-17). Sensitive plant survey records date back to 1981. From 1981 to present (1996), timber sales and other ground-disturbing activities served as the impetus for most surveys.

Table 4-17 -- Sensitive Plants of the Bull Run Watershed

SPECIES	FS STATUS	ONHP STATUS	HABITAT
pale sedge *Carex livida*	Sensitive, Documented	List 2	emergent wetlands
Howell's daisy *Erigeron howellii*	Sensitive, Documented	List 1	basalt outcrops
Indian rice *Fritillaria camschatcensis*	Sensitive, Documented	List 2	emergent wetlands
fir clubmoss *Huperzia occidentalis*	Sensitive, Documented	List 2	riparian areas, damp forest
bog clubmoss *Lycopodiella inundata*	Sensitive, Documented	List 2	wetlands
scheuchzeria *Scheuchzeria palustris*	Sensitive, Documented	List 2	emergent wetlands
krushea *Streptopus streptopoides*	Sensitive, Documented	List 2	mature forest on thick duff
Strickland's taushia *Taushia stricklandii*	Sensitive, Documented	List 2	wetland meadow edges

SPECIES	FS STATUS	ONHP STATUS	HABITAT
lesser bladderwort *Utricularia minor*	Sensitive, Documented	List 2	wetland ponds, depressions
tall agoseris *Agoseris elata*	Sensitive, Suspected	List 2	dry-moist meadows
lance leafed grape fern *Botrychium lanceolatum*	Sensitive, Suspected	List 2	mesic meadows, open forest
moonwort *Botrychium minganense*	Sensitive, Suspected	List 2	wet old-growth cedar forest
mountain grape fern *Botrychium montanum*	Sensitive, Suspected	List 2	wet old-growth cedar forest
pinnate grape fern *Botrychium pinnatum*	Sensitive, Suspected	List 2	wet cedar forest
tall bugbane *Cimicifuga elata*	Sensitive, Suspected	List 1	mesic forest openings
cold-water cordalis *Corydalis aquae-gelidae*	Sensitive, Suspected	List 1	cold springs, streams
three-leaflet goldthread *Coptis trifolia*	Sensitive, Suspected	List 2	wetland edges
ground cedar *Diphasiastrum complanatum*	Sensitive, Suspected	List 2	shrubby openings
Columbia lewisa *Lewisia columbiana*	Sensitive, Suspected	List 2	basalt outcrops
adder's tongue *Ophioglossum pusillum*	Sensitive, Suspected	List 2	wetlands
cottongrass *Eriophorum polystachion*	Inventory, Documented	Watch List	wetlands
longbearded hawkweed *Hieracium longiberbe*	Inventory, Documented	Watch List	rocky outcrops

SPECIES	FS STATUS	ONHP STATUS	HABITAT
stiff clubmoss *Lycopodium annotinum*	Inventory, Documented	Watch List	wetlands
loose-flowered bluegrass *Poa laxiflora*	Inventory, Suspected	Watch List	riparian areas
withered bluegrass *Poa marcida*	Inventory, Documented	Watch List	moist forest openings
wild cranberry *Vaccinum oxyoccus*	Inventroy, Documented	Watch List	wetlands with sphagnum moss
sweet gale *Myrica gale*	Inventory, Documented	Review List	wetlands

ONHP = Oregon Natural Heritage Program: List 1 = threatened with extinction throughout range; List 2 = threatened with extirpation or very rare in Oregon. Watch List = conservation concern. Review List = considered for listing (Oregon Natural Heritage Program, 1995).

Documented species:

Krushea, *Streptopus streptopoides*:: approaches the southern edge of its North American range in the Bull Run Watershed.

In fact, almost all the krushea in Oregon grows in the Bull Run Watershed. The end of its range is located just south of the watershed on North Mountain.

This little lily is more common from northern Washington to Alaska, and is sparsely distributed in northern Idaho. Sixty-two sites are documented in the Bull Run Watershed. Most of the plants are concentrated in a five-mile wide strip that runs north and south through its local range of approximately 140 square miles. Its distribution encompasses the interface of the Western Hemlock and Silver Fir zones.

Of the plant associations most common at krushea sites, three are more common in the Bull Run Watershed than anywhere else. (They are Western hemlock/Alaska-devils club [TSHE/VAAL-OPHO], western hemlock/Alaska huckleberry-oxalis [TSHE/VAAL/OXOR], and pacific silver fir/oxalis [ABAM/OXOR]).

A detailed description of its distribution, habitat, and management recommendations were compiled by the Oregon Natural Heritage Program in the draft *Species Management Guide for Streptopus streptopoides* (Kagan and Vrilakas, 1993). Important habitat characteristics include old-growth forest with 50-75% canopy cover, and a well-developed duff layer consisting of rotting wood and bark. Because of its strong relationship with decomposing wood, krushea may also have a fungal associate.

The largest krushea populations in the watershed occur in undisturbed old-growth forest (proposed Big Bend RNA).

Events that reduce canopy cover, moisture and duff can negatively impact krushea. Natural threats include windthrow and wildfire. Human-related threats include logging and slash-burning.

The draft species management guide lists five major sites which should be protected to assure the long-term viability of this species in Oregon. This protection could also help preserve the genetic viability of the species as a whole. These sites are: Mt. Talapus, proposed Big Bend RNA, above Cedar Creek, west of Township Meadows, and North Mountain. The Northwest Forest Plan also suggests protecting these sites as a mitigation measure (ROD, p. 33). (Chapter Six contains additional discussion of krushea's habitat and trends.)

Pale sedge, *Carex livida*: grows in three wetlands in the watershed. The only other population known on the Mount Hood National Forest is in the Zigzag Ranger District's Salmon River Meadows. Although its range is somewhat circumboreal, it is rare in Oregon. Besides the Mt. Hood NF populations, other sites are located in the Siskiyou Mountains. It also extends into Washington and northwest California. Pale sedge forms pale blue-green patches along the edges of small channels in wet meadows.

Howell's daisy, *Erigeron howellii:* Thomas Howell, an early Oregon botanist, first described a beautiful large white daisy in the west Columbia Gorge in 1880. Subsequently named *Erigeron howellii*, Howell's daisy, it was initially thought to be confined to drainages in the west Gorge. In 1984 a site was located along Blazed Alder Creek in the Bull Run Watershed. One site is also known to exist within the Salmon River Watershed. The greatest number of sites (17) are still located in the Columbia Gorge. Until recently, because of its limited distribution and numbers, Howell's daisy was a candidate species for listing by the U.S. Fish and Wildlife Service. This daisy grows in cool, moist, shaded rocky places (often on basalt outcrops). Potential habitat within the watershed includes other cool, shaded, moist cliffs and rocky areas.

Indian rice, *Fritillaria camschatcensis:* gets its name from its edible rice-shaped bulbets. This chocolate-colored lily grows in wetlands from Alaska's Kodiak Island to Snohomish County, Washington. Washington sites are relatively rare.

The Indian rice population at Latourelle Prairie – a cold, wet meadow located in the watershed's northern end – is disjunct and perhaps the most southern location in North America.

Indian rice was discovered in Latourelle Prairie in 1982. Approximately 250 plants were noted in the prairie's arms that had not been flooded by Boody Lake. One plant, however, was located in the flooded area. (For more information, see Special Habitats section.)

In an incomplete 1995 survey of the wetland, approximately 12 plants were identified in the flooded area. Historically, Indian rice might have been much more abundant throughout Latourelle Prairie. Habitat in the arms is similar to the wetland's main body.

While Indian rice may be moving back into former habitat, monitoring information is necessary to ascertain trends.

Fir clubmoss, *Huperzia occidentale* (also known as *Lycopodium selago):* is circumboreal in its distribution and nears the southern end of its range on the Mt. Hood NF. It is well distributed on the west side of the Forest, though not common. Seven sites are known in the watershed in a range of habitats that include mature riparian forest and wetland margins.

Bog clubmoss, *Lycopodiella inundata:* is a rare inhabitant of fens and bogs. It is interuptedly circumboreal and, on the Pacific Coast, reaches to northwest California. The two sites known in the Mt. Hood NF are located in the proposed Big Bend Research Natural Area (RNA), and the Multorpor Fen (private ownership) in the Zigzag Watershed. Both locations are classified as subalpine mires and are not common habitats in the Northern Cascades Province (Seyer, 1983). Within these mires, bog clubmoss inhabits the muddy, peaty depressions where little vegetation grows. The wetland habitat in Big Bend RNA appears to be stable. In addition, potential habitat exists within the watershed's other wetlands.

Scheuchzeria, *Scheuchzeria palustris* var. *americana,*: is rush-like and inconspicuous and grows from northern North America's west to east coasts in boggy, peaty meadows. While Scheuchzeria is more common elsewhere, it is rare in Oregon. It grows at one site in the watershed, a wetland in the proposed Big Bend RNA, in close proximity to bog clubmoss and pale sedge. Despite its rarity, populations with hundreds of individuals exist elsewhere on the Forest at Salmon River Meadows, Dinger Lake, and Little Crater Lake. The Big Bend site is much smaller than these sites.

Strickland's taushia, *Taushia stricklandii:* is a unique Northwest endemic.

Strickland's taushia populations are known only from Mt. Rainier and the divide between the Bull Run Watershed and the Columbia River's west tributaries.

Within the watershed, Strickland's taushia grows in a wet meadow at the head of West Branch Falls Creek. Just outside the watershed, large patches grow in several wet meadows at the headwaters of Moffet Creek. This cheery yellow umbel can reach 80-90% cover at the seasonally dry edges of these wet meadows. Taushia is predominately a Mexican genus. The three endemic *Taushia* species that occur in the Pacific Northwest are considered to be of high scientific value due to their ecological niche distinctions and evolutionary relationships (Kennison and Taylor, 1979). The populations on the Forest (pers. obs. Molly Sullivan, Zigzag District) and Mt. Rainier appear to be stable (G.Rochefort, pers. com.). No monitoring data, however, is available.

Lesser bladderwort, *Utricularia minor:* is a carnivorous floating plant. Though circumboreal in distribution, it is rare in Oregon. Within the Bull Run Watershed, lesser bladderwort grows in an arm of Latourelle. Populations are scattered throughout the Forest in the Zigzag District's Zigzag and Salmon River watersheds, and also within the Bear Springs and Clackamas Ranger districts. This aquatic plant grows in shallow, quiet waters that are often acidic and that draw down during summer. Waterfowl probably disperse propagules. Small ponds and channels in wetlands offer potential habitat within the Bull Run Watershed.

Northwest Forest Plan Survey and Manage Species

The Northwest Forest Plan lists fungi, lichens, bryophytes, and vascular plants to receive consideration through survey and management standards and guidelines (ROD pp C4 - C6, Table C-3 pp C49 - C61).

The Four *strategy ratings that apply* to Survey and Manage species:

1. Manage known site (beginning in 1995)

2. Survey prior to ground disturbing activities and manage newly discovered sites (for 1999 project implementation and beyond).

3. Conduct extensive surveys for the species to find high priority sites for species management.

4. Conduct general regional surveys to acquire additional information and to determine necessary levels of protection.

Species with strategy ratings 1 and 2 demand the most immediate attention. Guidelines for survey and manage species with ratings 1 and 2 are in draft form.

All survey and manage species were analyzed for distribution and habitat in the Bull Run Watershed. A table summarizing this information is on file with the Zigzag District Botanist. Strategy 1 and 2 species documented within the watershed are summarized in Table 4-18.

Table 4-18 -- Documented Survey and Manage Species

SPECIES	SURVEY AND MANAGE STRATEGY	HABITAT
FUNGI		
stalked orange peel fungus *Aleuria rhenana*	1,3	conifer litter
Bondarzewia's polupore *Bondarzewia montana*	1,2,3	base of large true firs
chanterelle *Cantharellus formosus*	1,3	conifer forest
Phaeocollybia kaufmanii, P. oregonensis	1,3	moist late successional forest
jelly-like black urn *Plectania melastoma*	1,3	conifer litter
coral fungi *Ramaria araiospora, R. stuntzii*	1,3	late successional forest on litter or wood
LICHENS		
Hypogymnia duplicata	1,2,3	foggy windy conifer forest
BRYOPHYTES		
bug on a stick (moss) *Buxbaumia piperi*	1,3	moist shaded rotting logs
Ulota megalospora	1,3	exterior canopy, often hardwoods

Strategy 1 & 2 Species

Fungi

Out of 234 fungi species listed in the Northwest Forest Plan, eight strategy 1 species have been documented within this watershed. Potential habitat also exists for many more of these 234 species.

Stalked orange peel fungus, ***Aleuria rhenama***, is a widespread but rare fungus associated with late-successional conifer stands. It lives on well-developed conifer litter. One site was located near the Oregon Mycological Society chanterelle study plots (see *Cantharellus formosus* below). The habitat and microclimate at this site should be protected from timber harvest activities (FSEIS Appendix J2, pp 197-198).

The root-rot fungus **Bondarzew's polypore,** ***Bondarzewia montana***, is also a widespread but rare saprobe generally associated with true firs. The fruiting body is a long-lived conk that forms near the base of trees. One site is located in the watershed's Larch Mountain. More locations are expected to be found for this polypore. While timber harvest should not be a threat at the Larch Mountain site, air pollution could prove to be (FSEIS Appendix J2, pp 186-188).

Recent taxonomic studies have revealed that the **common chanterelle** in this area is not *Cantharellus cibarius*, a strategy 3&4 species, but is actually a strategy 1&3 species, ***Cantharellus formosus***. The rating of *C. formosus* in the Northwest Forest Plan was based on an assumption of rarity. Recommendations have been made to change its rating to reflect a more abundant distribution. Chanterelles are popular edible fungi. Concerns regarding their sustainable harvest prompted a long-term research study by the Oregon Mycological Society in the south buffer of the Bull Run Watershed. Nine years of data collection from this study indicate that picking may stimulate chanterelle production (Norvell, 1995). The Bull Run Watershed currently provides abundant habitat for chanterelles.

Two types of ***Phaeocollybia*** have been documented on Larch Mountain, *P. kaufmanii complex* and *P. oregonensis*. Appendix J2 of the Northwest Forest Plan (FSEIS) discusses all species of *Phaeocollybia*. These gilled mushrooms are all endemic to low-mid elevation old-growth coniferous forests species. Logging of low-elevation late-successional forest has reduced habitat. Providing for habitat integrity, microsite protection, and connectivity between sites and late-successional forest patches should enhance viability (FSEIS Appendix J2, pp 166-168). The watershed's old-growth forest provides quality habitat now, and should continue to do so in the future

Jelly-like black urn, *Plectania melastoma*, is recorded from the chanterelle study plots (see Cantharellus). It is a widespread but uncommon saprobe on conifer litter in northwest and northeast North America and Europe. While past late-successional forest timber harvest has eliminated populations, jelly-like black urn can still grow in second growth forest. No mitigation measures were recommended in the FSEIS's Appendix J2.

Two coral fungi were also located in the chanterelle study plots, ***Ramaria araiospora* and *Ramaria stuntzii*.** Specific range information was not provided in the FEIS's Appendix J2, though many are west coast species. Generally, these and other listed coral fungi are found growing on litter/humus or wood in late-successional forest. Providing for habitat integrity, microsite conditions and connectivity to late-successional forest patches should enhance viability (FSEIS Appendix J2, pp 163-166). The watershed's Late-Successional Reserve (LSR) land allocation currently provides quality habitat and should continue to do so in the future.

Lichens

Of the 81 lichens listed in the Northwest Forest Plan, only one species with a strategy 1 rating is documented in the Bull Run Watershed. Eleven others may potentially occur here (Boyll, 1996). Excellent habitat is also present for many of the more common strategy 3 and 4 lichens, including old-growth canopies; tree boles; clear, cold streams; and foggy ridgetops.

Very old forests (500 years +), such as those found in the Bull Run Watershed, support a high diversity of lichen species, many which do not live in younger stands.

Hypogymnia duplicata is a rare leafy lichen found generally in low elevation, foggy, windy maritime forests within the Pacific Northwest and Alaska (FSEIS Appendix J2, pp 226-228). It is documented in the Bull Run Watershed just north of Log Creek at its confluence with the Bull Run River. Another site is located just outside the watershed on Larch Mountain. The Bull Run Watershed's Northwest Forest Plan Late-Successional Reserve (LSR) designation provides habitat protection for this site. The watershed's other foggy, wind-influenced areas also provide potential habitat for this rare leafy lichen.

Bryophytes

Of the 25 species of mosses and liverworts listed in the Northwest Forest Plan, two strategy 1 species are documented in the watershed, and potential habitat is present for another 13 species. Of all the plant groups listed, the bryophytes have the least amount of known information.

Bug-on-a-stick, or *Buxbaumia piperi*, is a tiny moss with a big capsule that grows on rotting logs' butt end and sides (decay class 3, 4, and 5). Sites average approximately 70% canopy cover. A documented site within the watershed is located at Lookout Mountain on Bureau of Land Management (BLM) land. *B. piperi* is fairly common but often overlooked. *B. piperi* is also listed as a managed late-successional reserve buffer species (ROD, C-27). The Bull Run Watershed's Late-successional forest should provide habitat for this species in the future.

An exterior canopy moss, ***Ulota megalospora***, has also been documented on Lookout Mountain. This creeping moss is more desiccation and light tolerant than most. It lives on the outer twigs of the canopy and occasionally on tree boles. A decline of this genus has been noted in Sweden due to air pollution (Hallingback, 1992). *U. megalospora* is also listed as a protection buffer species under the late-successional reserve standards and guidelines. Maintaining its habitat integrity should protect this species.

Vascular Plants

None of the 15 listed vascular plant species are known to occur within the Bull Run Watershed. Potential habitat, however, is present for six of these species: **sugarstick (*Allotropa virgata*), mingan's moonwort (*Botrychium minganense*), mountain moonwort (*Botrychium montanum*), three-leaved goldthread (*Coptis trifolia*), coldwater corydalis (*Corydalis aquae-gelidae*), and northern wild-licorice(*Galium kamtschaticum*)**. All are strategy 1 and 2 species.

Mt. Hood National Forest Inventory Plant Species

Unlike Regional Forester's Sensitive Species, Mt. Hood Inventory Species do not require any special protection or management. These plants are on the Oregon Natural Heritage Program (ONHP) Review or Watch Lists, and are recorded when found. Table 4-16 -- Special Habitats and Species of Concern lists the Inventory Species located in the Bull Run Watershed.

Noxious Weeds and Other Invasive Non-Native Species

Invasive, non-native plants pose one of the greatest threats to natural biodiversity. Table 4-19 lists species from the Mt. Hood NF Noxious Weed List that inhabit the watershed. Weeds in the watershed are generally confined to roadsides, reservoir sites, and old logged areas. For many years, non-native grass and legume species have been intentionally seeded on the watershed's skid roads and landings for erosion control and forage. These species may be persistent, but do not appear to be invasive.

Table 4-19 -- Noxious Weeds of the Bull Run Watershed

STATUS	COMMON NAME	SPECIES
POTENTIAL INVADERS	brown knapweed	*Centaurea jacea*
NEW INVADERS	diffuse knapweed meadow knapweed	*Centaurea diffusa* *Centaurea pratensis*
ESTABLISHED INFESTATIONS	Canada thistle Scotch broom St. Johnswort tansy ragwort	*Cirsium arvense* *Cytisus scoparius* *Hypericum perforatum* *Senecio jacobaea*

The **knapweeds** are of the highest concern due to their New Invader status. Occasional plants appear along Road 10 at the east end of the watershed. They are pulled yearly. No large infestations have been noted.

Canada thistle is common in timber harvest areas and other disturbed sites, particularly in the watershed's west end. Because it readily re-sprouts from root fragments it is difficult to control manually. Canada thistle usually disappears as shade and native plant cover increase. Biocontrol agents are available for release on dense populations.

In the spring, bright yellow **Scotch broom** flowers mark the roadsides and reservoir edges of the watershed. Scotch broom is a European species widely planted for its attractive flowers, form, and erosion control attributes. The City of Portland planted broom in the watershed in the 1920s to help stabilize road banks between the main gate and headworks. As late as 1979, scotch broom was still planted for erosion control along road cuts near the reservoirs.

Scotch broom has spread out from these sites along road corridors to other parts of the watershed. Its current rate of spread is not known. While some satellite sites have been manually controlled over the years, biocontrol agents are more appropriate for large infestations.

Several seed weevil (*Apion fuscirostre*) nursery sites are located in the watershed. The Oregon Department of Agriculture annually collects and releases weevils to new sites. The weevils eat broom seed, thus helping to limit seed production. At some sites in the watershed, such as the Walker Prairie Evaluation Plantation, broom has competed with reforestation efforts. Dense shade can eliminate broom. The seed bank, however, is viable for 50+ years. Soil disturbance can also induce germination. Around the reservoirs, Scotch broom has displaced the native flora.

St. Johnswort is a widespread invader of disturbed areas in the watershed, particularly along sandy, gravely roadsides. It is not an aggressive competitor with native plants. As a popular medicinal herb with many applications St. Johnswort is collected as a special forest product in other watersheds. Like Canada thistle, it should disappear over time as shade and vegetative cover increases.

Any livestock owner can identify **tansy ragwort**. This weed is toxic to livestock and will actively invade disturbed areas with the potential to form large stands. Within the watershed it grows along roadsides and in clearcuts. Two biocontrol agents are present in the watershed, the cinnabar moth, *Tyria jacobaeae,* and the flea beetle, *Lonitarsus jacobaeae*. Both are highly effective at controlling tansy. The cinnabar moth will occasionally eat other native *Senecios*. Tansy itself does not currently appear to be a competitive threat to native plants.

The weeds listed above would be expected to decrease over time within the LSR and Riparian Reserve portions of the watershed.

The dense shade of conifer forests and increased competition from native understory species should reduce the numbers of these generally sun-loving, disturbance-loving weeds. Habitat for weed species will still be provided along some roadsides, reservoir margins, and other disturbed areas. In the Little Sandy subwatersheds where timber harvest may still occur, weeds may continue to appear in new openings, skid trails, and landings. (These weed habitat areas are located in some private lands and within the following conceptual landscape "Design Cells" as described in Chapter Five.)

Conclusions: Botany

- Seventy-seven species (60 percent) of vascular plants listed as closely associated with old-growth forest in the Northwest Forest Plan are found within the Bull Run Watershed.

- Nine Regional Forester's Sensitive Plants, six Mt. Hood National Forest Inventory Plants, and eleven strategy 1 Survey and Manage species have been documented within the Bull Run Watershed - more species than in either the Salmon, Zigzag or Upper Sandy watersheds.

- Almost all the krushea in Oregon, including the southern most krushea in North America, grows in the old-growth forests of the Bull Run Watershed. The remainder grows just south of the watershed on North Mountain. To help maintain species viability in Oregon, a draft Species Management Guide suggests protecting this watershed's four key sites. The ROD also suggests protecting these sites.

- Latourelle Prairie is the only known site for indian rice in Oregon. A good portion of its habitat was flooded by Boody Lake between 1959 and 1977.

- Wetlands near the divide of the Bull Run Watershed and Columbia River's west tributaries contain one of only two Strickland's taushia populations known in the world.

- Seven noxious weeds grow in the watershed. Scotch broom is prevalent along roads near the reservoirs.

Wildlife

Late-Successional Reserves and Riparian Reserves were designated by the Northwest Forest Plan to provide for both aquatic and terrestrial species. The Northwest Forest Plan also established survey and management standards and guidelines to provide benefits to amphibians, mammals, bryophytes, mollusks, vascular plants, fungi, lichens, and arthropods. Additional standards and guidelines were also prescribed for Matrix lands to provide for terrestrial species' needs. This assembly of reserves and standards and guidelines creates a terrestrial ecosystem management strategy analogous to the objectives of the Aquatic Conservation Strategy (Mellen, Huff, and Hagestedt, 1995).

Within this Watershed Analysis, the approach for wildlife discussions includes examining Northwest Forest Plan "species of concern" where finer-scale attention was deemed necessary by this plan. These include C-3 species, threatened or endangered species, and protection buffer species in the Matrix. In addition, species deemed to be at risk or sensitive were also considered.

Based on habitat requirements, 250 terrestrial species, including aquatic amphibians, could potentially occur within the Bull Run Watershed. (A full listing of these species with potential habitat is available in the Analysis File.)

Threatened and Endangered Species

Peregrine Falcon (*Falco peregrinus anatum*)

The peregrine falcon, rare to uncommon in Oregon, is listed by the U.S. Fish and Wildlife Service as an "Endangered Species." The species is particularly dependent on cliff habitat, especially for nesting and roosting. The height of cliffs aids hunting by providing predictable updrafts and thermal currents for soaring, as well as a greater field of view. Peregrines feed almost exclusively on birds, many of which are associated with riparian zones and wetlands. The Mt. Hood Forest Plan identifies a small portion of the Bull Run Watershed as a potential peregrine falcon recovery area.

In 1994, a review of potential cliff sites was conducted on the Mt. Hood National Forest through photo-interpretation, topographic map review, and a helicopter flight (Pagel, Kott, Huff, 1994). Six sites within the Bull Run Watershed were identified as medium or medium-high potential sites. Two of the six sites were observed to protocol standards. No peregrines were found at either area.

Although nesting peregrines have not been documented in the Bull Run, the Columbia River Gorge Scenic Area, located adjacent to the Bull Run Watershed, currently supports high quality habitat. Three wild pairs have been documented nesting in the cliffs on the Gorge's Oregon side. These peregrines are suspected to also utilize the Bull Run Watershed as a foraging site.

Efforts to reestablish peregrines across the Mt. Hood National Forest have been part of a cooperative program between the Oregon Department of Fish and Wildlife, The Peregrine Fund, and the Forest. A peregrine hacking site (the release of young raptors by humans) was introduced on the Zigzag Ranger District's Tom, Dick, and Harry Ridge from 1990-94. The site is located just south of the Bull Run Watershed. More than 25 birds were released from this site over the five-year period. Several hacking programs have also been introduced in the Columbia River Gorge. A high concentration of peregrines inhabit the Columbia River Gorge. Some of these raptors can be seen foraging in the Bull Run Watershed.

Bald Eagle ***(Halieatus luecocephalus)***

The bald eagle, a year round resident in Oregon, is listed as "threatened" in this state by the U.S. Fish and Wildlife Service, and is protected at the federal level by the Endangered Species Act of 1973, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act.

While bald eagles still occupy most of their historic range in the northwest, populations have been steadily declining for many years (Brown, 1985). Recently, however, this decline seems to have slowed, or even stopped. Eagles have fared better in Oregon and Washington than in most areas. Substantial populations still exist in these two states. In fact, recent surveys indicate that more than 100 breeding pairs and approximately 600 wintering birds occur in Oregon, with the largest concentration in the Klamath Basin.

Bald eagles inhabit forested lakeside or riparian associated habitats of Oregon during both the wintering and nesting seasons. In the winter, they are more abundant on the Columbia River and lower elevations. During their spring and summer breeding seasons, they move up into the Bull Run drainage to forage. Although many bald eagle sightings have been documented in the watershed, nesting activity has not.

Nesting, perching, roosting, and foraging habitats are all important components that determine an area's suitability. Bald eagles exhibit a strong preference for large, dominant or co-dominant trees in a heterogeneous stand of mature or old-growth coniferous timber near large bodies of water. This allows easy access to their preferred diet of fish and waterfowl.

In June 1993 a bald eagle specialist conducted a helicopter survey within the Bull Run Watershed to assess the presence of nesting bald eagles and their habitat (Frenzel, 1993). While neither bald eagles nor nest sites were observed during the survey, nesting habitat was identified at all of the watershed's large water bodies. These areas were determined to contain relatively large expanses of larger trees, with an uneven canopy and fairly high basal densities. The areas also possessed adequate numbers of prominent trees and perching snags (Frenzel, 1993).

In addition, there appears to be an adequate fish prey base throughout the bald eagle breeding season, indicated by the presence of nesting osprey -- which prey on similar species of fish as bald eagles.

For the most part, bald eagle nesting and foraging habitat in the Bull Run Watershed occurs around Bull Run Lake and both reservoirs. The most likely sites for nesting -- where suitable nest trees occur -- are located within a one-half mile radius of the lake and the reservoirs.

The Mt. Hood Forest Plan identifies two 40-acre bald eagle habitat areas within the Bull Run Watershed on the south shores of both Bull Run Lake and of Reservoir No. 1 (Figure 4-24.) These habitat areas were selected in response to the Pacific Bald Eagle Recovery Plan (USDI Fish and Wildlife Service, 1986). Proposed management direction for Zone 12 of the Recovery Plan (in which Bull Run resides) is to "identify and protect nesting and feeding areas, and to manage potential nesting habitat for eagles."

Northern Spotted Owl (*Strix occidentalis caurina)*

Northern spotted owls are listed as a threatened species by the U.S. Fish and Wildlife Service (USFWS), and are protected under the Endangered Species Act (ESA) of 1973. When listed as a threatened species in 1990, the USFWS identified "Critical Habitat" as required by the ESA. A Critical Habitat Unit (CHU) encompasses the Bull Run Watershed and vicinity.

A total of 69% of the watershed is also designated as Late-Successional Reserve (LSR) by the Northwest Forest Plan. The entire LSR Oregon 201, is 110,400 acres and encompasses a large percentage of the Bull Run Watershed and Columbia River Gorge Scenic Area. The objective of an LSR is to protect and enhance conditions of late-successional and old-growth forest ecosystems, which serve as habitat for late-successional and old-growth related species including the northern spotted owl (ROD C-

9). A management assessment should be prepared for each large Late-Successional Reserve (or group of smaller LSRs) before habitat manipulation activities are designed and implemented.

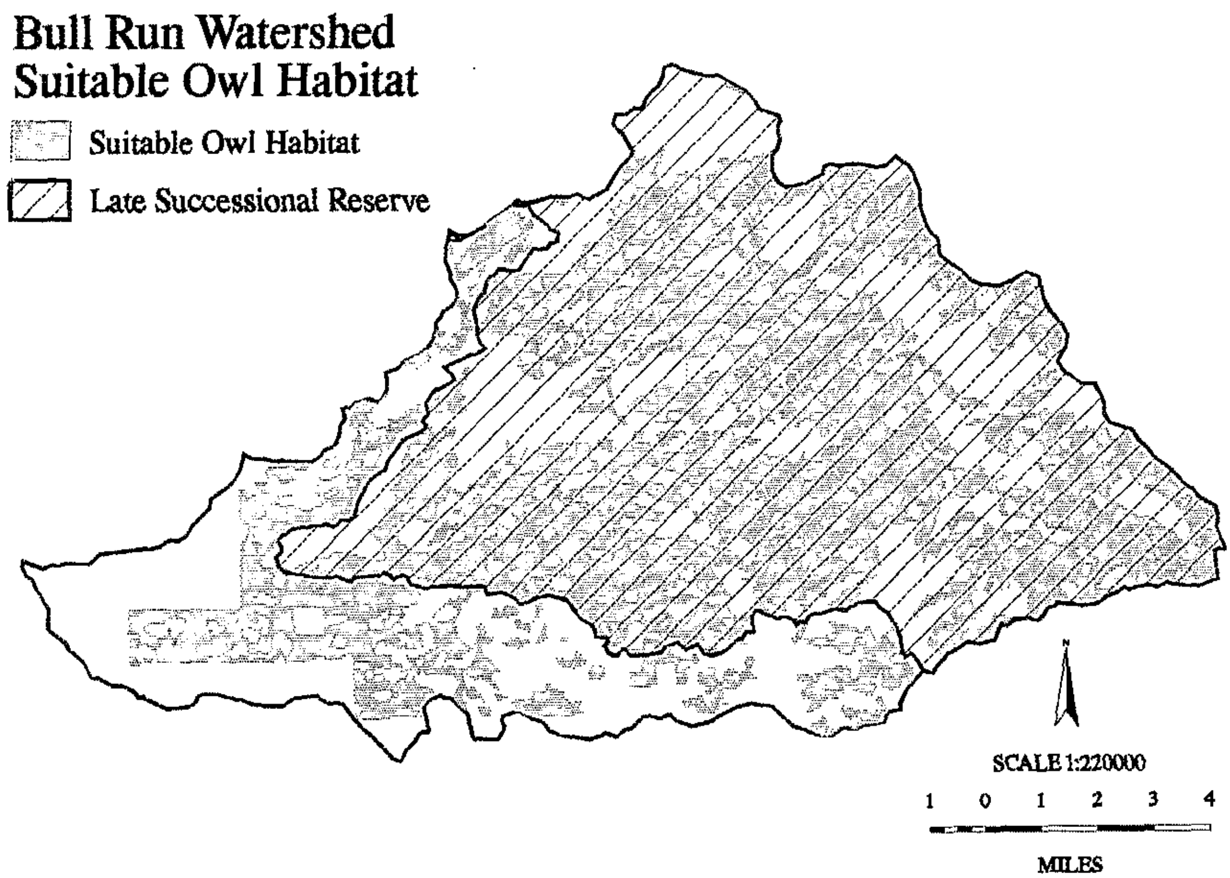
Spotted owls are closely associated with old-growth stand conditions in the temperate and high temperate conifer forest plant communities (Forsman, 1976, USDI, FWS, 1982). Multi-layered old-growth forests are the preferred nesting habitat of spotted owls in Oregon and appear to be the most consistent feature of forests occupied by spotted owls. Mature and second-growth stands with scattered old-growth and broken-topped trees provide suitable nesting sites for owls. Canopy closure averages 70% at most nest sites.

In a joint effort with the City of Portland Water Bureau, biological technicians field-verified suitable owl habitat on a stand level while surveying for spotted owls (USDA 1996). Suitable owl habitat includes nesting, roosting, and foraging habitats. All suitable habitat is at a minimum dispersal. Photo interpretation was used for some lands that were not included in the field verification, including parts of the Little Sandy.

From these methods, 43,210 acres (approximately 49% of the watershed) were determined to be suitable owl habitat. (Because private lands were not included, the actual percentage of the watershed may be slightly higher.)

(Note: The final report on habitat verification, USDA 1996, uses the Bull Run Watershed Management Unit as a boundary. Within this boundary, 51,519 acres were determined to be suitable owl habitat. However, this boundary is somewhat different than the Watershed Analysis boundary. These administrative boundaries are described in Chapter 1).

Figure 4-24 -- Suitable Owl Habitat



The Bull Run Watershed contains some of the best and most continuous owl habitat within the Mt. Hood National Forest. It also serves as an important connection between the Forest and Washington state lands.

Dispersal habitat is used for foraging and serves as a crucial link for owls to travel between blocks of suitable nesting habitat. It is used sometimes for roosting, but does not have the characteristics necessary for nesting. This type of habitat can become suitable over time with proper conditions. Dispersal habitat is defined as a stand of trees with an average diameter at breast height (DBH) of 11 inches, and average canopy closure of 40%. Dispersal habitat within the Bull Run Watershed was calculated at approximately 56,000 acres, or 63% of the watershed.

Twenty known northern spotted owl pairs owl are located within the Bull Run Watershed. An additional pair is located on the watershed's boundary. Seventeen of these pairs are located within the Late-Successional Reserve (LSR). Of the three pairs outside the LSR, one is located on City of Portland lands and two inhabit Matrix lands within the Little Sandy Watershed.

In addition to the larger, mapped LSRs (shown on Alt. 9 map with the Final SEIS), 100-acre LSRs are to be designated around each known spotted owl activity center not already protected by another reserve (C-10). Here, this standard and guideline is applicable to the two pairs within the Matrix. With this standard, one hundred acres of the best northern spotted owl habitat will be retained as close to the nest site or owl activity center as possible. This is intended to preserve an intensively used portion of the breeding season home range. Because these areas are considered important to meeting objectives for species other than spotted owls, they are to be maintained even if vacated by spotted owls.

Although one spotted owl pair is located on City of Portland lands, the City intends to manage these lands for late-successional habitat. Adjacent federal land is largely in Riparian Reserve status, which should likewise maintain habitat characteristics for this pair of spotted owls.

Regional Forester Sensitive Species

Known to Occur Within the Bull Run Watershed

Common Loon (*Gavia immer)*

The common loon is a large diving bird that winters on the ocean and breeds on freshwater lakes. Common loons migrate long distances and are frequently seen on freshwater lakes, particularly in the spring. The common loon diet is primarily fish, although crayfish, leeches, and aquatic insect larvae are also eaten.

It is listed as a "sensitive species" by the U.S. Forest Service's Region 6 and the U.S. Fish and Wildlife Service, and is considered extirpated as a breeding species by the Oregon Department of Fish and Wildlife (Corkran, 1988; Corkran, 1989; McIntyre, 1988; Richards and Musche, 1985).

The common loon's nesting distribution covers much of sub-Arctic Alaska and Canada, and the Northern United States. Nesting pairs of common loons are rare in the Pacific Northwest. In Oregon, no confirmed nests have been identified since 1947, however, nesting possibly occurred at Bull Run Lake in the late 1970s (Corkran, May 1995). In addition, in 1992-93, common loon nesting was reported -- but not confirmed -- in the Oregon Cascades at a lake north of Crater Lake. A limited number of nests are known in Washington.

Common loon breeding habitat is large freshwater lakes in bare or forested habitats, from low to moderately high elevation (below timberline). Nests occur on or along the edge of water, often in dense aquatic vegetation. In the Pacific Northwest, the nest is often on a large, half-submerged log. Floating nest platforms are readily accepted.

Currently, no known common loon nests have been identified within the Mt. Hood National Forest. During the spring and fall months, numerous migrating loon occurrences have been sighted on Forest lakes, including, since the 1970s, lakes and reservoirs in the Bull Run Watershed. Construction of the reservoirs created foraging habitat for loons.

Since 1986, common loon field surveys have been completed yearly in the Bull Run Watershed. The majority of sightings occur during April and May. From surveys repeated twice weekly, it appears that most loons use the reservoirs for only a few days, presumably as a migration stop-over point before continuing to breeding grounds farther north. Common loons exhibiting pairing and territorial behavior, however, have been consistently observed on the eastern one-third of the Upper Reservoir since 1980. It is believed that nesting or unsuccessful nesting attempts may have occurred at this location. Because nesting attempts might have failed due to fluctuating water depths that inundate the shoreline vegetation, three floating platforms were built. Loons have yet to be observed using these structures (Corkran, May,1995).

Potential impacts to common loon populations appear to be related to human disturbance during the breeding season. Heavy recreational use, especially near lakes and rivers in warm weather months, decreases potential for nesting sites. While the Bull Run Watershed's limited access contributes to a higher potential for nesting loons, its reservoirs and Bull Run Lake support minimal emergent aquatic vegetation for nesting habitat.

Cope's giant salamander (*Dicamptodon copei*)

Cope's giant salamander inhabit fast flowing first to third order streams with clear cold water, and streamside forest. Water temperatures usually range from 8 to 14 degrees Centigrade (46.4 to 57.2 degrees Fahrenheit) and are seldom higher than 18 degrees Centigrade (64.4 degrees Fahrenheit). Recent data identifies that Cope's occurrences have been found in water temperatures not exceeding 10 degrees Centigrade (50 degrees

Fahrenheit)(Corkran, pers. comm., 8/28/95). Stream substrate consists of cobble and small boulders, some large logs and no silt. They occasionally occur in clear, cold mountain lakes and ponds. The elevational range is from sea level up to approximately 1,350 m (4,400 ft.) (Nussbaum, 1983 & Corkran, Thoms, 1994). More recent data collected by Corkran, 1994, identifies their elevation limit to be 1000 m (3,500 ft.).

Current distribution of the species is from western Washington to northwestern Oregon. It occurs in the Olympic Mountains and Willapa Hills of western Washington, the Cascade Mountains in southern Washington and northern Oregon, and in the northern Oregon Coast Range.

Surveys for Cope's giant salamander have been conducted in the Bull Run Watershed by the Wetland Wildlife Watch Volunteers (Corkran, 1995). These surveys have documented the presence of Cope's larvae and neotenic adults in several localities within the watershed, including tributaries to Bull Run Lake, Cougar Creek, and Bear Creek. Cope's giant salamanders apparently rarely transform into a terrestrial form in nature. It is known primarily in the larval and neotenic (retention of larval characteristics, such as gills and tail fins) forms.

In general, Cope's giant salamander are believed to be declining. The "sensitive status" was applied due to the species' restricted distribution, combined with potential for habitat destruction from increases in water temperatures.

Red-legged Frog ***(Rana aurora)***

The geographic distribution of the red-legged frog extends from southwest British Columbia through western Washington and Oregon into northern California. They are found throughout western Washington and Oregon at elevations ranging from sea level to 860 meters (2,830 ft.) on Mt. Rainier, and to 1427 meters (4,680 ft.) in the Umpqua National Forest. They also occur in the Columbia River Gorge as far east as White Salmon, Washington.

Breeding habitat includes marshes, bogs, swamps, ponds, lakes and slow-moving streams. In general, breeding sites seem to have one certain requirement, little or no flow. Outside the breeding season, red-legged frogs are highly terrestrial and are frequently encountered in woodlands adjacent to streams.

Red-legged frogs are common in the lower end of the Bull Run Watershed and breed there frequently.

Throughout its range, the species is currently declining. Possible causes for this decline: displacement by the introduced bullfrog, pesticide and herbicide runoff, and introduction of non-native fish. In the Bull Run, population trends are unknown.

California Wolverine (*Gulo gulo luteus*)

While the wolverine occupies a variety of habitats, they are usually remote and devoid of humans and human developments. Preference for some forest cover types, aspects, slopes, or elevations are attributed to a greater abundance of food, but also to avoidance of high temperatures and of humans (USDA, RM-254, 1994).

The species distribution is circumpolar; occupying tundra, taiga, and forest zones of North America and Eurasia (Wilson, 1982). Wolverines (low densities) extend as far south as California and Colorado and as far east as the coast of Labrador.

The wolverine is a scavenger, largely dependent on large mammal carrion. While they have been described as "opportunistic omnivores" in summer and primarily scavengers in winter, they can also prey on ungulates or larger mammals under various conditions (such as deep snow). Mule deer and elk were the primary ungulates in the diet of wolverines in Montana. Small mammals are primary prey only when carrion of larger mammals is unavailable, however wolverines are too large to survive on only small prey. Studies have shown the paramount importance of large mammal carrion, and the availability of large mammals underlies the distribution, survival, and reproductive success of wolverines (USDA, RM-254, 1994).

Reasons for this species' decline could be due to: low reproductive rates, delayed sexual maturity, high mortality from trapping (trapping currently legal in Alaska and Montana), and fragmentation of large areas that are not trapped.

A wolverine was recently sighted at the Bear Creek House in 1996. A sighting was also reported in the Upper Sandy Watershed at the foot of Crutcher's Bench. Tracks have been confirmed southeast of the watershed in a fork of the Salmon River.

Although they have been known to avoid clearcut areas and heavily stocked stands, the entire Mt. Hood National Forest is considered generalist habitat for wolverines. Because of its limited human harassment, the Bull Run Watershed provides high quality habitat. The Bull Run Watershed also has a very healthy population of black bears and cougars which would provide carrion for wolverine to scavenge. While the watershed most likely provides good foraging and transitional habitat, wolverines are more likely to be attracted to higher elevation habitats near timberline in adjacent wilderness areas. Potential denning habitat would most likely occur at higher elevations than in the Bull Run.

Regional Forester Sensitive Species

That Could Potentially Occur in the Bull Run Watershed

Harlequin Duck (*Histrionicus histrionicus*)

Harlequin ducks inhabit turbulent mountain streams in coniferous forests with dense shrubby streamside vegetation. In-stream structures (logs, boulders) are important for providing loafing sites for this species. Slower side channels and slower moving waters are important for brood-rearing. Generally, males and females arrive in the streams of the Mt. Hood National Forest in March and leave to winter at the coast in September. In general, nests are found on the ground near streams, in tree cavities, and cliffs.

The species range is the Pacific and Atlantic sides of North America, Greenland, Iceland, eastern Siberia, and the Kurile Islands. The species range in Oregon is along the coast in the winter, especially along rocky shores. During the spring and summer, harlequin ducks nest along streams of the Cascade Range and Wallowa Mountains. A nest site was recorded on the Salmon River near Wemme in 1931, and on Clear Creek near its confluence with the Sandy River in 1991. The species has been sighted regularly throughout the summer south of the Bull Run Watershed on Still Creek, Camp Creek, and the Zigzag River.

No harlequin duck nest sites have been recorded within the watershed, nor have surveys documented Harlequin ducks on the stream systems within the Bull Run. Potential habitat exists in the upper Bull Run River. Because harlequins are an aquatic duck that follow the stream system up in turbulent waters, low flows in the lower Bull Run River and the calm flows of reservoirs provide a barrier. Large woody debris levels may also be limiting habitat.

The species has been and is declining. It is identified as a "sensitive species" due to impacts on breeding habitat from: timber harvest, recreation increases, and degraded riparian habitats.

Townsend's big-eared bat *(Plecotus townsendii)*

Townsend's big-eared bats occur in numerous plant community types, using caves, buildings, mines, and bridge undersides for nursery and hibernation purposes. These sites must meet exacting temperature, humidity, and physical requirements. In dictating the presence of this species, suitable undisturbed roost, nursery, and hibernaculum sites appear more important than other habitat factors. Food consists of insect -- primarily moths -- and other arthropods. Besides aerial feeding, this bat also gleans insects from plants. They are a protected species on the Oregon Sensitive Species List. In Oregon, they are a statewide resident, but are scattered due to the fragmented nature of their habitat.

No known caves or mines occur in the Bull Run Watershed. Bridge surveys were conducted within the watershed for a variety of bat species during the summer of 1995. No Townsend's big-eared bats were observed.

The species is rapidly declining in Oregon and other states. Populations have declined 58% west of the Cascade range during the 1975-85 time period. East of the Cascades, the decline has been 16%.

Disturbance at hibernaculum and nursery sites appears to be the main reason for their decline. However, the number of suitable caves or other structures that can support the species is limited. The species also has a low reproductive rate (one young per year). A female produces only five to eight young in a lifetime (Marshall, 1992).

Larch Mountain Salamander *(Plethodon larselli)*

The Columbia River Gorge in Washington and Oregon comprises the range for the Larch Mountain salamander. The range in Oregon is the Columbia River Gorge in Multnomah and Hood River counties between Bridal Veil on the west and Mitchell Point on the east. While the range's southern edge has not been identified, the salamander has been reported from near the summit of Larch Mountain -- a record which has been questioned (Marshall, 1992). Similarly, the northern range has not been identified, but four populations have been found north of the Gorge near Mt. St. Helens, and also south of Mt. Rainier. They have been found to 3400 ft. (Leonard, et.al, 1993).

Habitat for the species is small-sized angular talus slopes where talus is kept moist by a covering of mosses and dense overstory of coniferous trees. The species is terrestrial and is almost never found associated with water.

Potential habitat for Larch Mountain salamander may exist in the northern end of the Bull Run Watershed, however the southern extent of its range is in question. All survey work for this species has been conducted in the Columbia River Gorge Scenic Area, where documented sightings have been reported. No documented sightings have occurred within the Bull Run Watershed.

Survey And Manage Species (C-3 Species)

Table C-3 of the Northwest Forest Plan lists four arthropods, five amphibians, one mammal, and forty three mollusk species with special survey and management needs.

The Mt. Hood National Forest is outside the range for the listed arthropod species. Of the five amphibians, only one species, Larch Mountain salamander, is known to occur or may potentially occur within the Forest. The Larch Mountain salamander is also a Regional Forester's "sensitive species." Beginning in 1995, the red tree vole has been documented in the watershed.

The list of 43 species of mollusks was interpreted by Mt. Hood National Forest Wildlife Biologist Robert Huff. His June 1994 document identifies which species occur or may potentially occur within the Forest. The terrestrial species are: *Hemphillia malonei, deroceras hesperium, Hemphillis pantherina, Prophysaon coerulem*, and *Prophysaon dubium*. These species inhabit moist forest within riparian areas and upland forests. They are often found in forest litter.

As of 1995, species in the Northwest Forest Plan table with a "survey strategy 1" (manage known sites) must be considered in project implementation. The Larch

Mountain salamander, red tree vole, and lynx ("survey strategy 2" species) require surveys to precede design of all ground-disturbing activities that will be implemented in 1997 or later. The Larch Mountain salamander and lynx are also both sensitive species and Protection Buffer Species (ROD C-28 and C-47). Extensive and general regional surveys (strategies "3" and "4") are required for many other species (ROD C-4 - C-6). All amphibians, mammals and mollusks are "survey strategy 1" or "2," while all arthropods are "survey strategy 4." (For the full listing of species, refer to ROD Table C-3, page C-59 and C-61.)

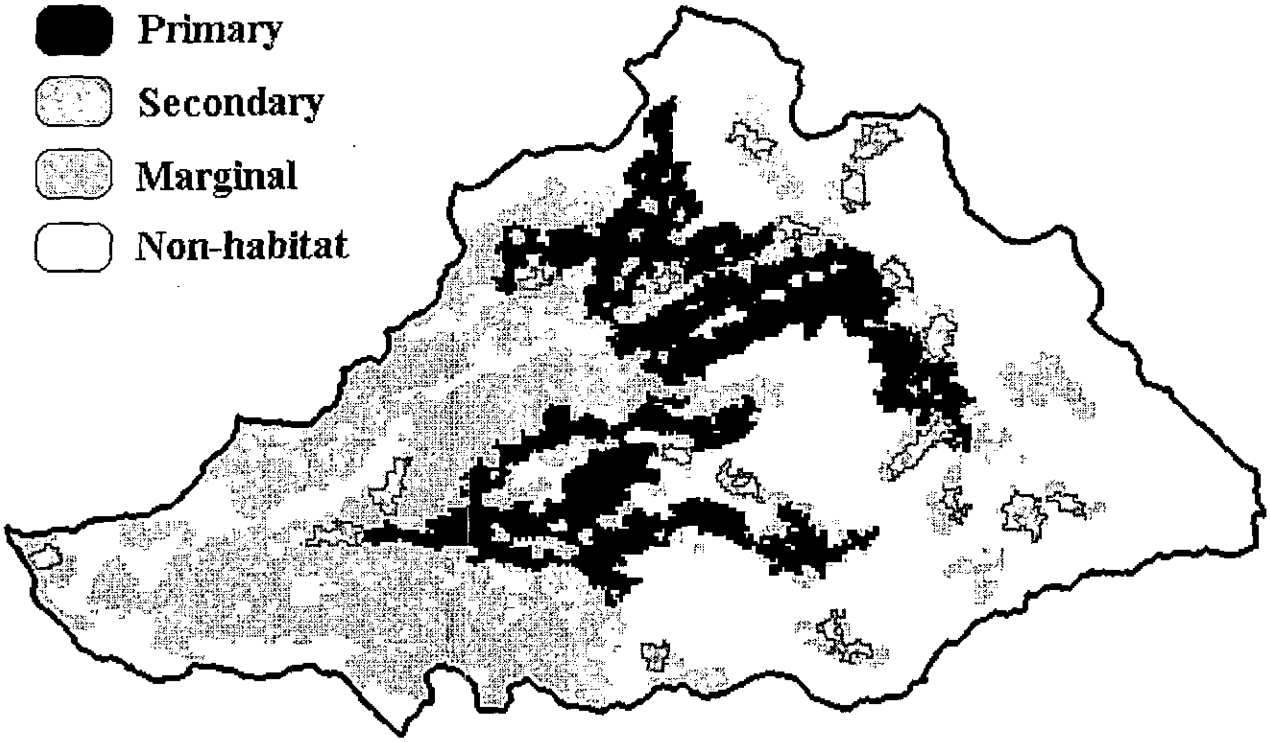
Red Tree Vole ***(Phenacomys longicaudus)***

The red tree vole spends most of its life in the canopy of coniferous trees and feeds on the needles. The voles main source of water is derived from fog drip and raindrops on Douglas fir needles. It has been well documented that red tree voles are strongly associated with Douglas fir trees (Carey 1991; Huff, Holthausen and Aubrey 1992), and to a lesser extent with western hemlock, grand fir, and Sitka spruce. The voles are considered to be closely associated with old-growth Douglas fir forests (Carey et al. 1991).

Most tree vole nests are in the lower one third of the canopy, from 10-150-feet up. At night the vole gathers fir needles for nests. Some of the larger tree vole nests may be as many as 100 years old. Because the red tree vole is almost entirely arboreal and stays within the forest canopy, the northern spotted owl, a subcanopy forager, is believed to be its main predator (Forsman 1976). Red tree voles in Oregon are distributed along the entire length of the coast, and in the northern Cascades on the western slope (Maser, Mate, Franklin, and Dryness, 1981).

A habitat model (See Figure 4-25) developed by the Mt. Hood National Forest's wildlife and ecology departments was used to create a map of red tree vole habitat on the Forest, based on Huff, et al., 1992.

Figure 4-25 -- Red Tree Vole Current Habitat



Primary habitat includes stands classified as large conifer (> 21" DBH) greater than 300 acres which occur at less than 3,000 feet in the Western Hemlock or Pacific Silver Fir vegetation zones. Secondary habitat requirements are the same, except size of habitat is 75 to 300 acres. Marginal habitat includes closed small conifer stands, less than 3,000 ft. in elevation, greater than 75 acres within the same two vegetation zones.

The modeling indicates that the Bull Run Watershed contains the largest and most continuous red tree vole habitat on the Forest. 13,093 acres or 15% of the watershed is in primary habitat; 2,957 acres, or 3%, is in secondary habitat; and 20,837, or 23%, is considered marginal habitat. The high level of precipitation and occurrence of fog drip may also contribute to high quality habitat

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In 1995, a survey of red tree vole habitat was conducted on the Forest which included a portion of the Bull Run Watershed. Eight red tree vole nests were found in the watershed, with four exhibiting evidence of red tree vole occupation. All nests were located in large Douglas-fir trees, yet surrounding stands included both second-growth and old- growth stands.

Protection Buffer Species

Protection Buffer Species in Matrix (ROD C-45)

Protection buffer species are defined as rare and local endemic species identified in the Scientific Analysis Team Report likely to be assured viability if they occur within designated areas. Where these species occur in the matrix, however, specific standards and guidelines will be applied. These species are: the white-headed woodpecker, black-backed woodpecker, pygmy nuthatch, flammulated owl, and lynx.

Because the white-headed woodpecker, pygmy nuthatch, and flammulated owl occur in ponderosa pine forests, they are highly unlikely to occur within the Bull Run Watershed. It is also unlikely that lynx would occur within the watershed because it is rare within the range of the northern spotted owl, occurring primarily in the Okanogan area of Washington. Winter track surveys have been conducted on the Zigzag and Columbia Gorge ranger districts since 1990. No lynx tracks have been identified.

The black-backed woodpecker, *Picoides arcticus*, could potentially occur within the watershed, however no sightings have been documented. Primary habitat for the black-backed woodpecker is lodgepole pine forest, usually within the Pacific Silver Fir or Mountain Hemlock vegetative zones. There are Matrix lands within the Pacific Silver Fir Zone in the Upper Little Sandy subwatershed in which protection buffer guidelines would need to be considered if this species was found.

The black-backed woodpecker is also known to follow pest infestations, or burned-over areas where prey is found in dead or dying conifers. It is known to flake away large patches of bark rather than drilling in for larva and insects. A recent study by Hutto, 1995, suggests that standing dead forests created by stand-replacing fires may be an important habitat for black-backed woodpeckers.

It is unlikely that the great gray owl, another protection buffer species, would occur in the Bull Run Watershed, but instead occur closer to the crest of the Cascade Range. Within Oregon, great gray owls have been found in the central western Cascades, the south central Cascades, and in the northeast portion of the state in lodgepole pine and mixed conifer forests (Hayward 1994). Large meadows have often been a component of their habitat. Great gray owls have been found breeding on the Willamette National Forest (south of the watershed), and have been reported on the Warm Springs Indian Reservation to the southeast and Gifford Pinchot National Forest to the north (Hayward 1994; Garehardt 1995).

There have been few documented occurrences of great gray owls on the Mt. Hood National Forest. All occurrences were auditory reports that were not visually verified.

Species Afforded Additional Protection Within Matrix

In addition to protection buffer species, several bat species are protected by additional standards and guidelines within Matrix lands (ROD C-43). Surveys are to be conducted of crevices in caves, mines, and bridges and abandoned buildings for presence of roosting bats. Species potentially occurring within the Bull Run Watershed include the silver-haired bat, long-eared myotis, and long-legged myotis.

Silver-haired bats, *Lasionycteris noctivagans*, are closely associated with old growth/mature forests. They roost in the fissures and grooves of the bark of large trees and snags. Long-eared myotis, *Myotis volans*, and Long-legged myotis, *Myotis evotis*, use a variety of habitats. They are associated with coniferous forests and are known to use mines, bridges, and abandoned buildings. Long-legged myotis are also known to use shrub wetlands and wet meadows.

Pileated Woodpecker And Pine Marten Areas (B5 Areas)

Page C-3 of the ROD states that: *"Administratively Withdrawn Areas that are specified in current Forest Plans to benefit American martens, pileated woodpeckers, and other late-successional species are returned to the Matrix unless local knowledge indicates that other allocations and these standard and guidelines will not meet the objectives for these species"*.

A forest-wide analysis was drafted (July, 1995) that assessed the relative importance of individual B-5 land allocation areas based on their contribution to late-seral forest conditions at the watershed level. The analysis procedure started by "screening out" any B-5 area that was in reserved land allocations. The remaining areas, in Matrix allocations, were further reviewed for their relation to the Northwest Forest Plan land allocations.

Within the Bull Run and Little Sandy watersheds, nine B-5 areas remained in Matrix land allocations and were reviewed further. All nine of the B-5 areas were immediately adjacent to late-successional reserves or administratively withdrawn areas. Therefore, the Forest-wide analysis recommended that none of the B-5 areas within Matrix lands within the Bull Run Watershed be retained. These management areas are therefore returned to Matrix allocation. District biologists have concurred with this recommendation.

Snags and Coarse Woody Debris

Fifty-one wildlife species that potentially occur within the watershed are dependent on snags. Most of the primary cavity nesters are generalists and can make use of available snags in any seral condition. Three species, however, (black-backed woodpecker, pileated woodpecker, and three-toed woodpecker) require snag habitat in late-seral forest condition. While the majority of secondary cavity nesters are also generalists, two species (mountain bluebird and western bluebird) require snags in early-seral conditions, and four species (barred owl, marten, northern flying squirrel, and northern spotted owl) use snags in late-seral conditions.

No quantitative assessment of snag habitat has been conducted for the Bull Run Watershed. However, due to the watershed's high volume of late-seral forest, its overall low levels of harvest, and its low acreages impacted with recent fire (see this chapter's fire history map), the Bull Run most likely has the highest number of snags than other watersheds on the Mt. Hood Forest.

Large snags are most abundant within unmanaged large conifer stands that are widely distributed throughout the watershed. However, most of the areas affected by windthrow and subsequent salvage (such as Otter Creek) have low levels of snags and a current, open stand structure. Levels of snags in the salvage units differ depending on amount of windthrow and management prescription.

The watershed also contains trees infected with laminated root disease (*P. weirii)*. These trees continually add to snag levels, however these snags are less stable and are inevitably windthrown. The biology of *P. weirii* does not contribute to rot higher up in trees, and therefore may not create good habitat for cavity nesters.

Sixty-six wildlife species that potentially occur within the watershed are dependent on downed logs. Coarse woody debris is important in mineral cycling, nutrient mobilization, natural forest regeneration, and also creates a structure and diversity of habitats valuable to many terrestrial and aquatic wildlife species. Downed woody debris serves as sites for feeding, reproducing, and resting. It is also important for denning areas, invertebrate and vertebrate prey sources for birds and salamanders, and habitat for small mammals.

Coarse woody debris levels likely follow a similar pattern as snag levels. Unmanaged large conifer stands have higher levels of coarse woody debris than managed plantations. Most blowdown areas with subsequent salvage also experienced burning or yarding unmerchantable materials fuel treatments which reduced coarse woody debris levels. Areas with recent fire history (Linket and Log Creek fires) have experienced reduced – depending on the fire's intensity – coarse woody debris levels. Due to the Northwest Forest Plan's increased protection for this habitat component, trends for coarse woody debris within the Bull Run Watershed are likely to maintain or increase.

Life History Guilds

Wildlife species have been grouped into life history guilds based on how they are expected to respond to different amounts and distributions of habitat across the landscape (Mellen, Huff, Hagestedt, 1995). Home range size, patch configuration use, and structural stage use were used to group terrestrial species. Riparian associated species were grouped by water body, aquatic association, and structural stage. Species that require special habitats such as caves or cliffs were not grouped into guilds. The objective of the guilding approach is to predict terrestrial and amphibian occurrence relative to landscape patterns for the Mt. Hood Forest.

The following tables display the criteria used to group species by life history into guilds, and the amount of habitat for each guild located within the Bull Run Watershed. Amount of habitat is displayed by acres and percent of watershed. Historic habitat is also indicated, allowing habitat trends to be inferred.

In general, during the last 50 years, there have been increases in contrast habitats and habitats requiring openings or small trees, and decreases in habitats requiring large trees.

Table 4-20 -- 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 less than 60 acres
- MEDIUM: Home ranges 60 - 1000 acres
- LARGE: Home ranges more than 1000 acres

PATCH CONFIGURATION:
- PATCH: Species requiring one homogeneous patch (one structural stage) during life cycle (or breeding period for migrants).
- MOSAIC: Species capable of aggregating patches of like structural stages that are dispersed in a mosaic pattern across the landscape.
- CONTRAST: Species using two different major structural stages in close proximity, usually large tree and open.
- GENERALIST: Species whose primary habitat is not restricted to one major structural stage.

STRUCTURAL STAGE:
- OPEN: Includes grass/forb, shrub, leave tree/shelterwood, and open sapling/pole.
- SMALL TREE: Includes closed sapling/pole, open small conifer (less than 21")
- LARGE TREE: Includes large conifer (more than 21") and old growth.

RIPARIAN: Species that require aquatic or riparian habitats (may use terrestrial habitat if riparian habitat is nearby. May use special habitats, but do not require them).

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

STRUCTURAL STAGE:
- OPEN: Grass/forb/shrub.
- FORESTED: Hardwood sap/pole, hardwood small tree/large tree, conifer sap/pole, and conifer small tree/large tree.

Example: TSPO equates to Terrestrial, Small home range, Patch configuration, and Open structural stage..

Table 4-21 – Historic and Current Habitat Available for Terrestrial Guild Groups

GUILD CODE	HOME RANGE	PATCH TYPE	STRUCTURE STAGE	HISTORIC ACRES	HISTORIC % OF WA	CURRENT ACRES	CURRENT % OF WA
TSPO	Small	Patch	Open	4,757	6%	11,172	13%
TPSPT	Small	Patch	Small Tree	0	0	0	0
TSPLT	Small	Patch	Large Tree	48,247	58%	27,298	31%
TSMO	Small	Mosaic	Open	4,797	6%	11,947	13%
TSMST	Small	Mosaic	Small Tree	0	0	0	0
TSGOS	Small	Generalist	Open/Small Tree	29,255	35%	57,383	65%
TSGSL	Small	Generalist	Small/Large Tree	48,795	59%	73,692	83%
TSGG	Small	Generalist	All	78,608	95%	87,426	98%
TMPO	Medium	Patch	Open	0	0	0	0
TMMO	Medium	Mosaic	Open	3,873	5%	7,716	9%
TMMLT	Medium	Mosaic	Large Tree	16,203	20%	11,597	13%
TMGG	Medium	Generalist	All	78,608	95%	87,426	98%
TLMO	Large	Mosaic	Open	4,229	5%	1,598	2%
TLMLT	Large	Mosaic	Large Tree	47,765	58%	24,949	28%
TLGG	Large	Generalist	All	78,608	95%	87,426	98%
TSC	Small	Contrast	Contrast	1,892	2%	6,491	7%
TMC	Mosaic	Contrast	Contrast	3,243	4%	8,062	9%
TLC	Large	Contrast	Contrast	4,661	6%	12,557	14%

[Note: Current habitat is based on the ISAT vegetation database, modified for the Bull Run Watershed. Historic vegetation is based on a 1940s' database. Because the historic vegetation database did not include a portion of the watershed's western end, an exact comparison of acres is not possible. A comparison of percentages is therefore more accurate.]

Table 4-22 -- Current Habitat Available for Aquatic/Riparian Guild Groups

GUILD CODE	WATER BODY	AQUATIC ASSOCIATION	STRUCTURE STAGE	TOTAL ACRES	% OF WATERSHED
LAKEA	Lake	Aquatic		1413	2%
LAKEARO	Lake	Aquatic, riparian	Open	1628	2%
LAKERO	Lake	Riparian	Open	215	<1%
LKRVA	Lakes/Rivers	Aquatic		1,594	2%
LKRVARO	Lakes/Rivers	Aquatic, riparian	Open	6,125	7%
LKRVARF	Lakes/Rivers	Aquatic, riparian	Forested	31,518	35%
LKRVARG	Lakes/Rivers	Aquatic, riparian	All	36,156	41%
LKRVRO	Lakes/Rivers	Riparian	Open	4333	5%
LKRVRG	Lakes/Rivers	Riparian	All	34,274	39%
RIVA	Riverine	Aquatic		approx. 181	<1%
RIVARF	Riverine	Aquatic, riparian	Forested	28,435	32%
RIVARG	Riverine	Aquatic, riparian	All	33,056	37%
RIVRO	Riverine	Riparian	Open	4316	5%
RIVRF	Riverine	Riparian	Forested	28,254	32%

[Note: The aquatic portion of rivers was approximated from data available solely on surveyed streams. The actual number should therefore be higher.]

Deer and Elk

Deer and elk, although not "species of concern," are an important recreational and economic resource both to hunters and those wishing to view the animals. Although most of the Bull Run Watershed is closed to public access and hunting, portions of the lower

Little Sandy subwatershed allow hunting on foot on gated roads. A portion of the Little Sandy subwatershed is also allocated as deer and elk winter range.

Deer and elk need both forage and cover within their home range if they are to acquire and conserve the energy they require daily. Areas with high quality forage and cover with reasonable freedom from human disturbance provide the most productive habitat for deer and elk.

Historically, deer and elk used naturally occurring forest openings. Today, in a managed forest, deer and elk use forage created by clearcut logging adjacent to forest stands (Brown 1985). Elk are classified as a contrast species. Based on the analysis of life history guilds, 14% of the watershed is potential habitat for elk (TLC habitat), whereas 98% of the watershed is available for deer, a generalist species. Historically, only 6% of the watershed was potential habitat for elk, indicating an increase in elk habitat from created openings.

Overall though, elk population numbers appear to be declining within the Zigzag and Columbia Gorge Ranger Districts. Many factors may affect this, including: high human presence, low amounts of available forage, and high road densities.

Roads may inhibit deer and elk use of quality foraging, rearing, and wintering areas. The Mount Hood Forest Plan standards state: *"By year 2000, roads open to motorized vehicle traffic should be reduced to not exceed 2.0 mi/sq. mile within inventoried deer and elk winter range, and 2.5 mi/sq. mi within deer and elk summer range (FW-208)."*

Road density by subwatershed is displayed in Table 4-23. Road densities exceed the summer range standard in several subwatersheds: Headworks, Lower Bull Run, Lower Little Sandy, North Fork, and South Fork. The Lower Little Sandy also exceeds the winter range standard, however, actual road use in the watershed is low compared to watersheds with public entry.

Table 4-23 Road Densities

Subwatershed	Road Density (miles per square mile)
Blazed Alder	1.65
Bull Run	1.69
Fir Creek	0.49
Headworks	3.25
Lower Bull Run	2.20
Lower Little Sandy	3.02
North Fork	2.72
South Fork	2.05
Upper Little Sandy	3.13

The lower portion of the Little Sandy subwatershed is identified as severe and normal winter range. Normal winter range is defined as areas having less than 18 inches of snow, and areas used by the animals during mild winters. These winters occur in eight or nine years out of a ten year period. Severe winter range is used during severe weather -- which generally occurs one or two years each decade. Road densities in these areas should not exceed 2.0 mi/sq. mi (as previously stated).

Road density within the winter range allocation (B10) in the Little Sandy Watershed is 3.12 miles/square. This exceeds the standard of 1.5 miles per square mile. Management actions should therefore be taken to reduce road densities to acceptable levels. (See Chapter 7, Recommendations.)

Neotropical Migratory Bird Program

In May of 1990, the National Fish and Wildlife Foundation launched the Neotropical Migratory Bird (NTMB) Conservation Program, a domestic and international initiative for the conservation of neotropical birds. The Forest Service has participated in this program since its inception. A NTMB program emphasis within the Forest Service has been establishing a cooperative, coordinated monitoring program on National Forest System lands (Manley, et al, 1993).

The hierarchical monitoring framework consists of three levels: Level 1 entails monitoring population trends; Level 2 evaluates habitat relationships or management impact; and Level 3 monitors species' demographics and associated environmental factors.

Within the Bull Run Watershed, Level 2 monitoring is currently being implemented by establishing permanent sampling stations in old-growth habitats. Since 1994, bird presence is monitored during the spring and summer. This monitoring is planned to continue until 1999. Twenty permanent census stations have been established within the watershed in Cedar Creek, Camp Creek, North Fork, and Bull Run River. All of these stands are located in Douglas fir and Western Hemlock old-growth stand conditions.

Regional NTMB monitoring strategy goals are: to determine population presence or absence and abundance trends, and relate species abundance or trends to habitat characteristics and land-use practices. Development of a baseline information source to evaluate trends and habitat characteristics is the primary outcome of these objectives.

Role of the Watershed as a Refuge

Within the Bull Run Watershed Management Unit, access has been limited and hunting is not permitted. Wildlife has therefore had limited encounters and harassment by humans -- allowing the watershed to serve as a unique refuge from human intrusion.

Based on the abundance and frequency of black bear sightings along the watershed's roadways, black bear concentrations appear to be high in the drainage. Bears in the Bull Run Watershed seem to be a "source" population to areas surrounding the drainage. When bear concentrations rise to high levels, the bear begin to emigrate out of the area, helping establish populations elsewhere on the Forest.

Plantations within the drainage have been used as foraging habitat for bears. The animals strip the bark from young (five to fifteen-year-old) sapling sized trees for the sap. The bark stripping also girdles the tree, resulting in tree mortality and loss of stand productivity. In the past, management practices have attempted to lessen bear damage to plantations. Many of these plantations, however, are now located within the Late-Successional Reserve, resulting in less emphasis to lessen or prevent this bear damage.

Cougars have also been frequently documented within the watershed. Lack of human interaction may be a contributing factor. Bald eagles and common loons, species that require high levels of seclusion, also utilize habitat within the watershed.

The lack of human harassment and development within the watershed, coupled with high quality habitats, has created an important refuge environment for several species.

Conclusions: Wildlife

- Peregrine falcons, which nest in the cliffs of the Columbia Gorge, are suspected to use the Bull Run Watershed as a foraging site. Potential nesting habitat also exists within the watershed for this species.

- Quality bald eagle nesting habitat occurs around Bull Run Lake and both reservoirs. Bald eagles use the watershed as foraging habitat, but nesting activity has not been documented.

- The Bull Run Watershed contains some of the best and most continuous northern spotted owl habitat within the Mt. Hood National Forest. Approximately half of the watershed is suitable owl habitat, with 63% dispersal habitat. Twenty known spotted owl pairs are located within the watershed.

- Common loons frequently use the reservoirs as a migration stop-over point. While nesting pairs of common loons are rare in the Pacific Northwest, it is believed that nesting or unsuccessful nesting attempts have occurred at the Upper Reservoir.

- Cope's giant salamanders have been documented in several locations within the watershed, including tributaries to Bull Run Lake, Cougar Creek, and Bear Creek.

- Red legged frogs are common in the lower end of the watershed and breed there frequently.

- Because of its limited human harassment, the Bull Run Watershed provides high quality habitat for wolverines, although potential denning habitat would most likely occur at higher elevations than in the Bull Run. A wolverine was sighted at the Bear Creek House in 1996.

- The Bull Run Watershed contains the largest and most continuous red tree vole habitat on the Mt. Hood Forest and eight red tree vole nests have been found in the watershed.

- Habitat trends over the last fifty years indicate increases in contrast habitats and habitats requiring openings or small trees, and decreases in habitats requiring large trees.

Hydrology

"In the world there is nothing
more submissive and weak than water.
Yet for attacking
that which is hard and strong,
nothing can surpass it."

Lao-Tzu
Legendary Chinese Philosopher
Sixth Century B.C.

Introduction

With respect to water quantity and quality, the Bull Run Watershed is unique in a local, regional, and even national perspective. Unit runoffs (inches per year) observed in this watershed can not be witnessed elsewhere in the United States outside of the Pacific Northwest. Even in a regional context, values seen here are rare. The Bull Run Watershed provides a great deal of water from a relatively small area. It is a highly concentrated and intense water source area (Aumen, Hawkins and Grizzard, 1989).

By any objective standard, the water quality of the Bull Run Watershed's streams can only be described as extraordinary. From the earliest days of using the basin as Portland's water supply, its purity has been lauded. At present, chemical measurement of dissolved species in the water require the utmost in analytical skill because of the minimal amounts of their concentrations – generally at or near the limits of detection for accepted analytical methodologies (Aumen, Hawkins and Grizzard, 1989).

This section of the analysis is organized into the following subsections:

1. Characterization
2. Flow Regime
3. Water Quality

Characterization

Stream Network

Figure 4-26 -- Stream Network

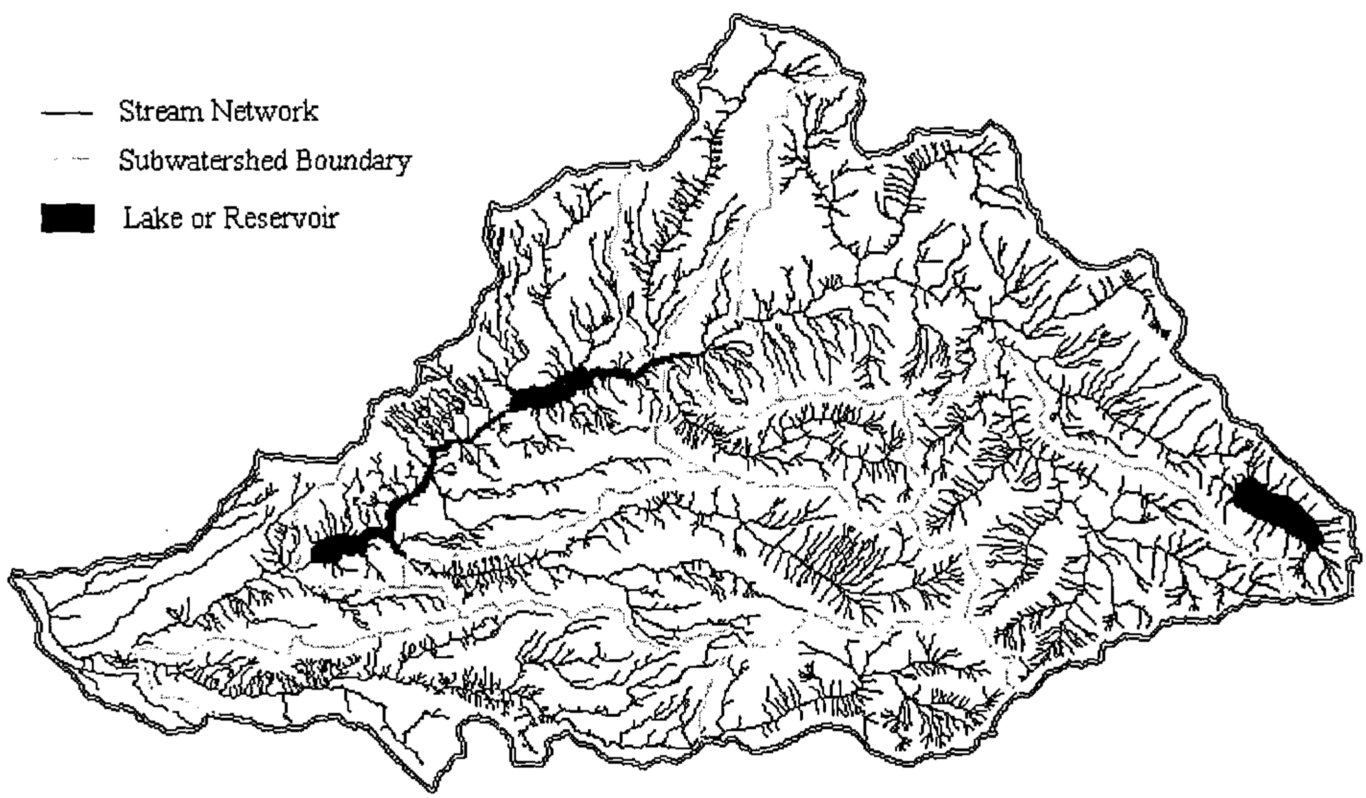


Figure 4-26 displays the stream network including intermittent streams.

The landscapes we observe in a watershed are formed by erosional and depositional processes resulting from a complex integration of climate, lithology, and vegetation patterns over extended time periods (Rosgen, 1996).

Stream densities throughout the watershed are variable with influences from associated geology, soils and precipitation.

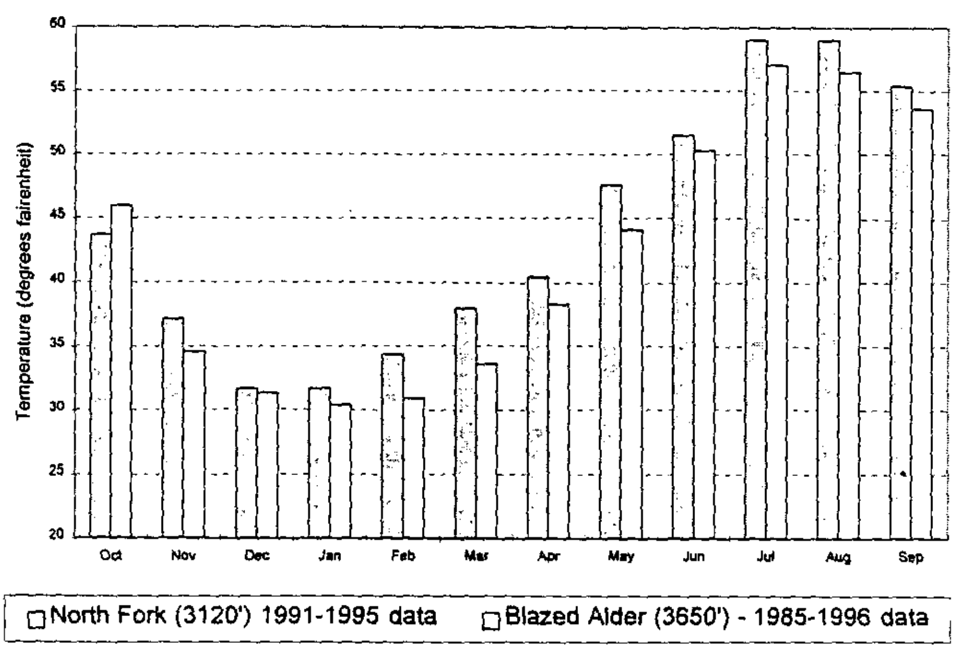
Table 4-24 Stream Densities

Subwatershed	Stream Density (miles per sq. mile)
Blazed Alder	5.30
Bull Run	4.50
Fir Creek	5.89
Headworks	4.84
Lower Bull Run	3.87
Lower LS	4.56
North Fork	3.81
South Fork	4.87
Upper LS	4.81

Climate

Climate is significant in determining: patterns of river and stream flow, moisture content of the soil, and plants that inhabit an area. Climatic conditions within the Bull Run Watershed are typical of the Western Cascade foothills. Temperatures are normally mild, with January lows just below freezing to the mid-20s, and July highs of approximately 80 degrees (Blowdown FEIS).

Chart 4-4 -- Daily Average Air Temperatures SNOTEL Sites

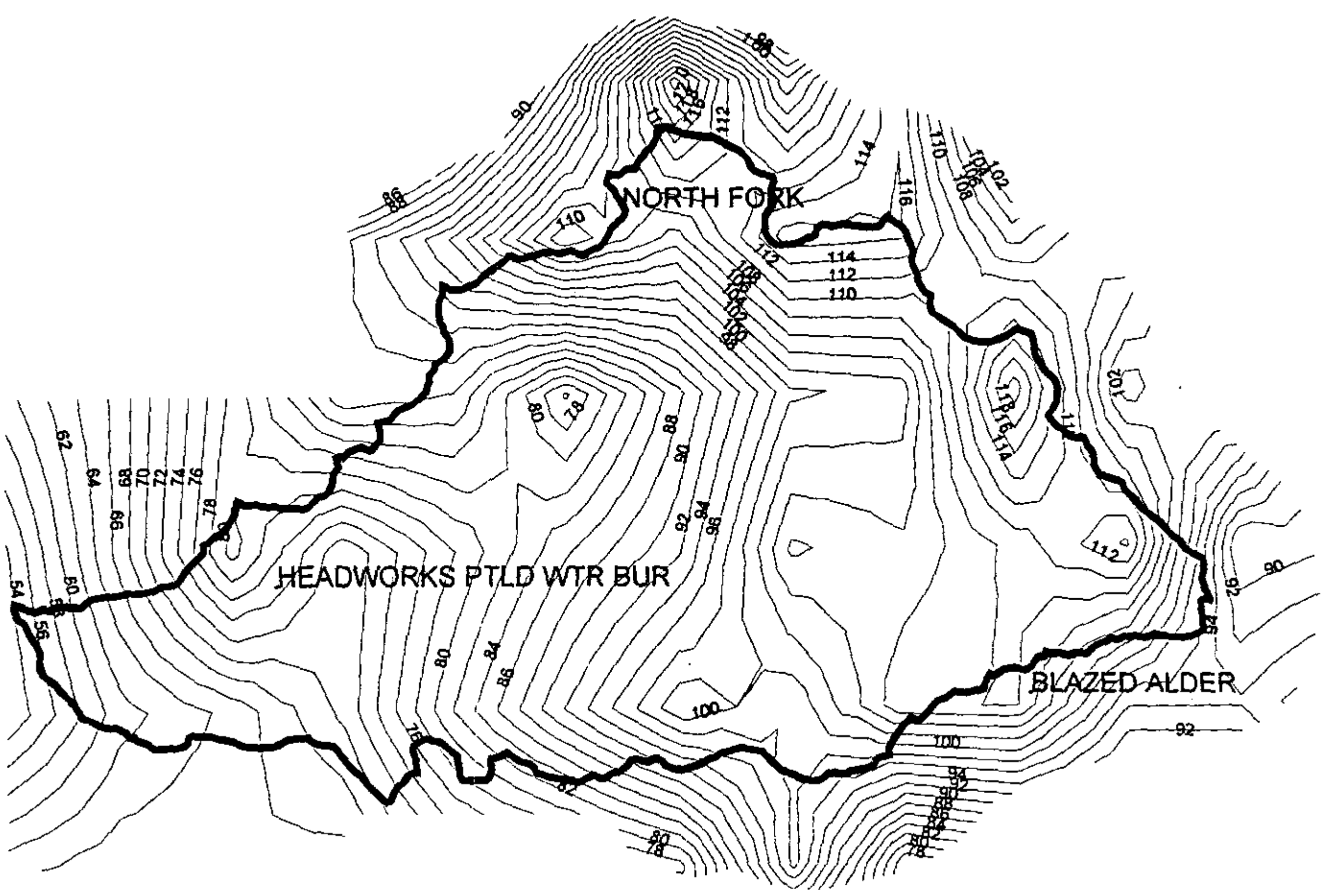


Average annual precipitation ranges from 52-118 (Figure 4-27). July and August are the driest months; November, December, and January are the wettest. Precipitation at the lower elevations is primarily in the form of rain. At higher elevations, 25 to 30% of the annual precipitation may be in the form of snow. Snowpack depth and period of accumulation vary with elevation. Snowfall is rare below 2,000 feet, while it often reaches a depth of 6 to 10 feet above 4000 feet. (Blowdown FEIS).

PRISM Mean Annual Precipitation (Daly C, 1994)

The following precipitation map was based on mean monthly precipitation for the period 1961-90 reported at NOAA cooperative stations and Natural Resource Conservation Service Snotel stations. Figure 4-27is from the state wide coverage clipped to the Bull Run watershed analysis area. Grid resolution is 2.5 minutes latitude/longitude, or about 4x4 km.

Figure 4-27 PRISM Average Annual Precipitation (1961-1990)



These DRAFT monthly precipitation estimates were generated by Christopher Daly using the PRISM model (Daly et al., 1994). They replace the previous US precipitation maps developed in 1991 and 1993. Data input to the model consisted of 1961-90 monthly average precipitation totals. A station was included in this data set if it had at least 20 years of valid data, regardless of its period of record.

This is part of a national effort by the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service) and Oregon State University to develop state-of-the-art precipitation maps for each state in the US. *Note: these draft maps will be superseded by final versions in Spring 1997.*

PRISM (Parameter-elevation Regressions on Independent Slopes Model) is an expert system that uses point data and a digital elevation model (DEM) to generate gridded estimates of climate parameters (Daly et al., 1994). Unlike other statistical methods in use today, PRISM was written by a meteorologist specifically to address climate. PRISM is well-suited to mountainous regions, because the effects of terrain on climate play a central role in the model's conceptual framework.

The primary effect of orography on a given mountain slope is to cause precipitation to vary strongly with elevation. Orographic effects may operate at relatively large spatial scales, responding to smoothed topographic features rather than detailed variations in terrain. Relationships between measured precipitation and elevation are sometimes strengthened when the elevation of each data point is given in terms of its height on a smoothed terrain. The relationship between precipitation and elevation varies from one slope face to another, depending on location and orientation. Thus, a mountainous landscape can be thought of as a mosaic of smoothed topographic faces, or "facets," each experiencing a different orographic regime. A topographic facet is a contiguous area over which the slope orientation is reasonably constant.

PRISM has been compared to kriging, detrended kriging, and cokriging in the Willamette River Basin, Oregon (Daly et al., 1994). In a jackknife cross-validation exercise, PRISM exhibited lower overall bias and mean absolute error.

The Oregon Department of Water Resources has recently abandoned its previous precipitation fields in favor of PRISM estimates for water supply forecasting. PRISM is also a useful framework for examining the effects of gauge undercatch on runoff prediction.

Chart 4-5 -- Average Monthly Precipitation (1981-1995) at SNOTEL sites

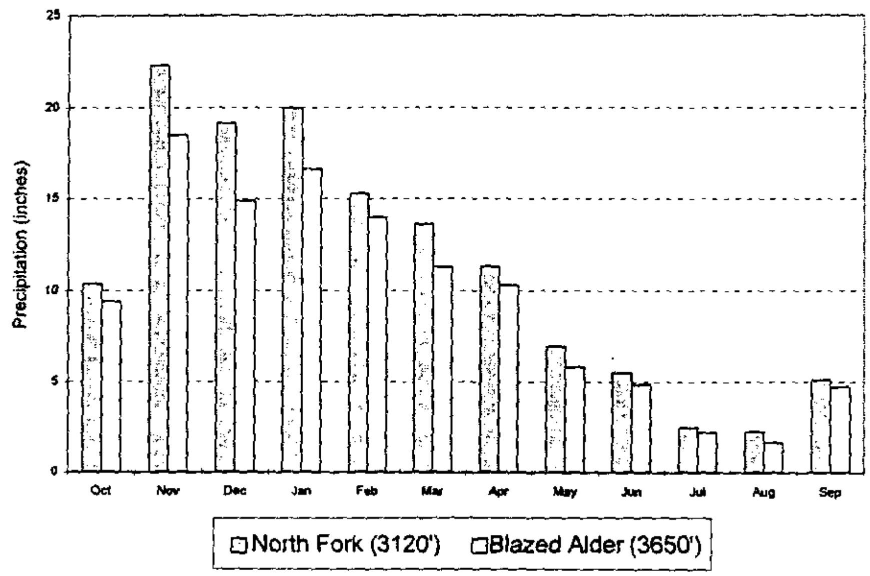
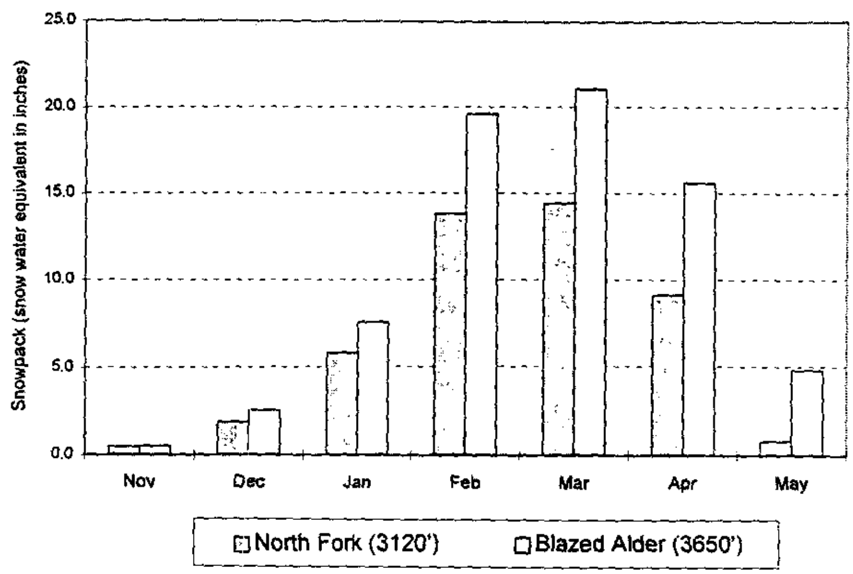


Chart 4-6 – Snowpack (Snow Water Equivalent) at SNOTEL Sites, 1996

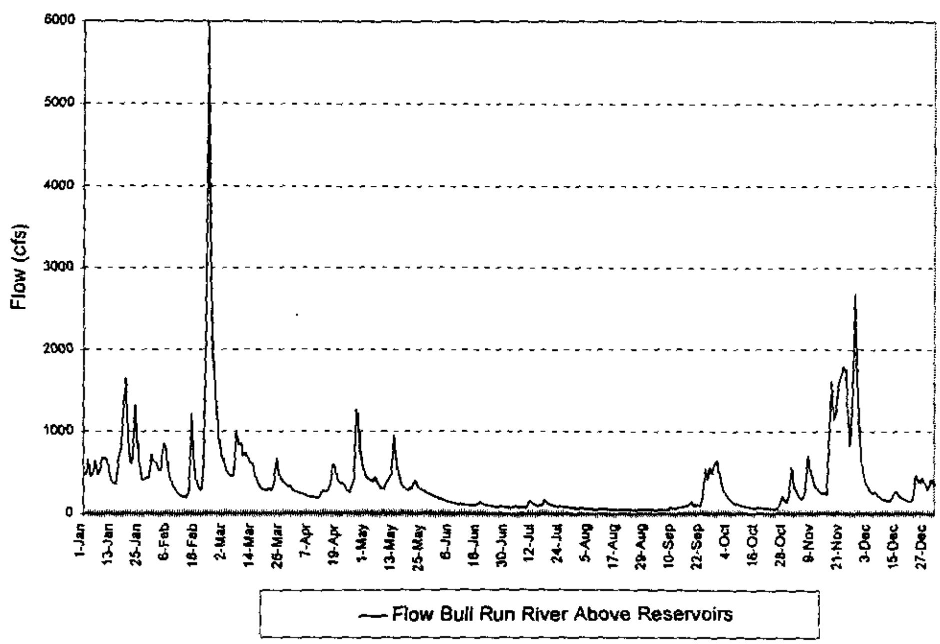


Streamflow

Stream flows within the Bull Run Watershed are characterized by low flows in the late summer (August and September) and high flows generated by, typically, a dozen distinct storm events during October through April (Aumen, Grizzard, and

Hawkins, 1989). Flows from the Bull Run River gage, plotted in Chart 4-7, demonstrate August and September's low flow period, and the high flows associated with October through April's storm events. The peak flow event in February and was generated by a rain-on-snow event. 1986 was selected as a representative year because of the typical low flow period and the rain-on-snow event in February.

Chart 4-7 – Flow: Bull Run River Above Reservoirs, 1986



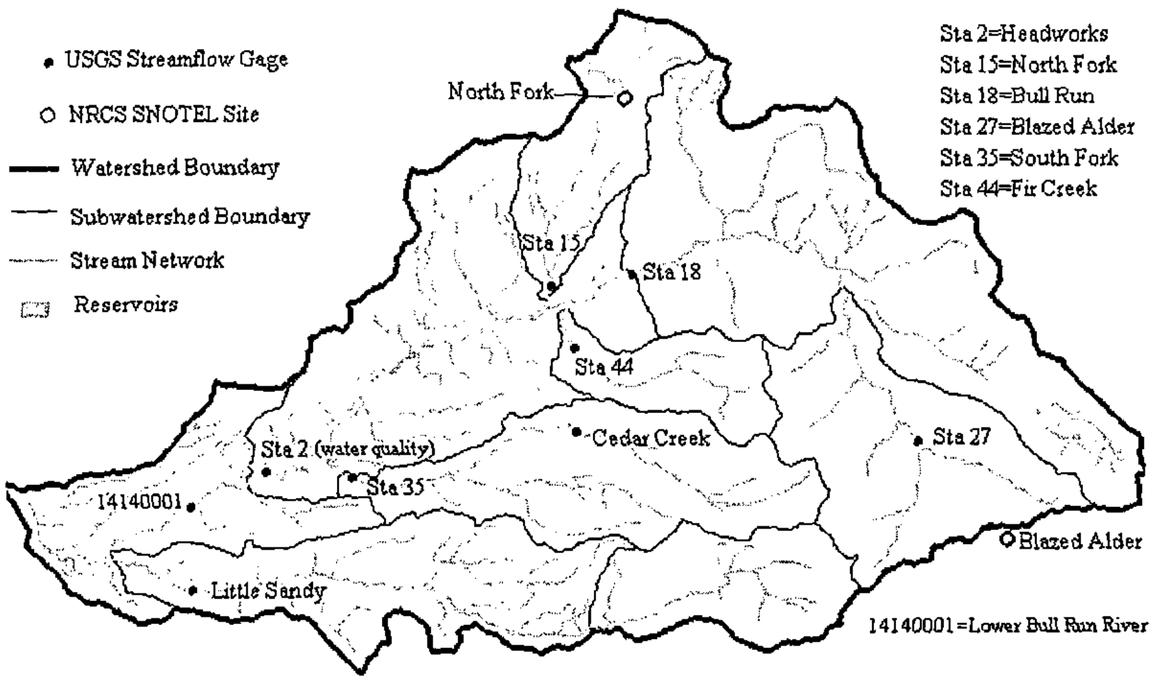
Monitoring Network

Although water quality data have been collected in the Bull Run Watershed since the turn of the century, a regular monitoring program for streams in the water supply drainage was not implemented until the 1970s. Water quality standards were established for the five Key Stations for which substantial water quality data was available.

- **Station 2 Headworks** -- Located below the major storage reservoirs and just above where water enters the screen house for disinfection.
- **Station 15 North Fork** -- Located on the North Fork River just upstream from the confluence with Reservoir #1.
- **Station 18 Bull Run** -- Located on the Bull Run River, upstream of the confluence with Reservoir #1.
- **Station 35 South Fork** -- Located on the South Fork River just upstream from the confluence of Reservoir #2.

  Station 44 Fir Creek -- Located on Fir Creek just upstream from the confluence of Reservoir #1. Fir Creek is an unmanaged subwatersed (no significant roading or logging) used as a "no management control" for the entire watershed. As with any wildland basin selected to represent a "control" there are limitations to comparisons when differences are slight. Limitations for comparability to Fir Creek relate to sensitive soils and geology, gradient, basin size, aspect, and precipitation regime.

Figure 4-28 -- Streamflow Gages and Snotel Sites



In addition to the Key Stations (excluding Station 2), streamflow gages on Blazed Alder, Cedar Creek, and the Little Sandy River were also used in this analysis.

Flow Regime

Aquatic organisms require adequate flows to be maintained at critical times to satisfy requirements of various life stages. For example, fish are adapted to natural variations in flow regimes but may be adversely affected by disturbances that alter natural flow cycles (Statzner et al. 1988). Timing, magnitude, duration, and spatial distribution of peak and low flows must be sufficient to create and sustain riparian and aquatic system habitat and to retain patterns of sediment, nutrient, and wood routing. The timing, variability, and duration of floodplain inundation and water table elevation in meadows, floodplains and wetlands affect maintenance of main channel connectivity within these areas (FEMAT).

Timber harvest and associated activities can alter the amount and timing of streamflow by changing onsite hydrologic processes (Keppeler and Ziemer 1990;

Wright et al. 1990). These activities (which include harvest, thinning, yarding, road building, and slash disposal) can produce changes that are either short-lived or long-lived -- depending on which hydrologic processes they alter and the intensity of the alteration (Harr 1983). Thus, changes in the hydrologic system caused by road building are most pronounced where road densities are the greatest (Harr et al. 1979; Wright et al. 1990; Ziemer 1981). Similarly, the effects of clearcut logging on hydrologic processes are greater than those resulting from thinning (Harr 1983; Harr et al. 1979).

Changes in hydrologic processes can be grouped into two classes according to causal mechanisms. One class consists of changes resulting from removing forest vegetation through harvest. These changes, which can be very large when located close to the harvest areas immediately following harvest, gradually diminish over time as vegetation re-growth occurs (Harr 1983; Harr et al. 1979; Harris 1977; Hicks et al. 1991b).

Processes that depend on the amount and size of forest vegetation include rain or snow interception, fog drip (Azevedo and Morgan 1974; Byers 1953; Harr 1982; Ingwerson 1985; Isaac 1946), transpiration (Harr 1983; Harr et al. 1979, 1982), and snow accumulation and melt (Berris and Harr 1987; Coffin and Harr 1992; Harr 1981; Troendle 1983; Swanson and Golding 1982). These processes (most of which are at least partially energy-dependent) all increase the amount or timing of water arriving at the soil surface, as well as the resultant amount of water flowing from a logged watershed (FEMAT, V-20).

Generally, the longevity of changes in these processes brought about by timber harvest is approximately three to four decades. It is related to vegetation characteristics such as tree height, leaf area, canopy density, and canopy closure (Coffin and Harr 1992; Harr and Coffin 1992; Troendle 1983; Hicks et al. 1991b).

A second class of changes in hydrologic processes consists of those that control infiltration and the flow of surface and subsurface water. This class is dominated by the effects of forest roads. The relatively impermeable surfaces of roads cause surface runoff that bypasses longer, slower subsurface flow routes (Harr et al. 1975, 1979; Ziemer 1981). Where roads are in-sloped to a ditch, the ditch extends the drainage network, collects surface water from the road surface and subsurface water intercepted by roadcuts, and transports this water quickly to streams (Wemple 1996; Megahan et al. 1992).

The longevity of changes in hydrologic processes resulting from forest roads is as permanent as the road. Until a road is removed and natural drainage patterns are restored, the road will likely continue to affect the routing of water through watersheds (FEMAT, V-20).

In 20-200 square mile watersheds, increased peak flows have been detected after roading and clearcutting occurred (Christner and Harr 1982; Jones and Grant, 1996). Higher flows result from: a combination of wetter, more efficient water-transporting soils following reduced evapotranspiration(Harr et al. 1982; Harris 1977); increased snow accumulation and subsequent melt during rainfall (Berris and Harr 1987; Harr 1986; Harr and Coffin 1992); surface runoff from roads (Harr et al. 1975, 1979); extension of drainage networks by roadside ditches (Wemple 1996); and possibly reduced roughness of stream channels following debris removal and salvage logging in riparian zones (Jones and Grant, 1996).

The alteration in stream flow regime resulting from timber harvest and associated activities can have both positive and negative effects on the aquatic system (Hicks, B.J 1991a). For example, decreased evapotranspiration following logging and prior to vegetation regrowth can increase summer stream flows which may bring about short-term increases in juvenile salmonid survival. Conversely, increased peak flows may increase bed-load movement and reduce survival of salmonid eggs and alevins (FEMAT, V-20).

Effects of streamflow changes on aquatic organisms have not been documented independently from other logging effects. The extent to which the positive effects of short-term increase in summer flows is offset by the detrimental effect of increased peak flows and resultant scour is unknown (FEMAT, V-22).

Statistical Methods

Throughout this section of the analysis similar statistical methods were used. This section summarizes the methods used, gives the rationale for why a particular method was used, and gives example output with explanations.

Trends Analysis

The Seasonal Kendall Trend Test used in this analysis is a component of the WQhydro software package, developed by Eric R. Aroner. Rinella (1987) provides the following explanation of this analysis method:

> *"The trends analysis used was developed to detect trends in water quality data. This technique is suitable for detecting time trends in water quality datasets that have: non-normal distributions; seasonally, flow relatedness; missing values; and values below the limit of detection."*

In this analysis, the median value for a particular variable was computed for each season and tested for a monotonic trend in time, using a modified form of Kendall's tau. In this modified Kendall's tau, only the median values from the same season for different years are compared.

The Seasonal Kendall Trend Test is a statistical tool that assigns a probability level to the occurrence of a trend for each variable-value time series. For example, a probability level of 0.0243 indicates a 2.43% chance that the trend evident in the sample does not exist in the population – and that the observed sample trend is the result of random sampling variability (Aroner, 1995).

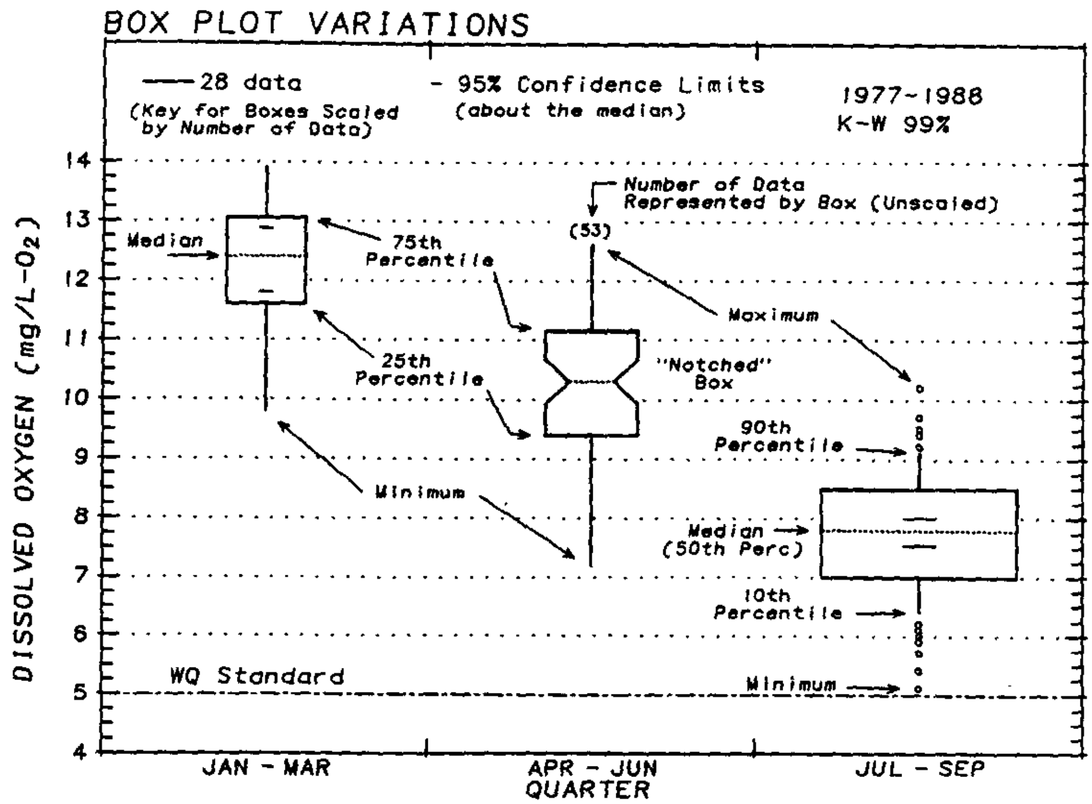
Because they represent statistical inferences regarding populations, the Seasonal Kendall Trend Test should therefore be treated similarly to other statistical tests. While these statistical statements can be precise, the hydrological significance and interpretation require careful thought and insight into the system's operation (Rinella, 1987). In this analysis, results that yielded probability levels (P-level) less than 0.10 were considered significant.

The seasonal Kendall slope indicator represents the median of the difference in concentration units per year of the ordered pairs of observations or residuals. A positive Kendall slope indicator is indicative of an increasing trend. The opposite is true with a negative seasonal Kendall slope indicator.

Seasonal Box and Whisker Plots by Station and Variable

Seasonal box and whisker plots and charts of monthly medians were used to graphically display differences between the monitoring stations that were later analyzed using the Wilcoxen test.

Chart 4-8 -- Sample Box Plot from WQhydro Software



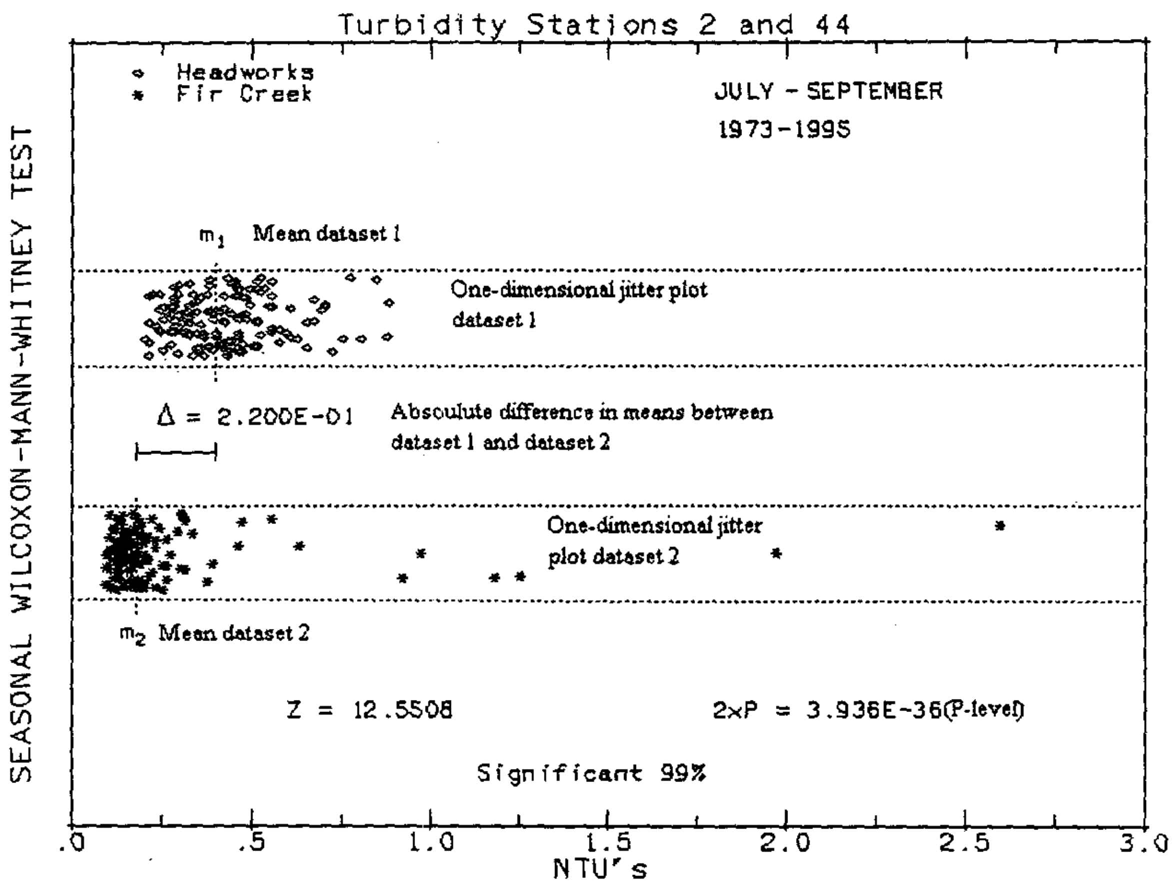
Box and whisker plots used in this analysis were created using WQhydro software (Aroner, 1995).

Chart 4-8 is an example of the output. The type of plot used in the analysis is detailed in the box on the far right. Median, 95% confidence limits, 25th and 75th percentile, 10th and 90th percentile, and maximum and minimums are portrayed with this type of box plot.

Seasonal Wilcoxen-Mann-Whitney Test

The Seasonal Wilcoxen-Mann-Whitney test is a non-parametric test used to determine the differences between two means.

Chart 4-9 – Example Seasonal Wilcoxen-Mann-Whitney Test Plot



Peak flows

This section examines streamflows in the Bull Run Watershed in areas above dams and diversions. This approach enables natural and management effects to be distinguished from dams and diversions' effects on the flow regime. Because the flow regime below the dams and diversions within the Bull Run Watershed is in an altered state associated with the structures, flows in this area are discussed separately. The effect of Bull Run Lake releases on the flow regime are also discussed in a separate section.

Introduction

Peak streamflows have important effects on stream channel morphology, sediment transport, and bed material size. Peak streamflows affect channel morphology through bank erosion, channel migration, riparian vegetation alteration, bank building, and deposition of material on floodplains. The vast majority of sediment transport occurs during peak flows as sediment transport capacity increases logarithmically with discharge (Ritter 1978; Garde and Rangu Raju, 1985).

The ability of the stream to transport incoming sediment will determine whether deposition or erosion occurs within the active stream channel. The relationship between sediment load and sediment transport capacity will affect the distribution of habitat types, channel morphology, and bed material size (MacDonald, 1991). Increased size of peak flows due to urbanization have been shown to cause rapid channel incision and severe decline in fish habitat quality (Booth, 1990).

Another important consideration is the impact of bankfull flow, often described as the high flow during two out of three years, or as a stream discharge having a recurrence interval of 1.5 years (Dunne and Leopold, 1978). The shape of the channel more closely reflects the bankfull width and height than it does the less frequent floods. If the bankfull flow is raised above the range of natural conditions, excess scouring can occur. If lower, the stream may not have the power to move its natural sediment load, causing sediment deposition within the watershed.

The Aquatic Conservation Strategy (ACS) provides clear direction that ***"the distribution of land use activities, such as timber harvest or roads, must minimize increases in peak streamflows"*** *(ROD B-9) to create and sustain riparian, aquatic, and wetland habitats, and to retain patterns of sediment, nutrient, and wood routing.*

Peak streamflows of large magnitude in the Bull Run Watershed are generated by rain-on-snow events. For this analysis, the entire watershed is considered to be in the transient rain-on-snow zone.

Within the Bull Run Watershed the most visible sites of erosion are stream channels, streambanks, and roadside ditches. The incidence of mass erosion and channel erosion will undoubtedly be increased by exceptionally large storms. Runoff from such storms can initiate serious and potentially persistent episodes of relatively high turbidity (LaHusen, 1994). An altered peak flow regime with increased magnitude of peak streamflows has the potential to exacerbate problems associated with channel erosion.

Record floods in the Sandy Basin occur predominantly during November through January, caused by: accumulated snow at lower elevations followed by a rapid rise in temperature, unusually high-elevation freezing levels, and heavy rainfall. In some instances, the ground is frozen prior to snow accumulation, producing more favorable conditions for high runoff (SCS 1976).

February 1996 Flood

In early February 1996, a rain-on-snow event subjected northwest Oregon to some of the most severe regional flooding in nearly 30 years.

Beginning in mid-January, unusually high amounts of snow accumulated in the mid to high elevations of the Cascades. By Jan. 31, average snowpack for the Willamette drainage was 112% of the long-term average. A Feb. 3 storm dropped rain on top of frozen soils and roads, and delivered freezing rain at lower elevations. These conditions set the stage for a rain-on-snow event.

On February 6, a strong subtropical jetstream reached Oregon, bringing record rainfall amounts and unseasonably warm temperatures for a 3-4 day period. The accumulated rainfall and snowmelt resulted in high levels of runoff within the Bull Run Watershed. At the North Fork Natural Resource Conservation Service Snotel Site combined rainfall and snowmelt was 4.9 inches on February 6, 7.4 inches on February 7, and 5.4 inches on February 8 for a total of 18.2 inches. For the same period there was 16.4 inches of runoff at the Blazed Alder Snotel Site. Maximum air temperatures at the North Fork Snotel Site went from -4^0C on February 4 to 8^0C on February 7.

The snowpack melted below approximately 3100 feet, with snowcover usually remaining in harvested areas above 2500 feet. The cooler temperatures near the Columbia Gorge resulted in snowcover persisting at lower elevations in this watershed (versus approximately 3,000 feet in the Clackamas watershed). The snowpack buffered the effect of the storm by storing water.

The flood recurrence interval for various U.S. Geological Survey (USGS) stream gaging stations in all subwatersheds within the Bull Run ranged from 25 to greater than 100 years (based on preliminary data). The flow recurrence interval appears to be correlated with the amount of watershed area under 2500 feet.

Table 4-25 -- February 1996 Peak Flows, Recurrence Intervals, and Percentage of Watershed Below 2,500 ft.

Stream Gage	USGS #	Peak Flow	Recurrence Interval	% of Watershed below 2500 feet
Blazed Alder Creek	14138800	1910 cfs	25 years	0
Bull R. above Res.#1	14138850	9140 cfs	50 years	22
Fir Creek	14138870	1100 cfs	25 years	30
S.F. Bull Run River	14139800	4360 cfs	> 100 year	46
Little Sandy River	14141500	5900 cfs	> 100 year	60

Peak Flow Regime Assessment for Bull Run Watershed

Peak flows will be assessed for the Bull Run Watershed above dams and diversions by:

- Examination of trends based on the historical record from the watershed's USGS gaging stations.
- Examination of differences between subwatersheds
- Assessing changes in peak flows associated with rain-on-snow events.
- Assessing changes in peak flows associated with increases in stream drainage networks.

Trends

Trends analysis using the Season Kendall Trend Test was completed for the measured instantaneous peak flow for the USGS flow gages within the watershed. The annual instantaneous peak flow, which focuses on the magnitude of the peak flow event -- not the timing or the duration, was used for this analysis.

Table 4-26 -- Bull Run Watershed Stream Gaging Stations

Site	Forest Service ID	USGS #	Elevation (feet)	Period of Record	Drainage Area	Maximum Discharge and year
Blazed Alder	27	14138800	2540	Oct 1963-Present	8.17 mi^2	2610 cfs (1964)
Bull Run River	18	14138850	1080	Aug 1966-Present	47.9 mi^2	9140 cfs (1996)
Cedar Creek		14139700	1960	June 1965-Present	7.93 mi^2	1990 cfs (1964)
Fir Creek	44	14138870	1440	Oct 1975-Present	5.46 mi^2	1290 cfs (1977)
North Fork	15	14138900	1060	Aug 1965-Present	8.32 mi^2	9700 cfs (1972)[2]
South Fork	35	14139800	990	Oct 1974-Present	15.4 mi^2	4360 cfs (1996)
Little Sandy		14141500	720	July 1919-Present	22.3 mi^2	5900 cfs (1996)

Through 1994, instantaneous peak flow data was obtained from USGS records on Hydrosphere CD's and Hydrodata for Windows software. For 1995-96, information was obtained directly from the USGS (pers comm, Ed Hubbard).

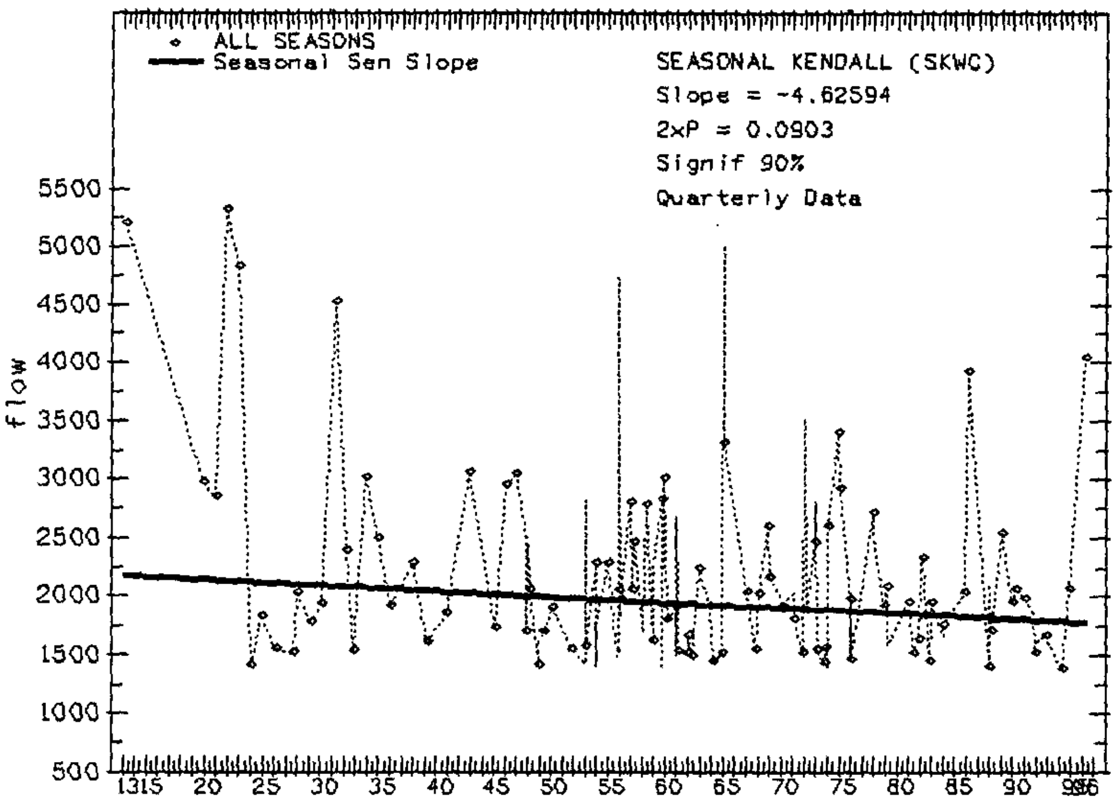
[2] Associated with the dam break flood of 1972

Table 4-27 – Peak Flow Seasonal Kendall Trends

Site	Slope (cfs per year)	P-level
North Fork	5.4	0.58
Bull Run River	-13.7	0.36
Blazed Alder	- 7.7	0.14
Cedar Creek	2.1	0.37
South Fork	16.4	0.45
Fir Creek	- 1.2	0.80
Little Sandy River	**- 4.6**	0.09

Bold = statistically significant trend

Figure 4-29 Season Kendall Trendline for the Annual Peak flow Event in the Little Sandy Subwatershed



Peak flows on the Little Sandy River demonstrate a statistically significant decreasing trend. The magnitude of the trend at the Little Sandy gage is slight when compared to the 1 year recurrence interval event. The change is 0.6% of the 1 year recurrence interval event, and 0.1% of the 25 year event. Records for the stream gage on the Little Sandy River are classified as good indicating that 95%

of the daily discharges are within 10% of the the true (Hubbard L, 1995). This would indicated that for the one year recurrence interval event of 832 cfs the discharge is $\pm$ 83.2 cfs. Based on the magnitude of this trend it may be within the sampling error associated with the records for the stream gage, however, based on the long period of record and the statistical significance level associated with the trend, factors that may influence the peak flow regime in this area were investigated.

For the same time period the 30 day duration low flows measured on the Sandy River at Marmot dam do not demonstrate a significant trend. This appears to indicate that climatic factors that would be affecting both areas are not the cause of the trend.

Changes in hydrologic processes associated with management activities can be grouped into two classes according to causal mechanisms. One class consists of changes resulting from removing forest vegetation through harvest. A second class of changes in hydrologic processes consists of those that control infiltration and the flow of surface and subsurface water. This class is dominated by the effects of forest roads (FEMAT V-20).

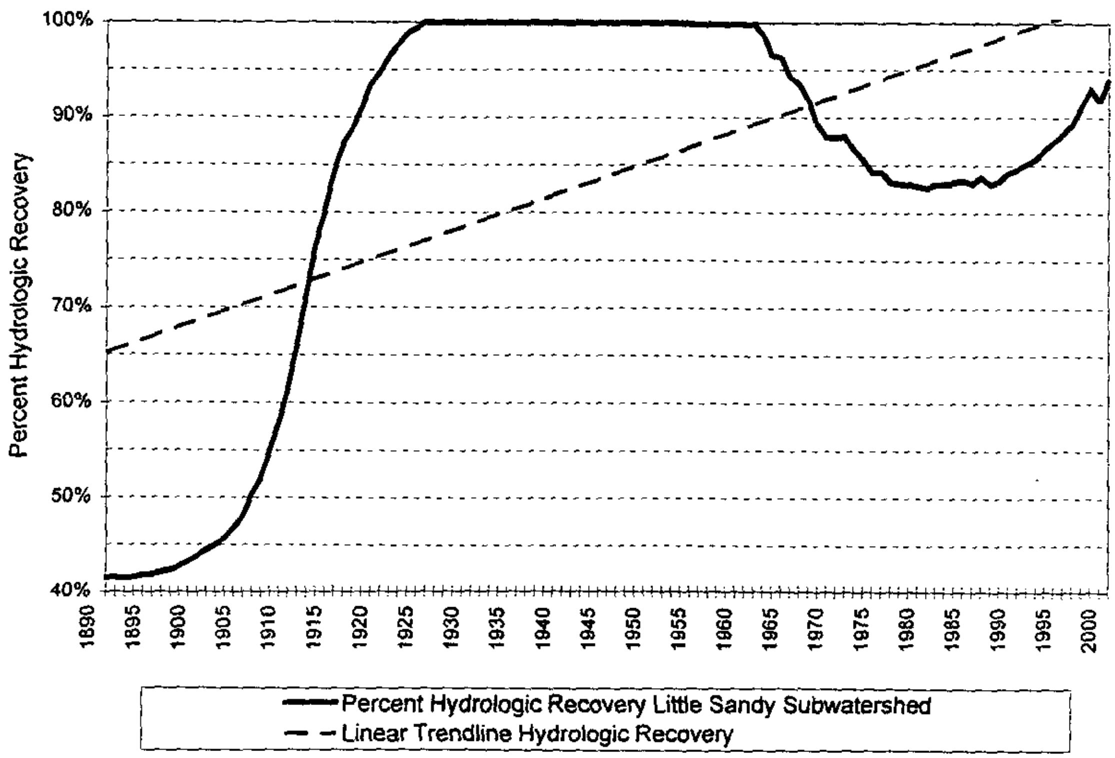
Alterations associated with the removal of vegetation were the focus of the analysis in examining the decreasing trend in peak flow magnitude as measured at Little Sandy stream gage. Aggregate recovery percent (ARP) values were calculated for the gaged area to assess any differences and their effect on peak flows.

The Aggregate Recovery Percent model (ARP) was developed for use in the transient snow zone (2400-4800 feet) and provides a methodology for indexing the susceptibility of a watershed to increased peak flows from rain on snow events associated with management created openings in the canopy. The ARP model measures the percent of watershed hydrologic recovery based on managed stand age and a recovery curve developed for the Mt. Hood National Forest. The recovery curve developed for the Mt. Hood National forest is a generalization of the percent canopy cover and tree diameter that may be expected in plantations at different ages. The model assumes that a plantation has fully recovered its snow handling capabilities at 35 years of age. It does not predict the increase in peak flows and is most useful when used in conjunction with information on watershed condition and sensitivity.

The Little Sandy has been gaged since 1913 and demonstrates a decreasing trend in peak flow magnitude over the entire period of record. This trend is attributed to hydrologic recovery of openings created by natural fire, planned reservoirs and timber management activities. Based on the fire history information from this analysis approximately 9216 acres of the Little Sandy subwatershed (65% of the gaged area) were impacted by stand replacement fires from 1875-1883.

Hydrologic recovery with respect to rain-on-snow events for the period 1890 through 2000 is illustrated in Chart 4-10, to reflect the impacts from historic fires and recent timber harvest. Hydrologic recovery of areas impacted by fires from 1875-1883 was started in 1890. This was done to reflect the time lag between the fire event and conifer regeneration.

Chart 4-10 Hydrologic Recovery Little Sandy Subwatershed 1890-2000



Hydrologic recovery was at about 77% when the gage on the Little Sandy was installed in 1913 and was in a period of rapid recovery until 1925 when the subwatershed was 100% recovered. In 1962 with the start of clearcut timber harvest in the area hydrologic recovery dropped to 83% in 1980 and has been recovering since then. The decreasing trend in the annual peak flow over the entire period of record is attributed to hydrologic recovery from natural fires.

Peak Flow Differences Between Subwatersheds

Peak flows by subwatershed were compared by dividing the instantaneous peak flow per year by the gaged area -- to ascertain peak flows (in cfs) per square mile. This enabled a per unit contribution with respect to peak flows, allowing different sized gaged areas to be compared.

Chart 4-11 -- Peak Flows by Subwatershed (All Data)

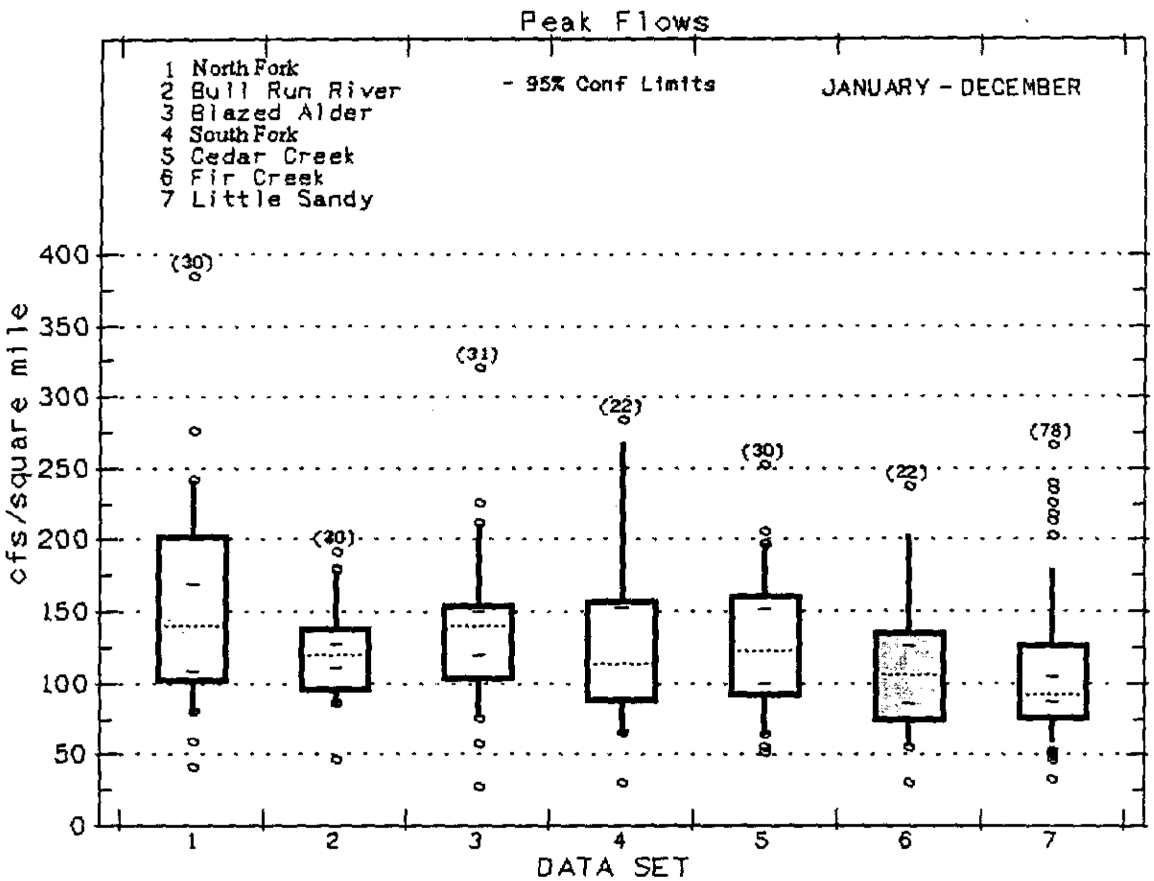


Chart 4-11 demonstrates that the managed watersheds and the control watershed (Fir Creek) maintain different peak flow regimes. The Seasonal Wilcoxen-Mann-Whitney test was utilized to compare the managed watersheds to Fir Creek. Streamflow gages with period of records larger than Fir Creek were adjusted to allow the same time periods to be compared.

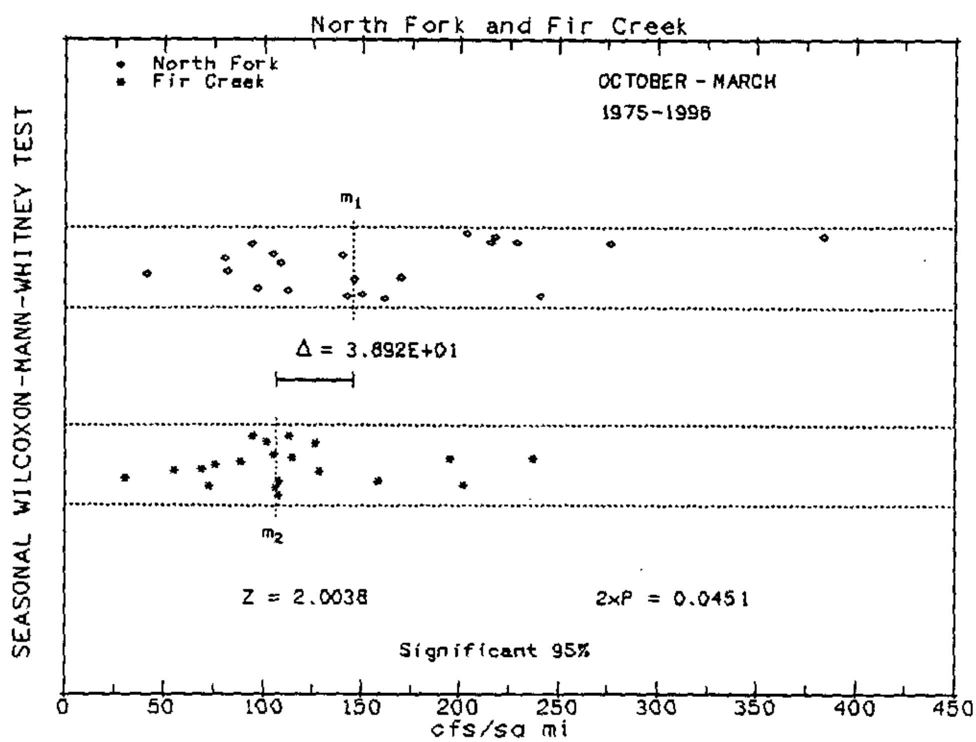
Chart 4-12 -- Seasonal Wilcoxen-Mann-Whitney Test Results

Station	Difference from Fir Creek (cfs per square mile)	P-level
North Fork	**38.92**	0.0451
Bull Run River	10.57	0.4425
Blazed Alder	**20.21**	0.0701
South Fork	7.001	0.6414
Cedar Creek	31.99	0.1712
Little Sandy River	19.38	0.1054

Bold = statistically significant difference

Statistically significant (P-level less than 0.10) differences in peak flows per square mile between the managed subwatersheds and Fir Creek were detected at North Fork and Blazed Alder. Because the median peak flow per unit area for Fir Creek (the control watershed) is 105.86 cfs/square mile, the percent increase for the other subwatersheds were: North Fork 37% and Blazed Alder 19%.

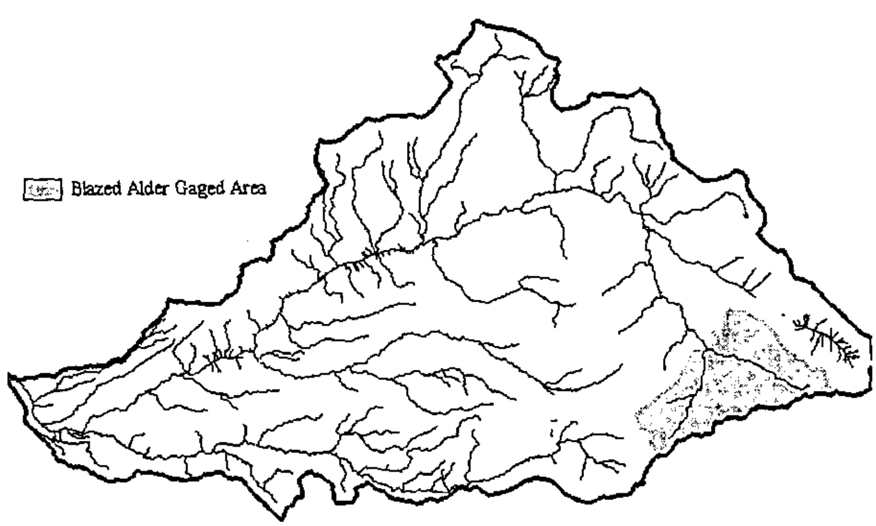
Chart 4-13 -- Seasonal Wilcoxen-Mann-Whitney Plot North Fork and Fir Creek



Differences in mean peak flows per square mile between Fir Creek and North Fork (Chart 4-13) are attributed to natural processes within these two watersheds. The Wyden Task Force (Aumen, Grizzard, Hawkins, 1989) found a considerable variation in unit runoff between different areas in the watershed. The Task Force attributed these discrepancies to variation in input precipitation, and to the natural variation between the subwatershed's runoff producing properties. The Task Force found the most intense water yeilding area in the watershed located in the West Branch Falls Creek and Palmer Lake area. This indicates greater water yields in the North Fork subwatershed.

The higher peak flows identified at the Blazed Alder gage may be associated with the elevation and associated snowpack of the gaged area. The Blazed Alder gage is at 2540 feet and is 1100 feet higher than the Fir Creek gage. The average elevation of the area draining into the Blazed Alder gage is 3293 feet compared to 2873 feet for Fir Creek. The 500 foot difference between the Blazed Alder and North Fork SNOTEL sites results in a 35-40% difference in snowpack (as expressed in snow water equivalent).

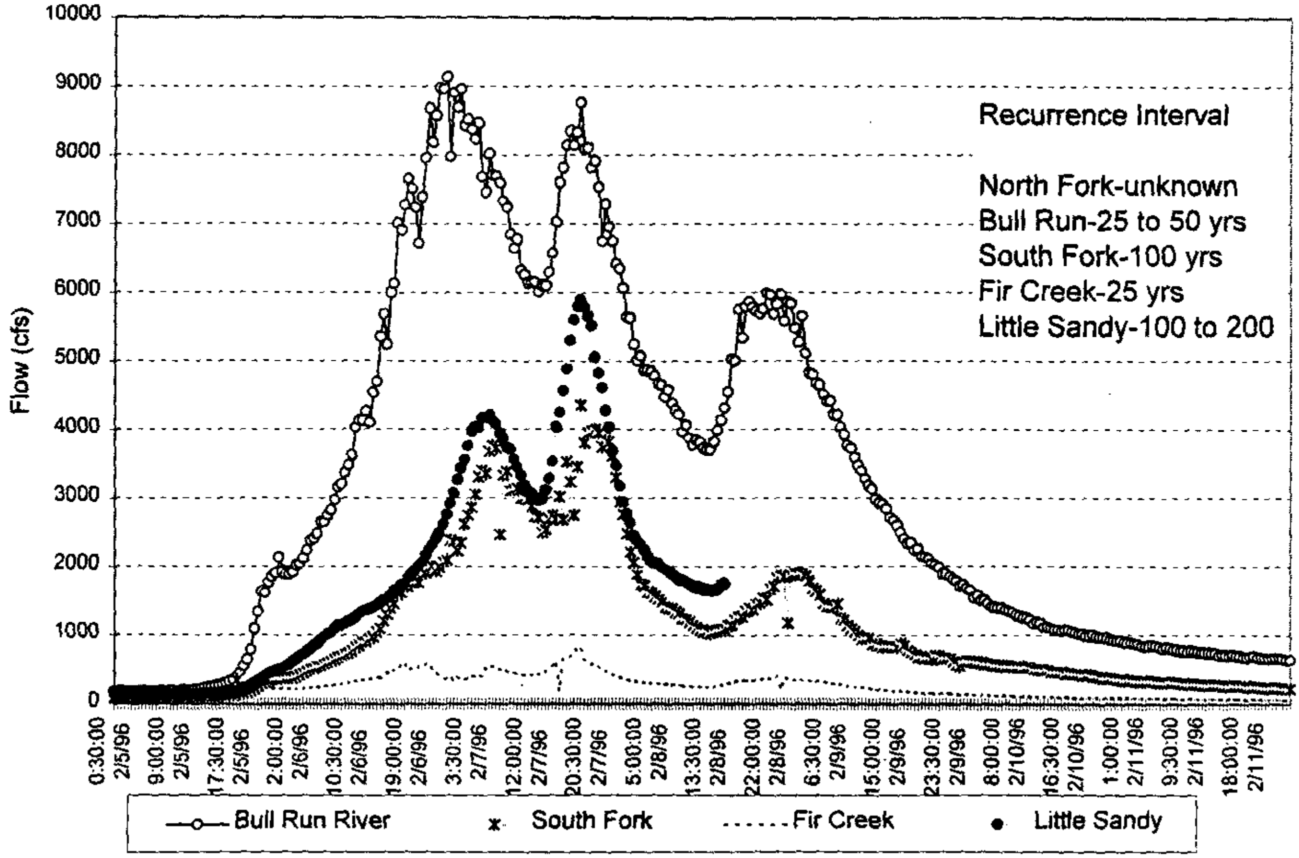
Figure 4-30 Blazed Alder Gaged Area



Timing and Magnitude of Peak Flows: February 1996 Storm

The hydrograph of half hourly flow data for the individual stream gages illustrates how timing and magnitude of peak flows varies by subwatershed.

Chart 4-14 -- Flow Response by Subwatershed: February 5-11, 1996



The Bull Run River proved to be the most responsive gage during this storm event. (The North Fork gage, normally very responsive, was not functioning properly during this storm.)

Traditionally, the South Fork and Little Sandy rivers respond very similarly and lag behind the Bull Run River. This is attributed to the precipitation intensity and on-site storage associated with soils across the watershed.

This storm, a rain-on-snow event, was accompanied by warm temperatures, heavy rainfall, and westerly winds. The precipitation intensity across the watershed explains some of the differences recorded between stations. Based on data from SNOTEL sites, precipitation intensities on Feb. 6 were much higher in the northwest part of the watershed (3.8 inches of precipitation at the North Fork site) than in its southeastern portion (1.2 inches of precipitation at the Blazed Alder site).

During this 1996 storm, the South Fork responded more slowly to precipitation and snowmelt than did the other stream gages. This South Fork area is assumed to have more on- site storage associated with deeper soils and floodplain connectivity in the Cedar Creek area. Thus, it has historically responded the slowest of any of the watershed's stream Key Stations during peak flow events.

Assessment Of Changes Due To Increased Peak flows From Rain-On-Snow

This assessment was completed using methodology from the Washington Department of Natural Resources (DNR) *Standard Methodology For Completing Watershed Analysis* (DNR, 1993). This method assumes that the greatest likelihood for significant, long-term cumulative effects on forest hydrologic processes is caused by the influence of created openings from timber harvest and roads on snow accumulation and snowmelt. The effect of vegetation change on peak flows during rain-on-snow events serves as the focus of this assessment.

The primary mechanism by which forest practices affect peak streamflows is alteration of snow accumulation and snowmelt in response to forest canopy density.

Peak flows are calculated for:

- 2, 5, 10, 25, 50, and 100-year recurrence interval peak streamflow events;
- two storm intensities (average and unusual);
- and three vegetative cover conditions (existing, 1944, and hydrologically recovered).

The vegetative cover conditions from 1944 (Clackamas County) and 1948 (Multnomah County) were modeled as a "snapshot" of historical condition.

The "average" storm represents a typical rain-on-snow event using average values for precipitation, storm temperature, wind speed, and snow accumulation. The "unusual" storm uses the average value plus one standard deviation for precipitation, storm temperature, wind speed, and snow accumulation. Hydrologically recovered conditions for vegetative cover were assumed to be 70% canopy closure of trees more than 8 inches diameter at breast height (DBH) in coniferous stands.

Chart 4-15 and Chart 4-16 detail changes in peak flows from a hydrologically mature condition.

Chart 4-15 -- DNR Methodology Predicted Peak Streamflows (Current Condition)

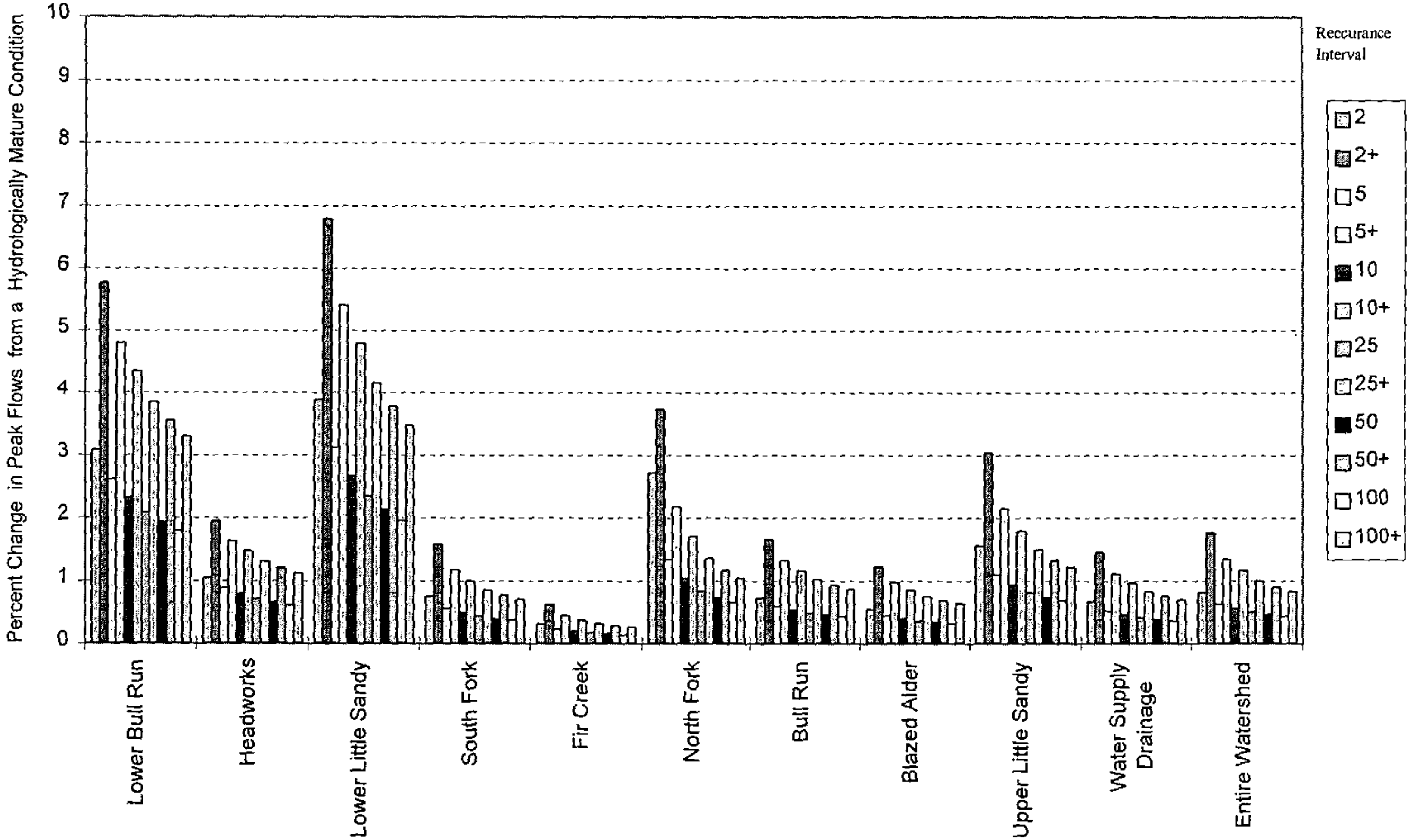


Chart 4-16 -- DNR Methodology Predicted Peak Streamflows (Historical Condition 1944-1948)

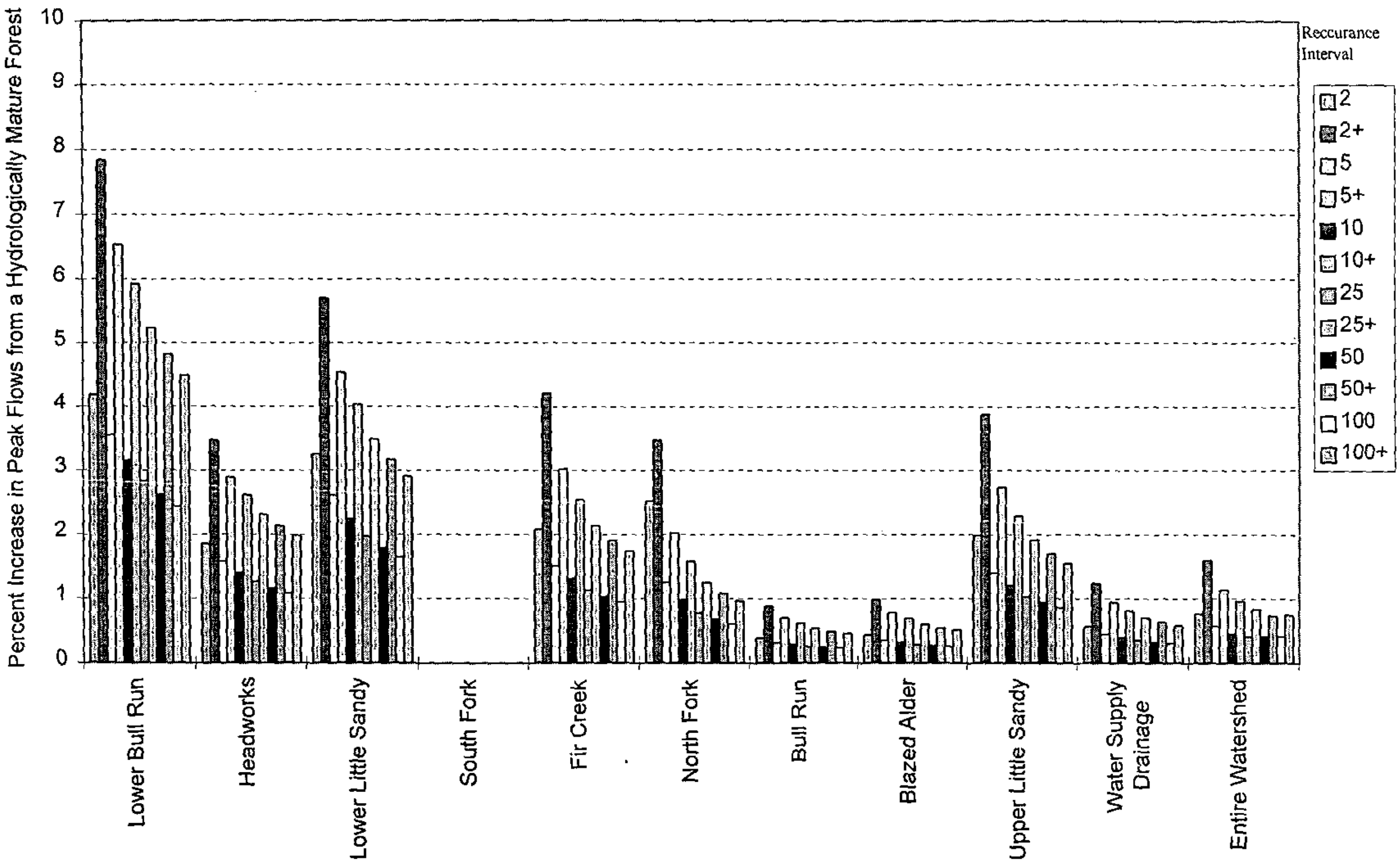


Chart 4-15 and Chart 4-16 detail increases for different recurrence interval peak streamflows for current stand conditions, and for stand conditions in 1944-48. The largest increases are ***predicted*** for the 2+ storm (a storm with a two-year recurrence interval and "unusual" weather conditions).

There is no expected adverse effect for peak flow increases up to 10%, given the inherent error in peak flow prediction methods and the fact that changes in peak flows of up to 10% are usually below detection limits using standard stream gaging methods. Peak flow increases greater than 10% offer the possibility for adverse effects and are assessed for impacts on beneficial uses (DNR, 1993).

Much of the total length of Bull Run Watershed stream channels are incised into massive and competent flows of andesite and basalt (LaHusen, 1994), so increases in peak flow magnitude under 10% would not be expected to result in increased levels of stream channel erosion.

Based on this methodology, none of the subwatersheds, the water supply drainage, nor the watershed as a whole, is at risk for adverse effects from increased peak flows.

Additionally, based on the conditions of the watershed from 1944-48, none of the subwatersheds, the water supply drainage, nor the watershed as a whole, were at risk for adverse effects during that time period.

The Otter Creek subwatershed was heavily impacted by 1973 and 1983 blowdown events and associated timber salvage[3]. Based on current canopy closure levels within the Otter Creek area, this area is of concern regarding increased peak flows from rain-on-snow events. Additionally, this area has soils with limited infiltration capacity with associated high stream densities and rapid response to precipitation and snowmelt. Because this area was too small (1,153 acres) to assess with the DNR methodology, it was compared to canopy closure levels from the entire drainage and the Lower Little Sandy subwatershed. Canopy closure was used as an indication of created openings.

[3] The last salvage activies occurred in this area in 1989

Figure 4-31 Otter Creek Drainage

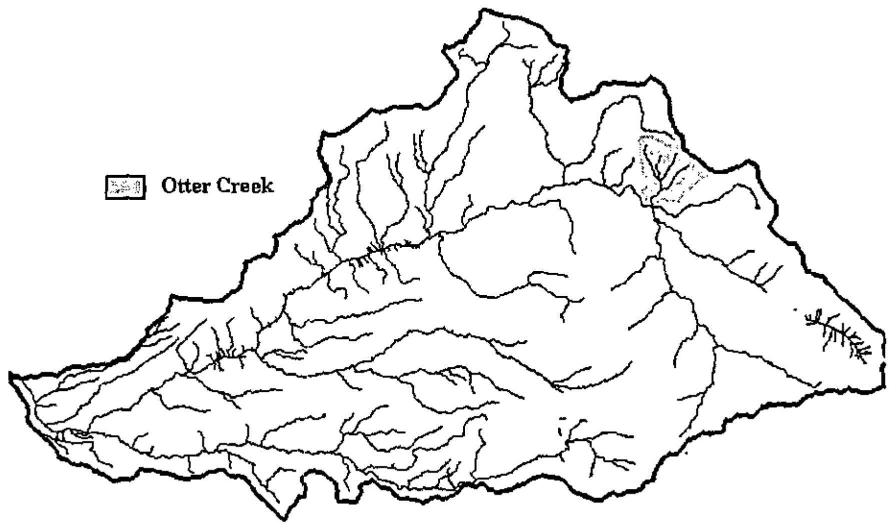
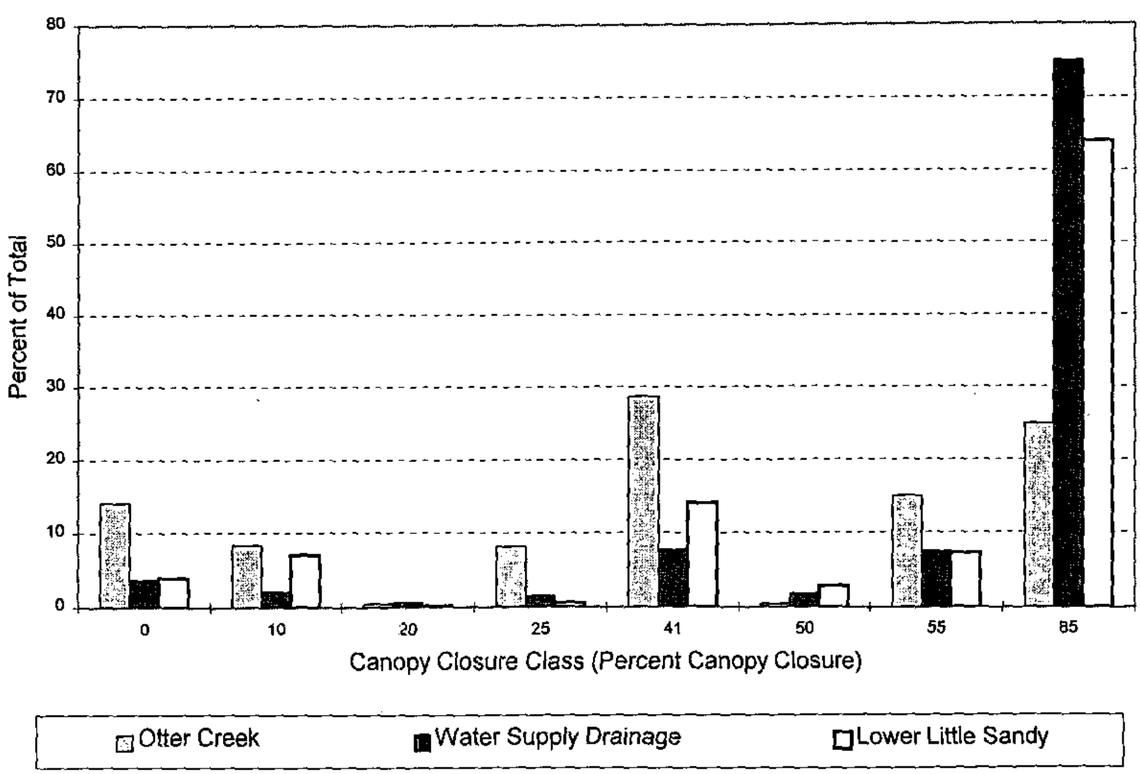


Chart 4-17 -- Canopy Closure Otter Creek



Using the DNR methodology, the Lower Little Sandy subwatershed was the closest to the limit of detection for increased peak streamflows -- with a 7% increase in the magnitude of the 2+ year recurrence interval event. Canopy closure levels within the Otter Creek area are much lower than the Little Sandy. Based on the percent of area with low canopy closure within the Otter Creek area, increased magnitude of peak flows are of concern.

Area	Percent of Area with 50% or Less Canopy Closure
Otter Creek	60
Water Supply Drainage	18
Little Sandy subwatershed	29

Stream Drainage Network Expansion

Current research suggests that roads function hydrologically to modify streamflow generation in forested watersheds by altering the spatial distribution of surface and subsurface flowpaths. In the two basins studied in the western cascades 57% of the road network is hydrologically connected to the stream network. Observations suggest that road segments linked to the channel network increase flow routing efficiency and hence provide a plausible mechanism for observed increases in peak flows (Wemple, 1996).

The relatively impermeable surfaces of roads cause surface runoff that bypasses longer, slower subsurface flow routes (Harr et al. 1975, 1979; Ziemer 1981). Where roads are insloped to a ditch, the ditch extends the drainage network, collects surface water from the road surface and subsurface water intercepted by roadcuts, and transports this water quickly to streams (Wemple 1996; Megahan et al. 1992).

An assessment of the increase in the channel network due to inboard ditches along roads has been completed using methodology that was developed on the Siskiyou National Forest (Elk River WA, 1994).

Channel network expansion is calculated by counting the number of stream crossings within a watershed, multiplying that number by the distance to the first culvert up from the stream crossing, and adding that distance to the stream network. This procedure adds the ditchlines from the stream crossing up to the first ditch relief culvert to the stream system.

For this analysis, it was assumed ditchlines on both sides of the stream crossing contributed to the increase in the stream network. Culvert spacing was estimated for each subwatershed by examining the actual culvert spacing, from the FES database for representative roads within that subwatershed. Culvert spacing varied from 400 to 500 feet between culverts. Stream length for each watershed was calculated from the streams coverage.

Bull Run Watershed
Road & Stream Intersects

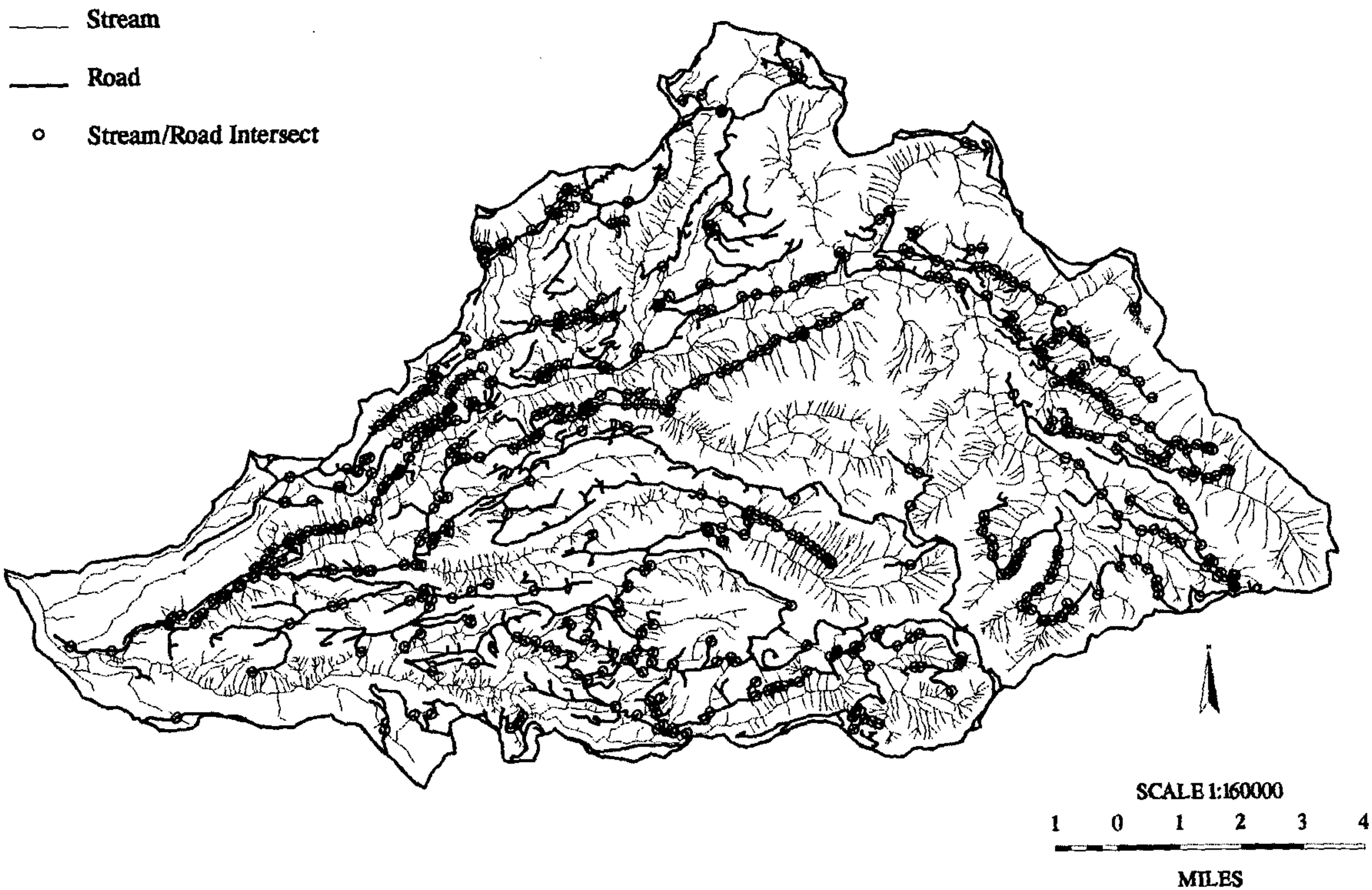
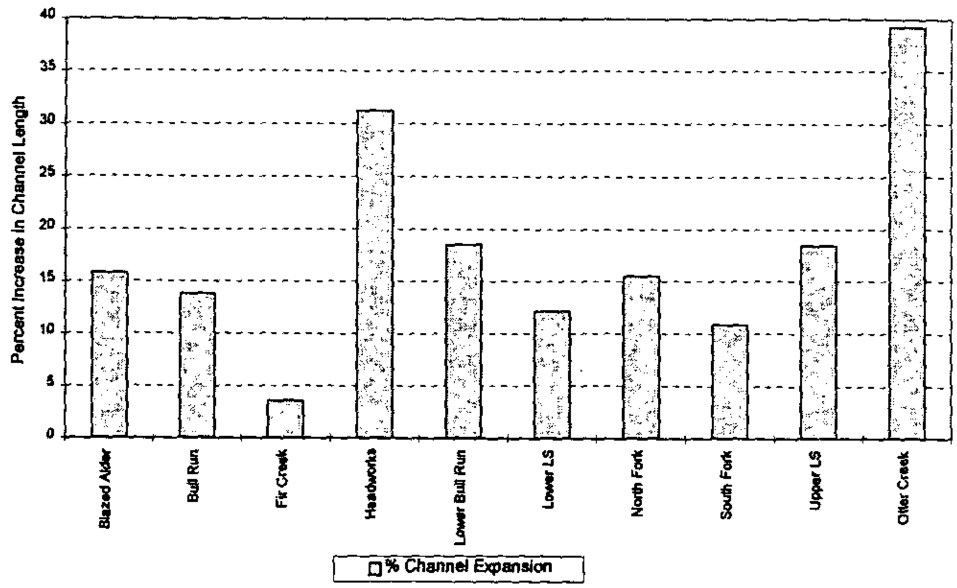


Chart 4-18 -- Stream Drainage Network Expansion



As Chart 4-18 illustrates, all the subwatersheds (with the exception of Fir Creek) exceed a 10% incease in the stream drainage network. Of the major subwatersheds, Headworks has by far the greatest extent of stream drainage network expansion (31%).

Otter Creek was included in this analysis to demonstrate levels of stream drainage network expansion in the watershed's most impacted (due to timber salvage and roading) area. The Otter Creek area has a 39% increase in the stream drainage network. While this process is of concern, the impacts on the timing, magnitude, and duration of the peak flow regime are variable depending in many factors.

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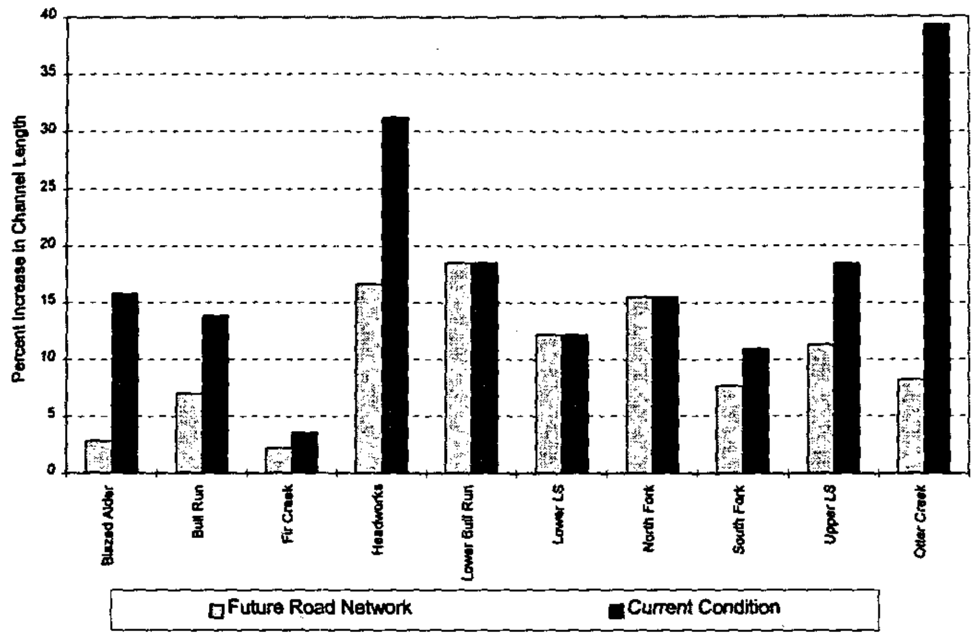
*The Aquatic Conservation Strategy (ACS) gives clear direction that: "**The distribution of land use activities, such as timber harvest or roads, must minimize increases in peak streamflows**" (ROD, B-9) to create and sustain riparian, aquatic, and wetland habitats, and to retain patterns of sediment, nutrient, and wood routing. Based on the ASC, this process should be addressed in management of the watershed.*

The Zigzag Ranger District has initiated plans to reduce the road system mileage within the Bull Run Watershed. Based on these plans, channel network expansion associated with roads would be greatly reduced. (See Chart 4-19.)

Chart 4-19 – Channel Network Expansion by Roads based on Future Road Design



The greatest changes associated with the future road network with respect to channel network expansion are noted in the higher elevations of the watershed such as Blazed Alder and Otter Creek. Recovery has also been observed within the Headworks subwatershed.

The longevity of changes in hydrologic processes resulting from forest roads is as permanent as the road itself. To properly address this process, active road decommissioning is needed. Until a road is removed and natural drainage patterns are restored, the road will likely continue to affect the routing of water through watersheds (FEMAT, V-20).

Conclusions: Peak flows

- The only statistically significant Seasonal Kendall trend for peak flow magnitude in the watershed is idenfied in the Little Sandy River. This trend is of very low magnitude (annual change is 0.6% of the 1 year recurrence interval flood event).

- Higher peak flows per square mile are evident between the unmanaged "control" watershed (Fir Creek) North Fork and Blazed Alder[4]. Differences in peak flows per square mile in North Fork and Blazed Alder are attributed to the watershed's precipitation patterns.

- Based on current stand conditions, all the major subwatersheds are below levels associated with the potential for adverse impacts from increased peak flows associated with rain-on-snow events. Although Otter Creek's area is too small to analyze with this methodology, based on canopy closure levels within this area, the potential for increased peak flows from rain-on-snow events raise concerns.

- Stream channel network expansion by roads is a concern in all the subwatersheds (except Fir Creek). The effect of this process on the timing, magnitude, and duration of peak flows is dependent on many variables unique to each basin and are not known at this time.

- Current reseach indicates that the road network may interact with the network of clearcuts to affect peak flows (Jones, 1996). No attempt was made to determine the combined effects of created openings and the road network on peak flows.

[4] Based on Seasonal Wilcoxen-Mann-Test of annual peaks

Base flows

Base flows are a critical component in maintaining aquatic habitat and water quality in the Bull Run Watershed. Base flow is the streamflow that originates essentially as groundwater from seeps and springs after rainfall and snowmelt have ceased. With the exception of the springs associated with Bull Run Lake on the Bull Run River, the apparent absence of springs in the watershed is notable, especially considering the Bull Run River's generous hydrologic budget and substantial base flow (Aumen, Gizzard, Hawkins, 1989).

Therefore, it is easily inferred that the base flow must arise from a wide variety of small seeps and unnamed springs, serving as diffuse and linear sources, most likely in close association with the channel network. These sources within the watershed are probably from relatively shallow origins in the geologic mantle. The aquifers are simply deep soil profiles, suggesting an expected link between the surface activity and the quantity and quality of base flow (Aumen, Gizzard, Hawkins, 1989).

Base flows serve as a critical component in maintaining the Bull Run Watershed's aquatic habitat and water quality. Base flow within the water supply drainage is critical to maintaining reservoir pool levels to prevent turbidity problems associated with erosion of shoreline deposits within the reservoir at extremely low reservoir levels. Base flow is also a critical component in buffering increased stream temperatures associated with increased solar radiation interception.

The following water quality parameters demonstrate increased values with lower stream discharges: pH, alkalinity, conductivity, and silica (Eilers, 1994).

ACS objectives state: *"The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected."*

For this analysis, base flows were assessed by:

1. Examination of studies on base flows within the Bull Run Watershed --

    - *Streamflow after patch logging in small drainages within the Bull Run Municipal Watershed, Oregon* (Harr, 1980)

    - *Fog Drip in the Bull Run Municipal Watershed, Oregon* (Harr, 1982)

    - *Fog Drip, Water Yield, and Timber Havesting in the Bull Run Municipal Watershed, Oregon* (Ingwersen, 1985)

- *Hydrologic Analysis of Water Yield and Low Flows, Bull Run Watershed* (Hawkins, 1995)

2. Seasonal Kendall Trends Analysis on the 30-day duration base flow for the gaged stations within the watershed

3. Comparison of water yield of managed watersheds to the control watershed

The effect of Bull Run Lake releases on streamflows was not removed from the datasets used in this analysis. (Effects from Bull Run Lake releases are discussed later in this chapter.)

Summary of Bull Run Base flow Studies

***Summary of: Streamflow after patch logging in small drainages within the Bull Run Municipal Watershed, Oregon* (Harr, 1980)**

Three experimental watersheds in the Fox Creek drainage were used to determine effects of patch logging on timing and quantity of streamflow. Annual water yields and size of instantaneous peak flows were not significantly changed, but low flow decreased significantly after logging of two small watersheds in small, clearcut patches totaling 25 percent of each watershed's area.

***Summary of: Fog Drip in the Bull Run Municipal Watershed, Oregon* (Harr, 1982)**

Research in the watershed's Fox Creek drainage revealed that harvesting 25% of a watershed resulted in a decrease in low flow amounts. This was attributed to a reduction in canopy interception of fog and consequent through fall precipitation. Fog drip accounted for approximately one-third of precipitation received during the May to September period. This loss of fog drip counterbalances increases in water yield associated with reduced vegetative water use (evapotranspiration).

Accurate assessment of the effects of timber harvest on annual and seasonal water yield will depend not only on the implementation of a long-term management plan, but also on the nature of fog drip itself.

Additional information would be helpful to determine: 1) the aerial distribution of fog drip throughout the Bull Run Watershed; 2) whether reduced fog drip is at least partially offset by increased fog drip in the adjacent downwind stand; (3) at what age a newly established forest begins to intercept substantial amounts of fog; (4) if there is a reliable relationship between annual precipitation and annual fog drip.

***Summary of: Fog Drip, Water Yield, and Timber Harvesting in the Bull Run Municipal Watershed, Oregon* (Ingwersen, 1985)**

Analysis of streamflow data from the "Fox Creek experimental watersheds" through 1983 indicate a significant recovery from the impacts on summer water yield due to a loss of fog drip on timber harvesting. Recovery begins about five or six years following harvest, possibly due to renewed fog drip from prolific revegetation. Apparently, once the temporary reduction in summer yield is offset by renewed fog drip, the expected increase in yield due to decreased evapotranspiration can be observed. Redistribution of fog drip may be a major factor in the measurements of local interception and water yield.

***Summary of: Hydrologic Analysis of Water Yield and Low Flows, Bull Run Watershed* (Hawkins, 1995)**

Based on annual water yields, a 7.38% increase exists between the pre (1920-1959) and post (1960-1992) treatment periods at the gage on the lower Bull Run River. This increase was broken down into components by determining the different process sources.

Table 4-28 -- Bull Run River Flow Increase Components

Components	Change in Flow (cfs)	Percent of Effect
Climate	6.32	11.4
Lower Bull Run Flows	29.90-33.92	53.9-61.1
Road Surface Effects	5.96	10.7
Silvicultural Effects	9.26-13.28	16.7-23.6

Components of the increase in annual flow include:

- Climate effects -- adjustment of the pre-treatment yields for the post-treatment climate.
- Lower Bull Run Flows -- adjustment for the 6.39 square miles of area added to the stream gage in 1959.

- Road effects -- estimated by considering the surface area and annual precipitation. It is assumed that roads are impervious surfaces and yield 100 percent of the precipitation on them.
- Silvicultural effects -- the residual left after subtraction of all other components and assumed to be tied to silvicultural effects (including fog drip)

There are distinct patterns to the seasonal flows and their treatment effects. The largest absolute increases are in the high flow months of April and May, and summer months of July, August, and September. The month of August showed an overall treatment increase of slightly more than 29%. All monthly treatment effects were positive.

As part of this study , the following management issues were identified:

- **Fox Creek comparisons** --The finding that logging-induced flow increased from the upper Bull Run watershed contrasts with the Fox Creek summer flow reduction findings. Two explanations are possible: 1) The conditions found at Fox Creek were not typical of the larger Bull Run basin; or 2) Errors occurred in the data or analysis of either study. Given the contrast between the findings of this study and Fox Creek studies, basin-wide fog drip measurements would be useful.
- **Impact timing** -- The timber harvest and road construction were not a discrete one-time event imposed instantaneously in 1960. Rather, there was continuous road construction and logging activity during a 25-year period. Some hydrologic recovery may have occurred on the earlier logged units that were mixed with the later impacts to produce the observed response.

Julia Jones Associate Professor with the Department of Geosciences at Oregon State University has been analyzing the long-term streamflow records from the Fox Creek and other experimental watersheds in the Cascades of Oregon and had the following comments on the draft Bull Run Watershed Analysis "Fog-drip (or more correctly, capture of additional water from clouds by canopy interception) may occur in portions of the Bull Run, but several observations (not considered by Harr [1980, 1982] or Ingwerson [1985]) suggest that it is a minor component of summer base flow: 1. my preliminary plots of long-term differences in summer flows between treated and control basins in Fox Creek show trends that do not correspond with the timing of the forest harvest treatments, 2. a very large patch of 1931 windthrow covers perhaps a third of the Fox Creek control watershed, so successional changes in vegetation (regenerating shrubs and Pacific silver fir) in this patch, which would have been 27 years post-disturbance when streamflow records began, masking forest harvest treatment effects, and 3. the Fox Creek basins are located in a portion of the Bull Run (adjacent to a major E-W trending ridge) optimally situated to capture cloudwater borne on incoming SW winds, so fogdrip processes in Fox Creek may not be representative of the entire Bull Run basin."

Seasonal Kendall Trends Analysis on the 30-day Duration Base flow

Trends analysis using the Season Kendall Test was completed based on daily averages for the 30-day duration low-flow. (The daily average flows were not adjusted for the effect of Bull Run Lake releases.) The 30-day duration was selected due to its effect on the primary beneficial uses of water quality and fish habitat. The 30-day duration low-flow was considered an indication of effects from tributaries on reservoir drawdown.

This trends analysis recognizes the magnitude of the low-flow event -- *not* its timing. The 30-day duration low flow was calculated using Durfreq software from Earthinfo.

Table 4-29 --Bull Run Watershed Stream Gaging Stations used in the Low Flow Analysis

Site	Period of Record	Drainage Area	Minimum 30 day low flow and year
Blazed Alder	Oct 1963-Present	8.17 mi^2	1.3 cfs (1991)
Bull Run River	Aug 1966-Present	47.9 mi^2	33.8 cfs (1987)
Cedar Creek	June 1965-Present	7.93 mi^2	5.4 cfs (1987)
Fir Creek	Oct 1975-Present	5.46 mi^2	1.8 cfs (1991)
North Fork	Aug 1965-Present	8.32 mi^2	9.1 cfs (1987)
South Fork	Oct 1974-Present	15.4 mi^2	8.2 cfs (1987)
Little Sandy	July 1919-Present	22.3 mi^2	9.6 cfs (1940)

Daily average flow was obtained from USGS records on Hydrosphere CD-ROMs through 1994.

Table 4-30 -- Low Flow Seasonal Kendall Trends

Site	Slope (cfs per year)	P-level
North Fork	- 0.062	0.67
Bull Run River	0.061	0.93
Blazed Alder	- 0.010	0.79
Cedar Creek	- 0.095	0.10
South Fork	- 0.168	0.47
Fir Creek	- 0.027	0.84
Little Sandy River	0.035	0.99

Bold = statistically significant difference

There are no statistically significant trends (P-level less than 0.10) detected for the 30-day duration low-flow.

Any trends in the Bull Run River may have been masked by Bull Run Lake releases. Bull Run Lake releases are used to augment flow in the lower Bull Run River to prevent the reservoirs from dropping below critical levels (where shoreline deposits become exposed and eroded by streamflow creating turbidity concerns).

Bull Run Lake has been in use as a reservoir since 1915 with water released during the summer low flow period to augement streamflows in the Bull Run River. Records of releases began in 1976. Water was released from Bull Run Lake in 1976 and from 1985 through 1992. Average flow augmentation from these releases was 12.8 cfs or 18% of the mean 30 day duration low flow at the gaging station on the Bull Run River (Station 18) (Bloem, 1990).

Recommendation (Analysis Gap): Assess low flows in the Bull Run River by removing augmented flows from Bull Run Lake. Assess the effect of reducted seepage from Bull Run Lake at lower lake levels following releases.

Differences Between Managed Subwatersheds and Fir Creek

Base flows by subwatershed were compared by dividing the 30-day duration low-flow per year by the gaged area to derive low-flow (in cfs) per square mile. This was accomplished to attain a per-unit contribution for low flows to compare different sized gaged areas. The effect of Bull Run Lake releases was not removed from the 30-day duration low flows.

Chart 4-20 -- Low flows (cfs/square mile) by Monitoring Station (All Data)

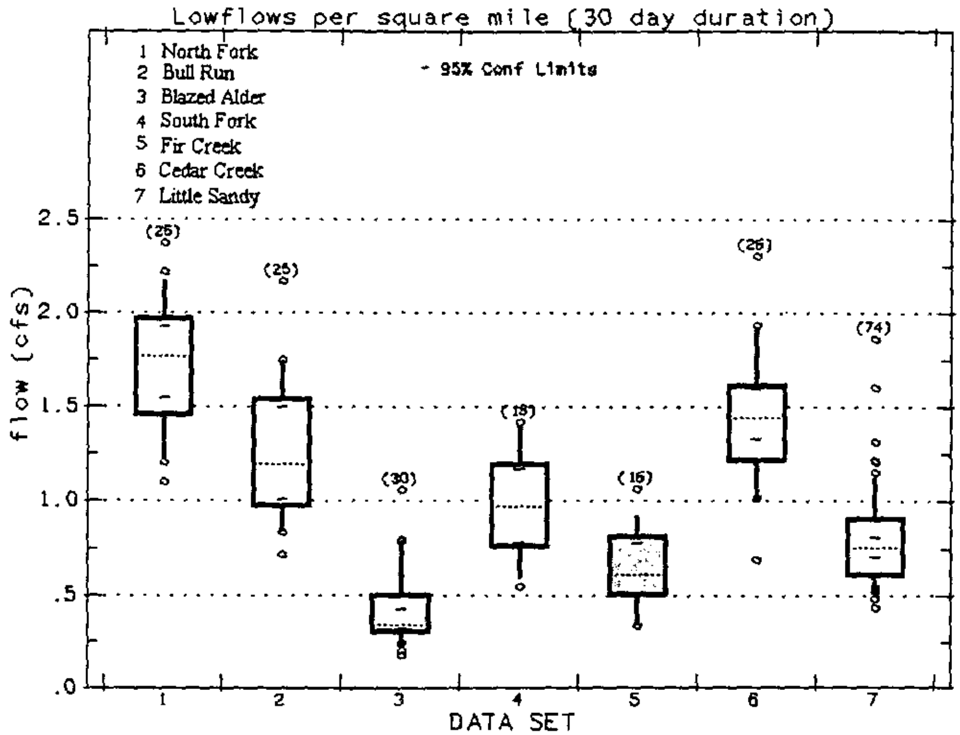


Chart 4-21 -- Low flows (cfs/square mile) by Monitoring Station (1976-1993 data)

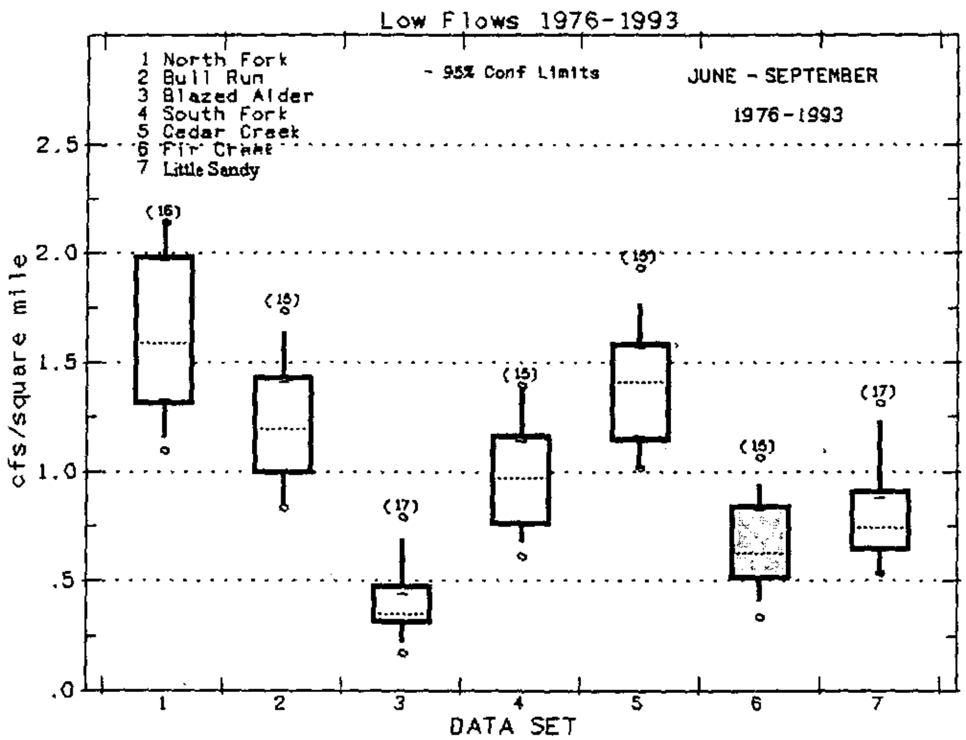


Chart 4-20 and Chart 4-21 demonstrate that managed watersheds have different low-flow yields per square mile than does the control watershed (Fir Creek). The Seasonal Wilcoxen-Mann-Whitney test for 1977 through 1992 was run to compare the managed watersheds to Fir Creek.

Table 4-31 -- Low Flow Seasonal Wilcoxen-Mann-Whitney Test Results

Site	Difference from Fir Creek (cfs per square mile)	P-level
North Fork	**1.005**	less than 0.01
Bull Run River	**0.5349**	less than 0.01
Blazed Alder	**-0.2525**	less than 0.01
Cedar Creek	**0.7394**	less than 0.01
South Fork	**0.3062**	less than 0.01
Little Sandy River	**0.1241**	0.04

There are statistically significant (P-level less than 0.10) differences in 30-day duration low-flows between all the gaging stations and Fir Creek. With the exception of Blazed Alder, all the sites have greater low-flows per square mile than Fir Creek.

Stream densities were compared to the median 30 day duration low flows for the different areas (Table 4-32). This comparison was accomplished using stream densities from the subwatersheds and low flows from the gaging stations. Stream densities were used an an indication of the available storage capacity of an area based on underlying geology.

Within the Bull Run Watershed base flows must arise from a wide variety of small seeps and unnamed springs, serving as diffuse and linear sources, most likely in close association with the channel network. These sources within the watershed are probably from relatively shallow origins in the geologic mantle. The aquifers are simply deep soil profiles, suggesting an expected link between the surface activity and the quantity and quality of base flow (Aumen, Gizzard, Hawkins, 1989).

The higher the stream density the lower the storage capacity of a given area. Lower storage capacities would indicate lower base flows.

Table 4-32 -- Stream Densities and Low Flow Yields

Subwatershed	Stream Density (miles per square mile)	Median 30 day duration low flow per square mile
North Fork	3.81	1.76 @ sta 15
Bull Run	4.8[5]	1.20 @ sta 18
Lower LS	4.56	0.75 @ gage at diversion
Upper LS	4.81	0.75 @ gage at diversion
South Fork	4.87	0.97 @ sta 35
Blazed Alder	5.3	0.34 @ sta 27
Fir Creek	5.89	0.61 @ sta 44

For the most part, the lower the stream density the higher the 30 day duration low flow, however, there are notable exceptions to this relationship. Bull Run, Little Sandy, and South Fork all have similar stream densities (in the range of 4.8 miles per square mile) and 30 day duration low flow yeilds per square mile from 1.20 cfs/mi^2 to 0.75 cfs/mi^2. The higher median low flows measured at the Bull Run gage may be associated with releases from Bull Run Lake. Historical releases augment the flow in the Bull Run River from 12.8 to 30.5 cfs (Bloem, 1990) or 0.26 to 0.64 cfs per square mile.

[5] Weighted average from Bull Run and Blazed Alder subwatersheds

Blazed Alder has low flow yields considerably lower than all the other subwatersheds and stream densities slightly higher than Bull Run, Little Sandy and South Fork subwatersheds. Blazed Alder also has stream densities that are similar to those of Fir Creek with much lower 30 day median low flows than Fir Creek.

The difference in mean low-flows per square mile and between Fir Creek and North Fork is partially attributed to the natural processes within these watersheds. This difference is also of a higher magnitude within the North Fork subwatershed when compared to the other subwatersheds. The Wyden Task Force (Aumen, et al, 1989) discovered a considerable variation between unit runoff among the watershed's different areas. The Task force, in turn, attributed this to variation in input precipitation as well as the natural variation between the subwatersheds' runoff producing properties.

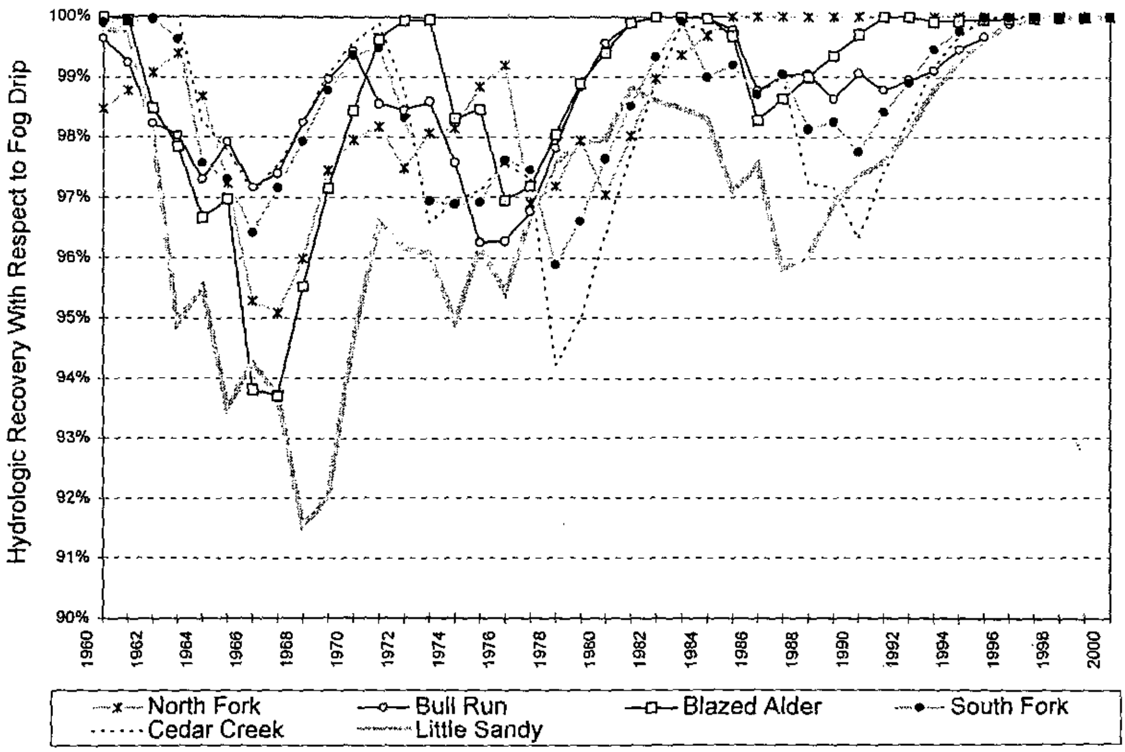
The North Fork subwatershed contains Latourelle Prairie, a 174-acre wetland complex located in the watershed's northern tip, and the single largest wetland in the watershed. Wetlands are important components in maintaining low flows. Water enters the headwater wetlands where it is temporarily stored and steadily released to lower order channels at a moderate rate (Zedler et al. 1985).

Higher low-flows per unit area in the Bull Run, Cedar Creek, South Fork and Little Sandy subwatersheds are consistent with findings from *Hydrologic Analysis of Water Yield and Low Flows, Bull Run Watershed* (Hawkins, 1995). The increase from treatment is attributed to silvicultural water yield effects that exceed fog drip reductions. This is consistent with Ingwersen's findings that once the temporary reductions in summer yield is offset by renewed fog drip, the expected increase in yield due to decreased evapotranspiration can be observed.

Blazed Alder has lower low-flow yields per square mile than the control watershed and all the other subwatersheds. Loss of fog drip and increased transpiration associated with riparian hardwoods were investigated as a potential cause of these lower water yields in Blazed Alder.

The reduction of fog drip associated with timber harvest in the Fox Creek basin was estimated to last five to six years after harvest (Ingwersen, 1986). Based on these findings a recovery curve was developed for clearcuts, so that clearcuts would recover 20% each year and be full recovered at five years. The recovery rate for fog drip may not be linear, but based on limited knowledge on the process of fog drip a linear recovery rate was used.

Chart 4-22 -- Hydrologic Recovery From Fog Drip



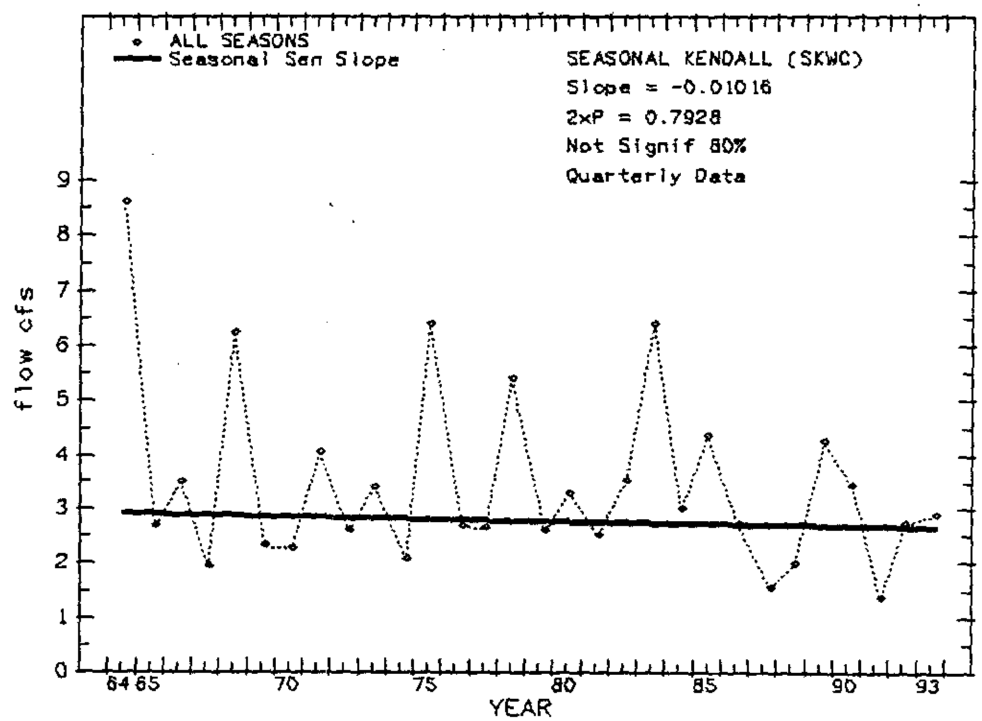
As Chart 4-22 illustrates, the Blazed Alder area does not appear to have significant losses in fog drip from 1976-93 associated with timber harvest. Blazed Alder also has more hydrologic recovery than many of the watershed's other subwatersheds. Thus, it appears that losses in fog drip do not account for its lower water yields. Limited area in wetlands was also investigated as a cause of these lower water yields within the Blazed Alder area, however, this subwatershed has the third-highest amount of acreage in wetlands when compared to the other subwatersheds.

Recent studies (Hicks, et al 1991) suggest reductions in streamflow following timber harvest may be related to the re-growth of deciduous riparian species which transpire greater amounts of water than do native conifer vegetation. Hardwood stands within the Riparian Reserves were identified from the ISAT database.

Only 1% of the Riparian Reserves within the Blazed Alder subwatershed are classified as hardwoods. Therefore, increased transpiration due to the conversion of conifer stands to hardwoods does not appear to be a process of concern.

The Blazed Alder stream gage, which has a relatively long period or record (1963-present), is not demonstrating a statistically significant trend over this period. The majority of timber harvest occurred prior to 1970, so stands would be expected to be hydrologically recovered with respect to fog drip. Based on Hawkins and Ingwersen's findings, rates of low-flow yields associated with silvicultural activities should be increasing in this area. Since theree is not a statistically significant trend at this station, it appears that the lower yields in the area may be the natural condition.

Chart 4-23 – Blazed Alder Seasonal Kendall Trendline



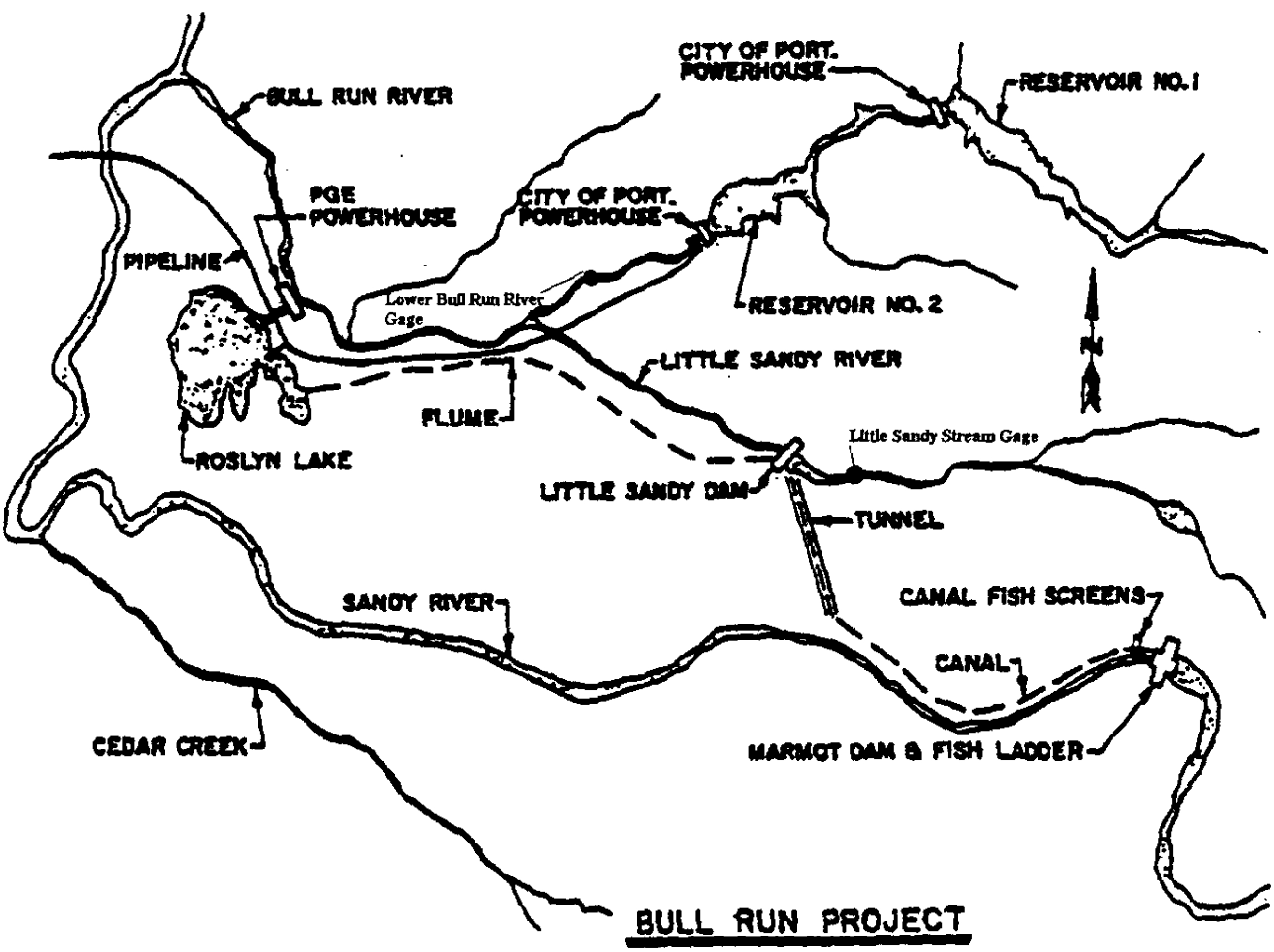
Conclusion: Low Flow

All the stream gages, except Blazed Alder, have greater low-flow yields per square mile than Fir Creek. This is attributed to natural variation between runoff-producing properties in these areas.

Flow Regime Lower Bull Run and Lower Little Sandy Rivers

The flow regime in the lower Bull Run River is severely altered due to the Little Sandy Diversion Dam, the Bull Run Reservoirs, and the Portland General Electric (PGE) power plant. Normal operating plans for the Bull Run powerplant call for diversion of all Little Sandy water (up to 800 cfs). If there is less than 800 cfs of Little Sandy water available, up to 600 cfs of Sandy River water is diverted, subject to availability and meeting minimum flow requirements.

Figure 4-33 -- Dams and Diversions Lower Bull Run Watershed



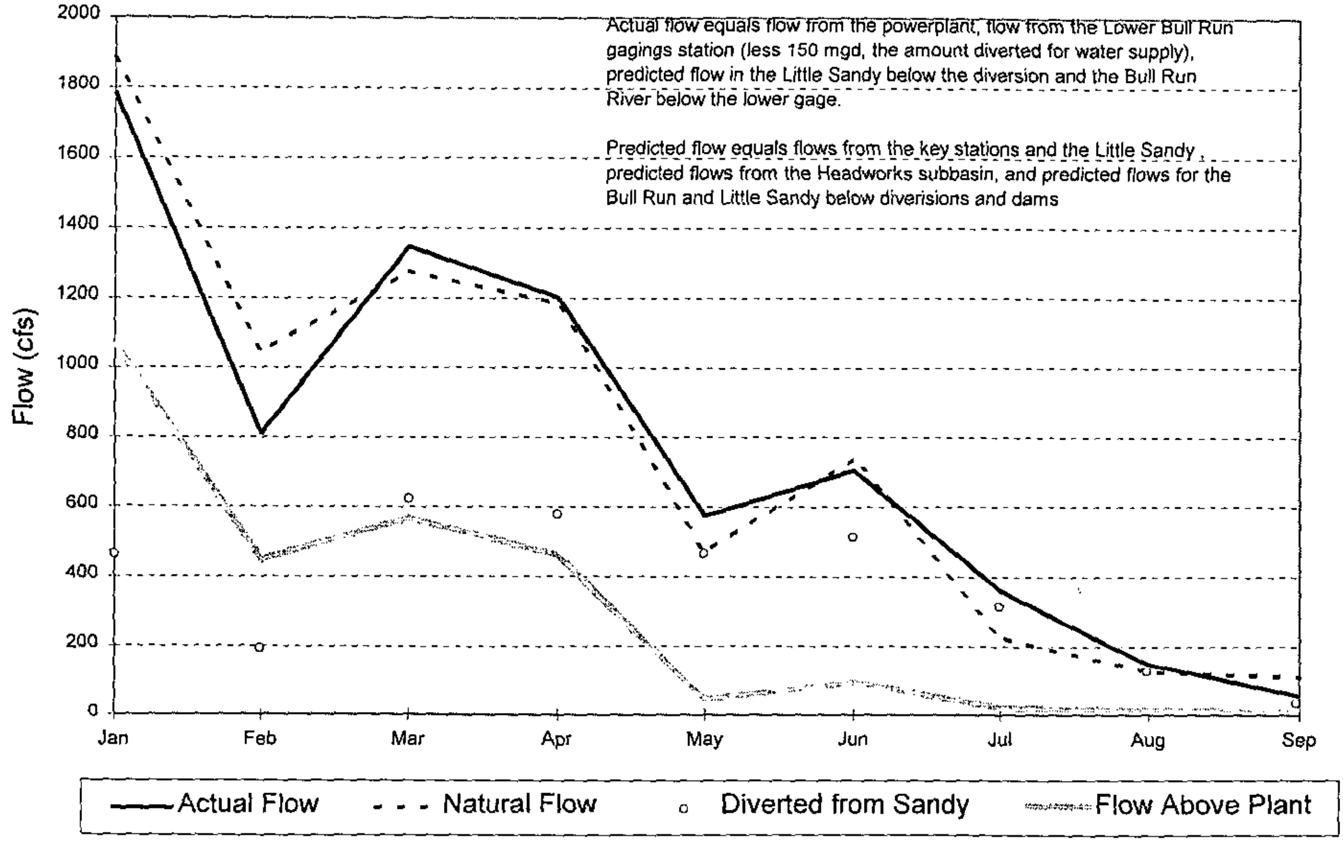
High flows and low flows were quantified on the Bull Run River at the lower gage (river mile 4.7) below the PGE powerhouse (river mile 1.5), and on the Little Sandy River at its confluence with the Bull Run River. Monthly averages and the year 1994 were used, because they were the only flows available from the Bull Run power plant. Both existing and natural flows were quantified.

Natural condition for the Bull Run River at the lower gage was estimated by adding the flow from the major tributaries to the reservoirs (Bull Run River, North Fork, Fir Creek, and South Fork) together with the estimated flow for the Headworks subwatershed and the area below it in the Lower Bull Run subwatershed. (This was accomplished by using the Bull Run gage contribution per acre for these areas).

The natural flow at the PGE powerhouse was estimated using similar methodology (and adding in the Little Sandy River). Flows for the Little Sandy were quantified using data from the gage above the diversion dam, calculating a per-unit contribution, and adding the additional acreage to the confluence with the Bull Run.

Actual flows on the Bull Run River below the PGE powerhouse are from the gage (at the lower gage site). They were estimated by adding together: data from the gage, an adjustment for the area between the gage and the powerhouse, and flows from the powerhouse (obtained from plant manager Loren Mayer). Actual flows for the Little Sandy at the confluence with the Bull Run were estimated by using the per-unit area contribution from the Little Sandy River gage and assuming that no flow gets by the diversion dam.

Chart 4-24 -- Flows: Bull Run River Below PGE Power plant 1994 (Monthly Mean)



Low Flows

Table 4-33 -- Typical Low Flows (Monthly Means)

Site	Natural Condition	Current Condition	Difference
Bull Run River at Lower Gage (July mean 1986[6])	202	5	-197
Little Sandy at Confluence with Bull Run (July 1986 mean)	45	4	-40
Bull Run River Below PGE Powerhouse (July 1994)	225	361	+136

[6] The year 1986 was used because data was available for the lower Bull Run streamflow gage without flow diverted from Reservoir 2 for City of Portland use added to the streamflow figures as is the standard practice in later years.

The low-flow regime in the lower Bull Run River exhibits two extremes. Current flows from the confluence with the Sandy River to the PGE powerhouse are 136% of the natural condition (due to water imported from the Sandy River). Above the PGE powerhouse, flows are minimal with 2% of the natural condition at the lower Bull Run gage, and 9% of the natural condition in the Little Sandy River. In July 1994, the flows above the powerhouse are predicted at 21 cfs, and, below the powerhouse, 361 cfs.

Low Flows

Peaking Operations

Effects of the operation of the Bull Run Powerplant on summer low flows in the lower Bull Run River were investigated as part of the analysis. Portland General Electric has instituted a program of passing natural flows through the plant during low flow periods to minimize impacts to fish and other aquatic resources (Exhibit S - Project No. 477).

Chart 4-25 Streamflow (cfs) Sandy River July 1995

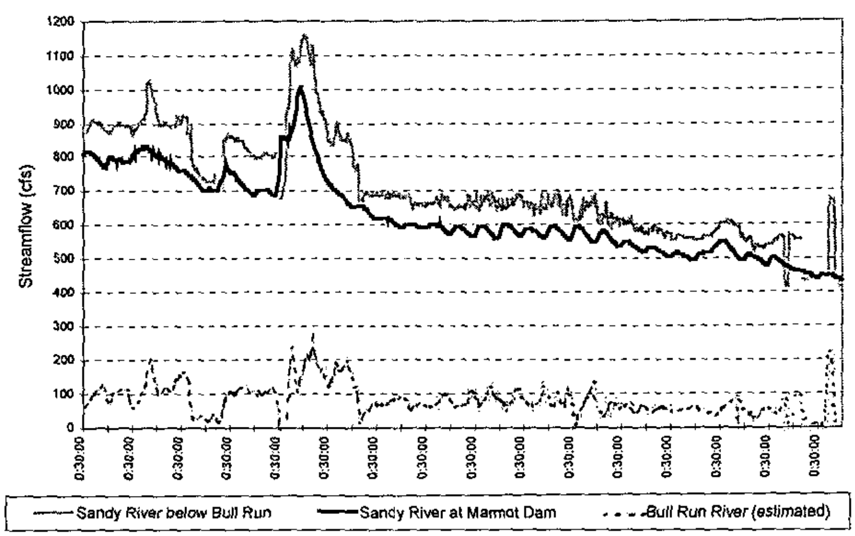


Chart 4-26 Streamflow (cfs) Sandy River August 1995

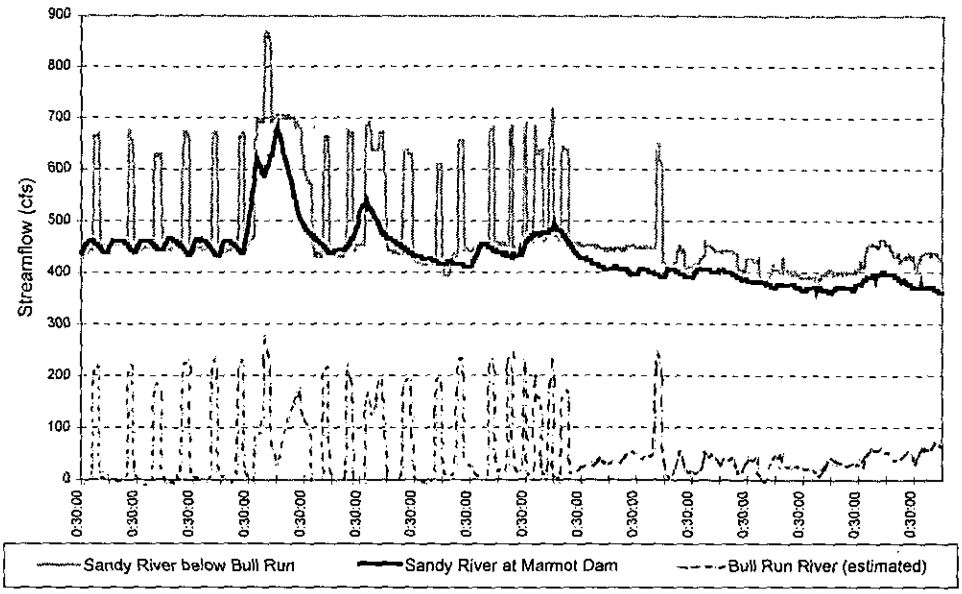
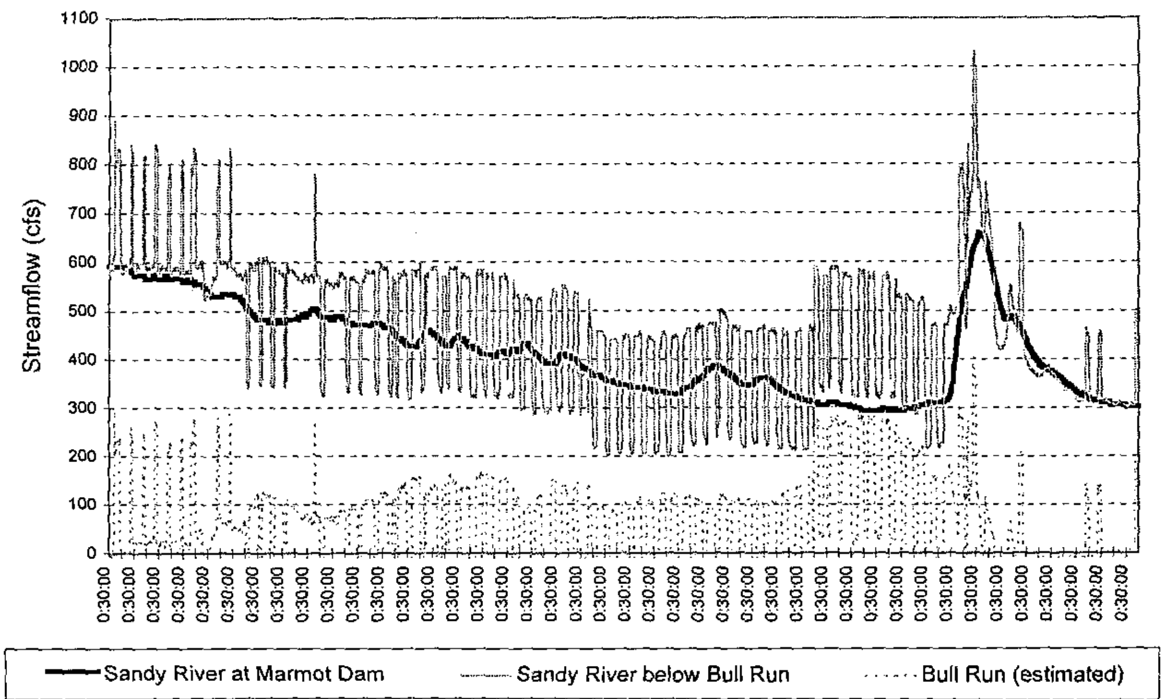


Chart 4-25 and Chart 4-26 illustrate the effects of the Bull Run powerplant on streamflows during the summer low flow period of 1995. There is not a streamflow gage on the lower Bull Run River so flows in the Sandy River above and below the diversions associated with the Bull Run Powerplant were used to assess the effects on streamflow in the lower Bull Run River. Streamflow in the Bull Run River was estimated by subtracting the streamflow from the Sandy River at Marmot Dam from the streamflow in the Sandy River below Bull Run. Cedar Creek is the only major tributary to the Sandy River between the two stream gages with and estimated 30 day duration base flow of 8.0 cfs and water rights for 29.5 cfs (Upper Sandy Watershed Analysis) it was assumed that the influence of streamflows from Cedar Creek on the Sandy River were minimal.

As the hydrographs illustrate for the most part streamflows in the Sandy River below the confluence with the Bull Run River have a similar pattern to the Sandy River above Marmot Dam approximating the natural low flow regime for the Sandy River. The peaking observed from late July to mid August is associated with non-routine equipment work. During this time the turbine with the capability to operate at low flows was removed for a major overhaul. When the turbine was brought back online in mid August streamflows again approximated the natural condition.

During the summer low flow period of 1996 peaking associated with the operation of the Bull Run powerplant occurred from early July to mid September. The variations in streamflow during this period are attributed to non-routine, major equipment work during this period. There are two conduits that deliver water from Roslyn lake to the Bull Run powerplant. During this period the penstock valve in the conduit that goes to the turbines that can be operated at variable rates was being replaced forcing the powerplant to operate on turbines that are designed to be operated at a full load of shut down. The replacement of the penstock valve was completed in mid September and after that period streamflows in the lower Bull Run and lower Sandy River appear to approximate streamflows in the Upper Sandy River.

Chart 4-27 Streamflow (cfs) Sandy River July 9-September 29, 1996



Operations of the Bull Run powerplant are successful in approximating the natural flow regime during the summer low flow period except during periods of non-routine major equipment work.

High Flows

Table 4-34 -- Typical High Flows (Monthly Means)[7]

Site	Natural Condition	Current Condition	Difference
Bull Run River at Lower Gage (Nov 86 monthly mean)	1837	1351	-486
Little Sandy at Confluence with Bull Run (Nov 86 monthly mean)	272	27	-245
Bull Run River Below PGE Powerhouse (Jan 94)	1882	1785	-97

The high-flow regime is altered, but not as severely as the low-flow regime. The Bull Run River at the lower gage is 73% of the natural condition; the Little Sandy is 9% of the natural condition; and the Bull Run River -- below the PGE powerhouse -- is 95% of the natural condition. Flow regime at the PGE powerhouse, however, is still in an altered condition. Flow above the PGE powerhouse in January 1994 was 1070 cfs, and below the powerhouse was 1785 cfs.

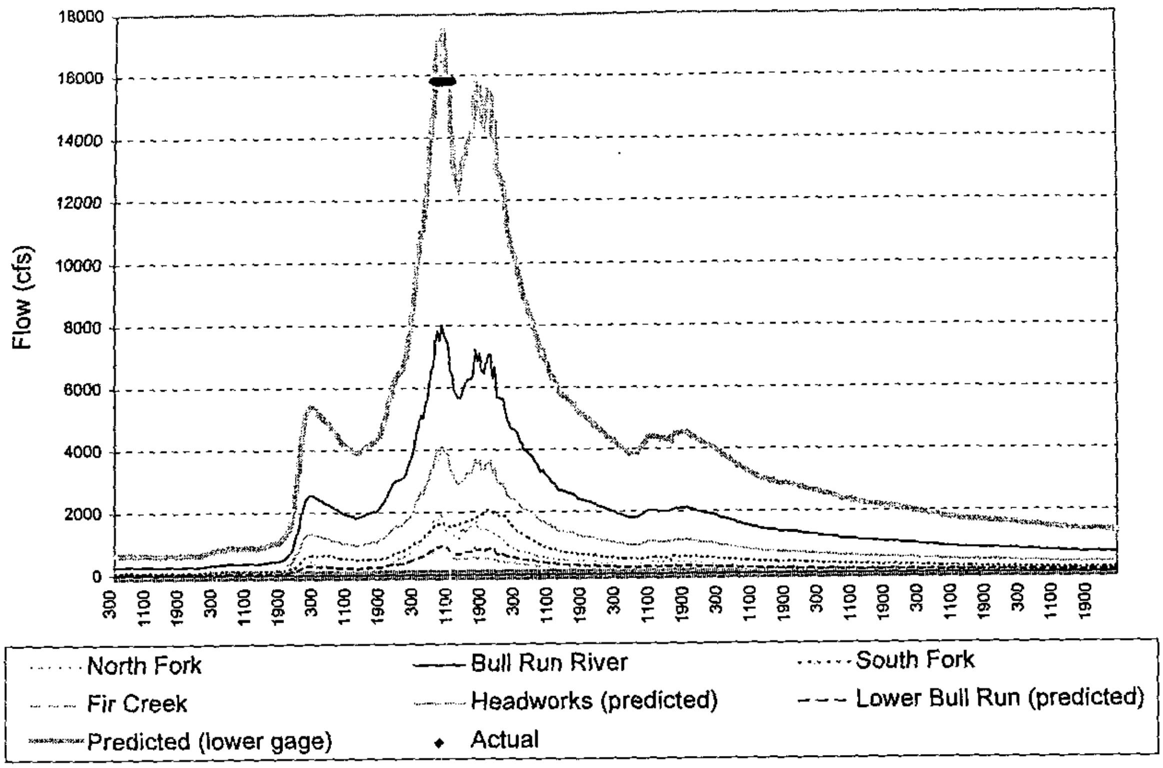
Instantaneous Peak Flows

Because of their effect on channel structure and the routing of large wood and sediment through the system, instantaneous peak flows are an important component of the peak flow regime.

The current condition and natural condition for the lower Bull Run River gage and the Little Sandy River at the diversion dam were examined for changes in instantaneous peak flows.

[7] Monthly means were used for comparison purposes because this was the only streamflow data available for the area below the PGE powerplant.

Chart 4-28 -- Peak Flows: Lower Bull Run River, February 1986

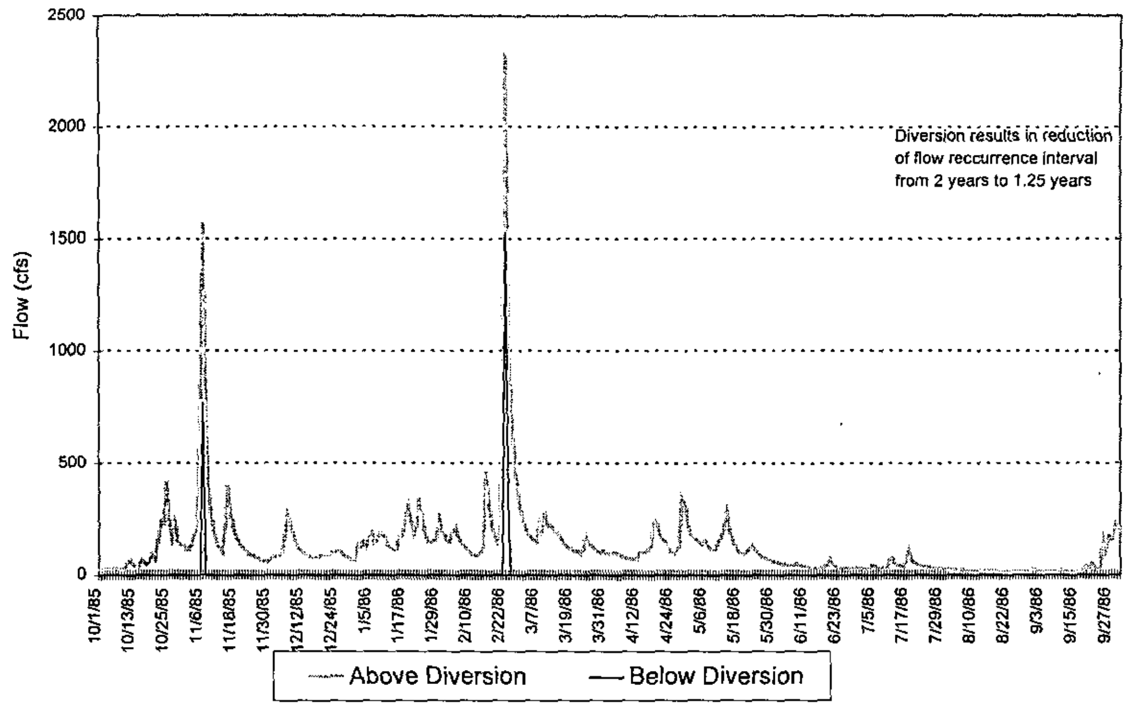


As Chart 4-28 illustrates, peak flows are slightly lower due to the influence of the Bull Run Watershed's reservoirs. Even though the reservoirs are not capturing these flows, they slow the velocity of the tributaries that flow into the reservoir pools. This impact spreads out the flow over time and lessens the magnitude of the peak flow.

Thus, the reservoirs alter the timing and the magnitude of the instantaneous peak flow in the lower Bull Run River. This difference, however, is not believed to be significant.

At the Little Sandy River diversion, the first 800 cfs from the river is diverted to the PGE power plant.

Chart 4-29 -- Streamflow Sandy River Water Year 1986



Because the 1-year recurrence interval event is 832 cfs, the diversion would only allow 32 cfs to pass through. For the 100-year recurrence interval event (5620 cfs), diverting 800 cfs would reduce it to a 50-year recurrence interval event. Within the Little Sandy River below the diversion dam there is an altered instantaneous peak flow regime associated with the diversion.

The 800 cfs removed at the Little Sandy diversion appears to have minimal effect on the hydrograph for the Bull Run River between the confluence with the Little Sandy River and the PGE power plant. February 1986 storm flows for the Bull Run River at the confluence with the Little Sandy River were estimated by adding the flows from the Little Sandy River to the flows from the Bull Run River at the lower gaging station. The diversion changed the flows from 20,117 cfs to 19,317 cfs or 4% for this event.

Conclusions: Flow Regime Lower Bull Run and Little Sandy Rivers

The low flow regime in the lower Bull Run and lower Little Sandy rivers is in an altered condition due to reservoirs on the Bull Run River, a diversion on the Little Sandy River, and Bull Run powerplant operations. The sections of the the Bull Run and Little Sandy rivers between the dams and diversions and the Bull Run powerplant flow very little water during the summer low flow period. Below the Bull Run powerplant summer low flows are increased above the natural condition due to importation of water from the Sandy River.

The Little Sandy River below the diversion for the Bull Run powerplant is dewatered for all but a few days in an average year (the 1 year reccurrence interval flood is 832 cfs and the first 800 cfs is diverted).

Water Quality

To protect your rivers,
protect your mountains.

Emperor Yu
1600 B.C.

Safe Drinking Water Act Requirements for Unfiltered Systems

The Bull Run watershed has unique status as an unfiltered surface water supply with specific requirements under the Safe Water Drinking Act.

Drinking water drawn from surface water sources (e.g. lakes, rivers, storage reservoirs) typically is both filtered and disinfected in order to assure that public health is protected and drinking water regulations are met. These drinking water treatment processes are part of the "multiple barrier" strategy that has been the mainstay of public health protection throughout this century. Other common elements of the multiple barrier strategy are watershed control and source water protection, and protecting water quality in the distribution system.

When the federal Safe Drinking Water Act was first adopted in 1974, treatment requirements for surface water were not specifically addressed. However, when Congress amended and reauthorized this legislation in 1986, it directed the Environmental Protection Agency (EPA) to implement requirements for filtration of surface water sources by 1989. EPA promulgated the Surface Water Treatment Rule in 1989 and provided an opportunity for systems that could continuously meet 11 specific criteria to remain unfiltered. Included in these criteria are requirements for a watershed control programs, source water standards for total and fecal coliforms and turbidity, and the requirement to accomplish the required level of virus and *Giardia* treatment through disinfection alone, as opposed to the combination of disinfection and physical removal typically available to filtered systems. Congress reiterated their interest in source protection when they amended and reauthorized the Safe Drinking Water Act in 1996. The amendments include requirements for the states to administerprograms which identify sources of contamination in water-supply watersheds and assess the succeptibility of water systems to those contaminants.

The Bull Run system has received a waiver from the requirement to filter under the Surface Water Treatment Rule. The active watershed control and source water protection programs that have been in place for decades were significant factors in the Oregon Health Division's granting of the filtration avoidance waiver. While not providing exactly the same kind of a "barrier" that a filtration plant provides, watershed control and source water protection, especially as practiced in the Bull Run watershed, do minimize opportunities for the introduction of contaminants and therefore allow public health to be protected using a simpler type of treatment.

Of the 11 criteria that must be continuously met in order to avoid filtration of the Bull Run system, the turbidity standard is the one of greatest concern to the Portland Water Bureau. The criteria requires that turbidity at the point of disinfection not exceed 5 NTU. If the turbidity does exceed this limit, an alternate supply must be used or the water must be blended with a supply of lower turbidity prior to applying the disinfection necessary to kill *Giardia*, viruses, and bacteria. If a system has a persistent problem meeting the turbidity criteria and if its alternative supply is also subject to reliability problems, the system can loose its waiver. A filtration plant for the Bull Run system would cost between $120 and $200 million, a significant cost to be avoided as long as public health can be protected and supply can be reliably delivered to the 800,000 consumers that rely on the Bull Run.

Water Quality Parameters

The Bull Run is the only watershed in the United States which has federal legislation, Public Law (PL) 95-200, which mandates the creation and utilization of site-specific water quality standards. Intensive water quality monitoring began in 1977 with the passage of this law. *The Final Environmental Impact Statement for the Bull Run Land Management Plan*, issued in 1979, contained the first set of water quality standards. These were reviewed by a group of experts in 1980.

Based on their subsequent report, the standards were revised by the Forest Service, acting in consultation with the City of Portland Water Bureau. These revised standards were distributed in 1984 and implemented by the Forest Service in 1985. Thirty-nine water quality parameters have standards established in the current *Bull Run Water Quality Standards* (1987 revision), five more are associated with the development of new standards.

In 1988 a technical review committee was commissioned by Representative Ron Wyden to assess the adequacy of the water quality monitoring program. The committee had the following recommendations for the water quality monitoring program:

1. Design a monitoring program to measure the movement of dissolved and suspended materials in the watershed over a range of streamflows occurring through a typical year.

2. Design automated sampling systems at the key stations which can perform sample collection functions at certain flow conditions without on-site personnel.

These recommendations have been implemented cooperatively by the Forest Service and the City of Portland Water Bureau.

Table 4-35 -- Standards Monitoring Program Bull Run Watershed

Standards Compliance	

Variable	Headworks (2)					Stream Key Stations (15,18,35,44)				
	Daily	Weekly	14 Days	28 Days	Annual	Daily	Weekly	14 Days	28 Days	Annual
Turbidity										
Temperature										
pH										
Conductance										
Color										
Suspended Solids										
Dissolved Oxygen										
Flow										
Heterotrophic Plate Count										
Total Coliform										
Fecal Coliform										
Algae										
Alkalinity										
Nitrate-N										
Ammonium-N										
Orthophosphate										
TOC										
HAC										
Arsenic										
Barium										
Cadmium										

Standards Compliance	

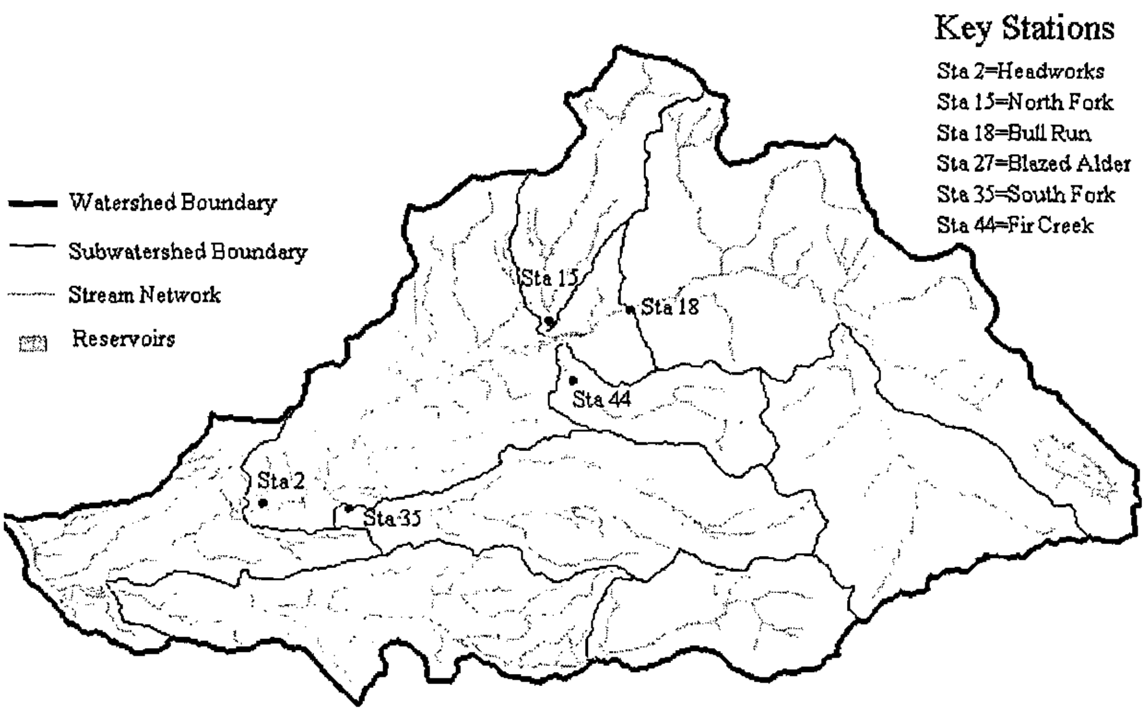
Variable	Headworks (2)					Stream Key Stations (15,18,35,44)				
	Daily	Weekly	14 Days	28 Days	Annual	Daily	Weekly	14 Days	28 Days	Annual
Chromium										
Copper										
Fluoride										
Iron										
Lead										
Manganese										
Mercury										
Selenium										
Silver										
Sodium										
Zinc										
Endrin										
Lindane										
Methoxychlor										
Toxaphene										
2,4-D										
2,4,5-TP										

There are data for these water quality parameters available for all the Key Stations from 1977 to present. The Key Stations are:

- **Station 2 Headworks** -- Located below the major storage reservoirs and just above where the water enters the screen house for disinfection.
- **Station 15 North Fork** -- Located on the North Fork River just upstream from the confluence with Reservoir #1.
- **Station 18 Bull Run** -- Located on the Bull Run River, upstream of the confluence with Reservoir #1.
- **Station 35 South Fork** -- Located on the South Fork River just upstream from the confluence of Reservoir #2.
- **Station 44 Fir Creek** -- Located on Fir Creek just upstream from the confluence of Reservoir #1.

Fir Creek has had no significant management activity (logging or roading) and is used in this Watershed Analysis as the control drainage for the entire Bull Run Watershed. As with any wildland basin selected to represent a "control"-- there are limitations to comparisons when differences are slight. The slope, runoff, geological characteristics, and watershed area of Fir Creek differ in important ways from the other key stations (Eilers et al, 1994).

Figure 4-34 -- Key Stations



From this list (Table 4-35) water quality parameters were selected for further analysis based on those with the greatest potential for change due to management activity or altered disturbance regime, and those with the potential for significant effects on drinking water quality or aquatic habitat.

Parameters selected include **turbidity, suspended sediment, nitrogen, phosphorous**, and **water temperature**.

Turbidity

Turbidity is an optical measure of water clarity and is also an indicator of the amount and type of material contained in the water. Municipal water suppliers are required to monitor turbidity and with a requirement for an unfiltered source that the raw water not exceed 5 NTU's (nephlometeric turbidity units). Because the watershed contains some geologic materials in localized areas with high turbidity potential and the City of Portland's water system is not filtered, activities with potential for increasing natural turbidity levels are of primary interest.

Because it is much easier to measure than suspended solids, turbidity is often used as a surrogate for suspended solids. Therefore, state water quality standards are tied to turbidity rather than to suspended solids. Turbidity, can also be caused by: finely divided organic matter, colored organic compounds, plankton and microorganisms. Thus, a correlation of turbidity and a weight concentration of suspended solids cannot be assumed.

The effects of management activities on turbidity will be discussed under suspended solids.

Suspended Solids

Suspended solids are one portion of the total sediment regime in surface water. They represent the concentration of organic and inorganic particles of material which are being carried by water. Suspended solids are often the source of turbidity within a stream system.

The most important potential adverse impact of forest management activities on streams is often an increase in inorganic sediment. Large increases in the amount of sediment delivered to a stream channel can: greatly impair or even eliminate fish and aquatic invertebrate habitat, and alter the structure and width of the streambanks and adjacent riparian zone. (MacDonald, 1991).

The physical effects of increased fine sediment load can be equally far-reaching. The amount of sediment can affect channel shape, sinuosity, and the relative balance between pools and riffles. Changes in sediment load will affect the bed material size, altering both the quality and quantity of fish and benthic invertebrates habitat. (MacDonald, 1991).

High levels of suspended solids are undesirable for municipal water supply because they can interfere with the disinfection of the water.

Forest management activities can affect suspended sediment in streams by altering both the erosion rate and the rate of transport into stream channels. Road building and road maintenance have been found to be primary sources of sediment inputs. This sediment can be eroded from the road surface, road fills, or slope failures associated with road construction and drainage (MacDonald, 1991).

Forest harvest can increase sediment yields by a variety of processes: surface erosion from landings, skid trails, and other compacted areas; slope failures triggered by the removal of tree cover; and surface erosion from burned areas or areas disturbed by site preparation activities. Surface erosion can include both dry ravel and surface creep (MacDonald, 1991).

Nutrients – Nitrogen and Phosphorus

Nitrogen and phosphorous are two important nutrients for plant growth. The amount of nitrogen and phosphorus released from decaying organic material, or from burning slash after timber harvest, is a major concern to both on-site productivity, as well as to downstream effects and the potential for increased nutrient enrichment in lakes or reservoirs promoting increased algal and bacterial populations.

A major concern regarding the Bull Run Watershed is the nutrient dynamics -- particularly with respect to nitrogen and phosphorus -- in the watershed's streams, rivers, and reservoirs. While these two nutrients are essential to biological communities, when their concentrations become too great they can cause water quality concerns (Aumen, 1986).

Significant increases of either nutrient (nitrogen and phosphorus) in Bull Run Watershed reservoirs or streams could result in increased populations of algae, some with the potential for causing taste and odor problems in water (Aumen, 1986).

Nitrogen

Nitrogen is one of the most important nutrients in aquatic systems. Most of the non-toxic effects of nitrogen result because increased inorganic nitrogen stimulates primary production (e.g., bacteria and algae).

Increased nitrogen loading in lakes and reservoirs is potentially more serious than an increase in stream nitrogen because of the potential accumulation of nutrients. Over time, the accumulation of relatively small nitrogen inputs may stimulate algae growth to where increased trophic levels occur (MacDonald, 1991).

Forest management activities such as logging, fire, and forest fertilization can alter the nitrogen cycle.

Within the Bull Run Watershed's Fox Creek drainage, partial clearcutting caused a four-fold increase in nitrate-nitrogen when slash was broadcast burned – and a six-fold increase when slash was allowed to decompose naturally. Nitrate-nitrogen concentrations returned to pre-logging levels after approximately five years (Harr and Fredrickson, 1988).

The water quality dataset used for this Watershed Analysis measures the nitrate form of nitrogen which is expressed as nitrogen..

Phosphorus

Within aquatic ecosystems, phosphorus is usually the limiting nutrient. Particulate inorganic phosphorus is mineral in origin. It enters the stream channel primarily by soil erosion and by sediment transport. Particulate organic phosphorus comes from a variety of sources and can enter the stream channel through fluvial transport or through direct deposition (MacDonald, 1991).

As with nitrogen increases, inorganic phosphorus can result in increases in primary productivity with the same concerns for potential increased nutrient levels in lakes and reservoirs.

Studies in the Pacific Northwest indicate that forest management activities are unlikely to substantially increase phosphate concentrations in aquatic ecosystems. Studies in the Bull Run Watershed's Fox Creek drainage indicated that clearcutting and burning had no effect on phosphate concentrations (Harr and Fredrickson, 1988).

The water quality dataset used for this Watershed Analysis measures the orthophosphate (PO_4) form of phosphorus which is expressed as phosphorous.

Water Temperature

Temperature controls many biologic and physical processes. Increased water temperatures are know to increase biological activity. A rough rule of thumb is that a 10 ^{0}C increase in temperature will double the metabolic rate of cold-blooded organisms. Temperature also controls the rate of many chemical reactions.

Temperature can be affected by management activities that remove stream shade, alter channel structure, or alter the flow regime.

Analysis Methods

A number of analysis methods were used to analyze changes in water quality between monitoring stations over time. Analysis methods used included:

- Seasonal Kendall Test for trends by water quality parameter and station to determine trends over time at the same monitoring station.
- Seasonal box and whisker plots between stations to demonstrate differences between monitoring stations.
- Wilcoxen Test by season between stations to analyze differences between monitoring stations.
- Seasonal box and whisker plots by station to help explain time trends and differences between monitoring stations.
- Comparison of continuous stream temperature data to State Water Quality Standards in the upper Little Sandy area to assess compliance with water quality standards in the upper Little Sandy subwatershed.

Information from these various analyses will be summarized in this document.

Water Quality Database

The database used for the water quality analysis is a subset of the City of Portland Water Bureau's master water quality database for the Bull Run Watershed. This database contains all the Key Station water quality information from 1977 to the present.

This master database was queried for all headworks and stream Key Station entries for: turbidity, suspended solids, nitrate-nitrogen, and ortho-phosphorus. It should be noted that sampling protocols have changed over time, with implementation of storm sampling in 1987 and flow based sampling in 1993.

Water temperature was obtained from USGS data via Hydrosphere CD-ROM, and Hydrodata for Windows software.

Water Quality Trends Analysis

The seasonal Kendall trends test used for this Watershed Analysis is the same used in *Water Quality Variations in the Bull Run Watershed, Oregon, Under 1978 to 1983 Management Conditions* (Rinella, 1987). This allowed the comparison of current analysis results with conditions from 1978 to 1983. For a more complete description of the statistical analysis methods see the flow section. The seasonal Kendall trends test was developed for a single observation for each month, so the dataset was reduced to monthly medians for all water quality parameters.

Flow Dependency

As a final step in the analysis, trends from *Water Quality in the Bull Run Reservoirs* (Eilers, 1994) were examined to identify trends that could be explained by streamflow. The trend analysis used by Eilers partitioned the sources of variation in the data. Variation in the data that could be explained by flow dependence, seasonality and autocorrelation were removed. Turbidity and suspended solids were found to be flow-dependent, while nitrate and orthophosphate were not.

Table 4-36 -- Summary of Seasonal Kendall Trends Analysis

Station	Turbidity[8]		Suspended Solids[9]		Nitrogen (NO_3)[10]		Phosphorous (PO_4)[11]		Temperature[12]	
	Slope	P-level	Slope	P-level	Slope	P-level	Slope	P-level	Slope	P-level
Headworks	**0.01 ltdl[13]**	2.6E-9	**0.0 ltdl**	0.0376	-0.000 ltdl	0.2669	**0.000 ltdl**	1.6E-15		
North Fork	**0.00 ltdl**	0.015	**0.0 ltdl**	3.3E-08	**-0.000 ltdl**	0.0484	**0.000 ltdl**	0.0268	**0.0 ltdl**	0.0052
North Fork (Rinella, 1987)	**0.02 ltdl**	0.000	**0.0 ltdl**	0.049	**0.031**	0.001	**-0.001 ltdl**	0.008	0.0 ltdl	0.741
Bull Run	0.00 ltdl	0.1550	**0.0 ltdl**	2.9E-05	**-0.000 ltdl**	0.0063	**0.000 ltdl**	0.0155	**0.0 ltdl**	0.0006
Bull Run (Rinella, 1987)	**0.01 ltdl**	0.010	-0.1	0.295	**-0.002 ltdl**	0.010	0.000 ltdl	0.796	-0.0 ltdl	0.444
South Fork	**0.00 ltdl**	0.0383	**0.0 ltdl**	1.4E-10	**-0.000 ltdl**	0.0001	**0.000 ltdl**	1.0E-5	**0.0 ltdl**	0.0103
South Fork (Rinella, 1987)	**0.02 ltdl**	0.00	**0.0 ltdl**	0.062	0.000 ltdl	0.597	0.000 ltdl	1.000	0.0 ltdl	0.956
Fir Creek	**0.00 ltdl**	0.0002	**0.0 ltdl**	1.5E-11	**0.001 ltdl**	0.0024	**0.000 ltdl**	7.5E-8	**0.0 ltdl**	0.0012
Fir Creek (Rinella, 1987)	**0.03 ltdl**	0.000	**0.0 ltdl**	0.098	0.000 ltdl	0.954	0.000 ltdl	0.486	0.0 ltdl	0.785

P value = actual estimated probability of a Type I error
Bold= P value less than 0.10 (there is a 10% chance that the trend evident in the sample does not exist in the population) considered to be significant trend
ltdl = less than laboratory detection limit
All slopes were rounded to the appropriate significant figures for each variable

8 Detection limit 0.05 NTU's
9 Detection limit 0.1 mg/L
10 Detection limit 0.005 mg/L
11 Detection limit 0.003 mg/L
12 Detection limit 0.1 degrees celcius
13 Less than the detection limit

Results of Seasonal Kendall Trends Analysis

Results of this trends analysis were similar to those of *Water Quality in the Bull Run Reservoirs* (Eilers, 1994) and *Water-Quality Variations in the Bull Run Watershed, Oregon, Under 1978 to 1983 Management Conditions* (Rinella, 1987) in that many of the trends that are statistically significant are not of practical significance and cannot be measured on an annual basis. Only those trends that are statistically significant with a magnitude of change above detection limits (on an annual basis) were investigated for causal factors (natural or management influenced factors).

Turbidity

There are statisitically significant trends for turbidity at Headworks, North Fork, and Fir Creek, however, the magnitude of these trends is very small (0.002 to 0.005 NTU's per year), not measureable on an annual basis, and not of practical significance.

Suspended Sediment

Suspended sediment demonstrates a statistically significant increasing trend for all Key Stations. This increase varies in magnitude from 0.01 mg/L per year to 0.02 mg/L per year (less than the detection limit for all stations). The trend is evident in Fir Creek with a similar magnitude of change. Therefore, it appears that the trend is not management related.

Trends for flow-adjusted-concentrations were found for North Fork, Bull Run River, and South Fork. The presence of a trend was established for Bull Run River; however, the large error associated with the models produced estimates for which the 95% confidence interval included zero. Thus, the statistical significance of these apparent trends is minimal (Eilers, 1994).

This same statistical dilemma is repeated at North Fork for total suspended solids (1980-1983); and South Fork for total suspended solids (1984-88). The statistical significance of these apparent trends is less important than the fact that the magnitude of the trends have no practical significance (Eilers, 1994).

Nitrogen

Nitrate nitrogen exhibits a decreasing trend of very low magnitude at all the Key Stations except Fir Creek where there is a significant increasing trend of very low magnitude. The magnitude of change is very small. Detection limits for nitrate are 0.005 mg/L and trends vary in magnitude from 0.00025 to 0.00059 mg/L per year.

Because nutrients did not exhibit a flow dependent relationship (Eilers, 1994), flow adjusted concentrations were not examined.

Phosphorus (Orthophosphate PO_4)

No trends were identified for phosphorus due to the slope or magnitude of change being zero. A large portion of the samples have levels of orthophosphate at the detection limit, it appears that this nutrient is quickly assimilated within the watershed's oligitrophic waters (Eilers, 1994).

Chart 4-30 – Season Kendall Orthophosphate Trend – Bull Run River

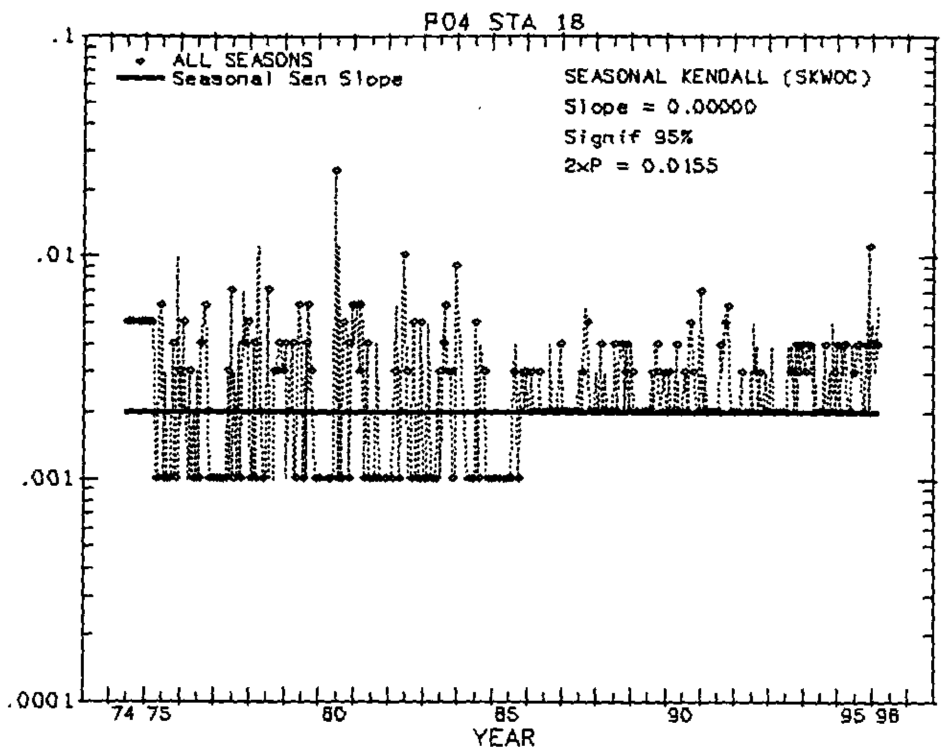


Chart 4-30 illustrates the dataset for all Key Stations. This trend is associated with the detection limits for orthophosphate (0.003) -- in which a large portion of the samples from the dataset reside.

Temperature

Significant increasing trends for temperature have been indicated at all Key Stations, including Fir Creek. The magnitude of change is very small (0.02-0.05^0 C per year) and not measurable on an annual basis. The slope at Fir Creek is similar to the other Stations so it appears that the trend cannot be cause related.

Comparison of Key Stations

This section of the analysis uses seasonal plots by key station, box and whisker plots, and the Season Wilcoxen-Mann-Whitney, to assess differences between managed areas and the unmanaged control -- and between each other.

Turbidity

Key Station turbidity levels are displayed in Chart 4-31. Differences between the streams flowing into the reservoirs and the reservoirs themselves are evident in time periods October through February, and August through September.

Chart 4-31 -- Turbidity Levels by Month and Monitoring Station

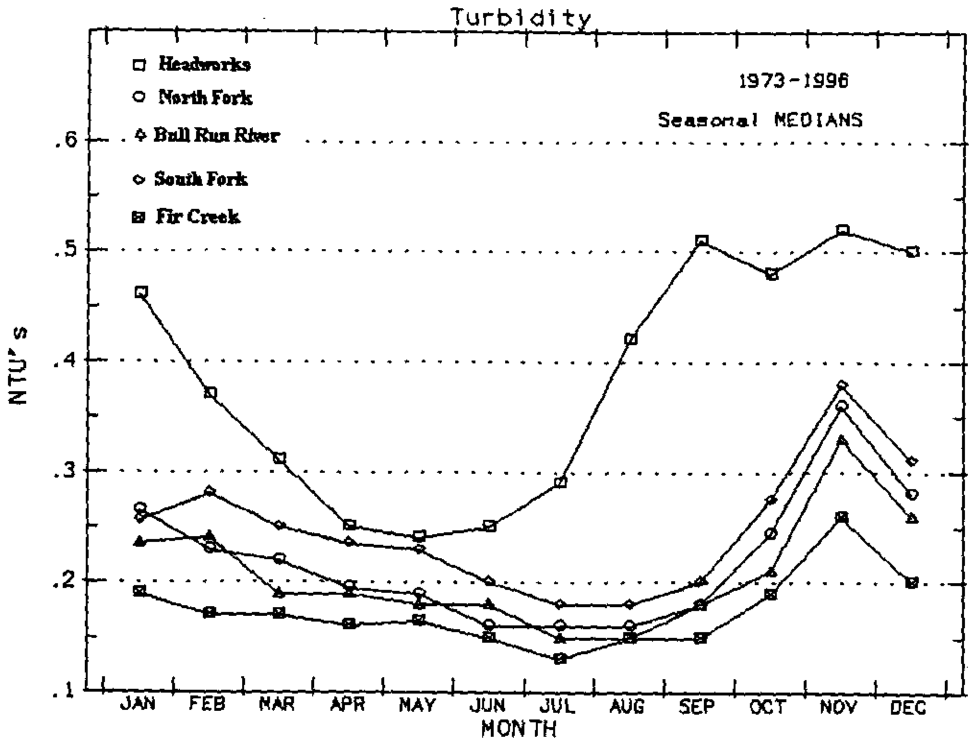


Chart 4-32 -- Turbidity Levels: July-Sept.

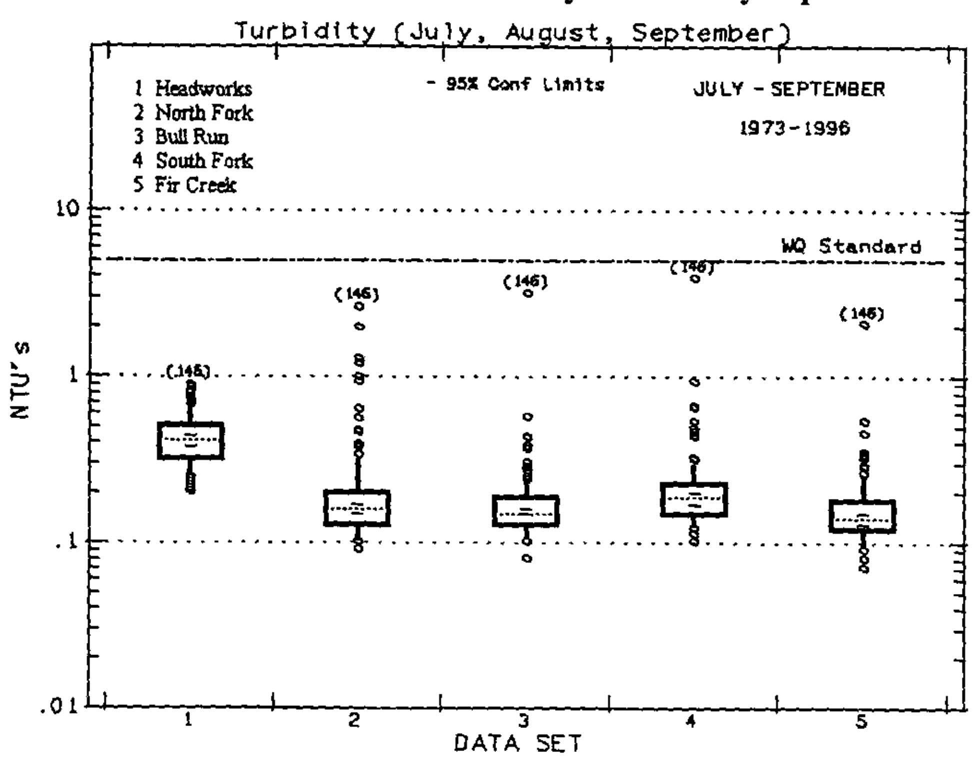


Chart 4-33 -- Turbidity Levels: Oct.-Dec.

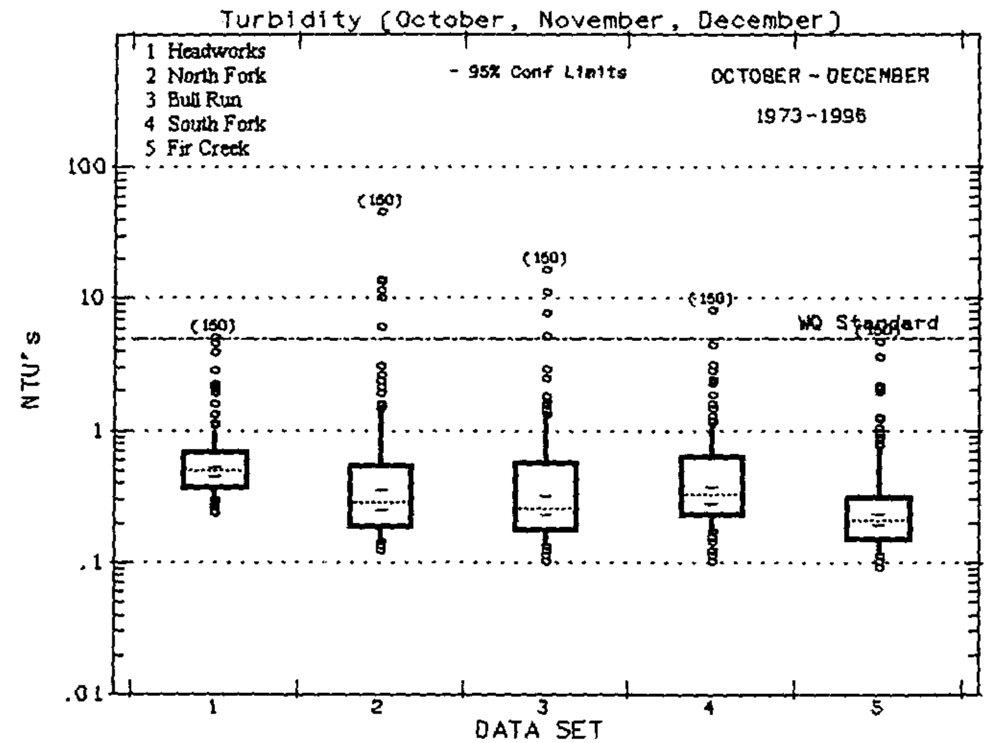
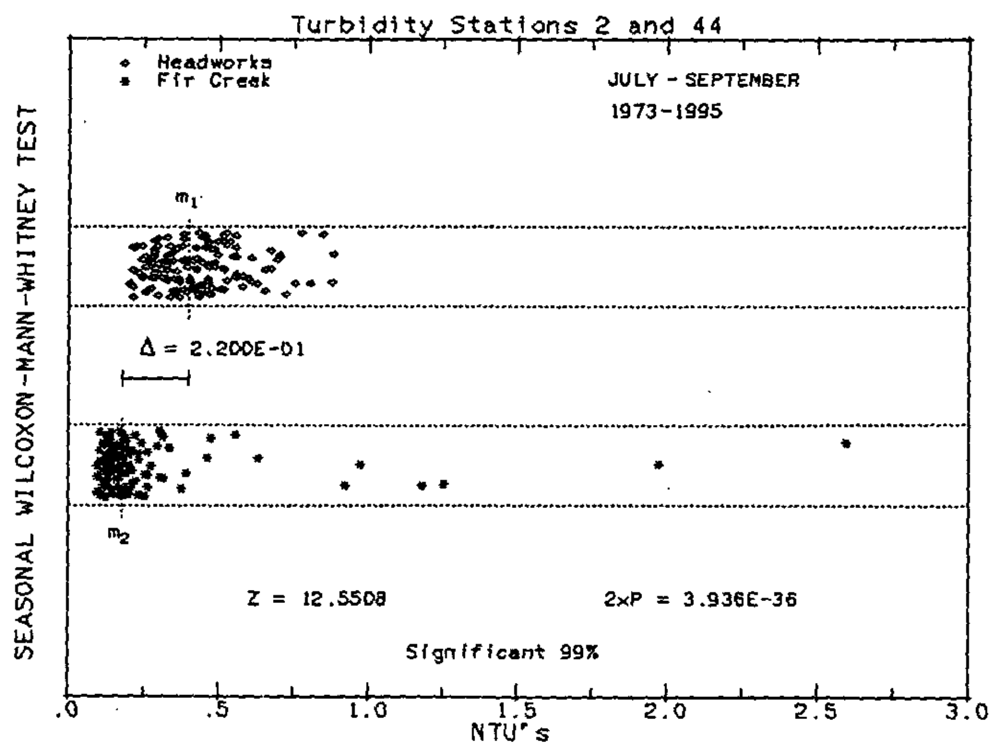


Chart 4-34 Turbidity Levels Headworks and Fir Creek (July-September)



Historical turbidity data should be used with some circumspection -- it reflects the sampling protocol used to gather the data. Lahusen (Lahusen, 1994) found that contrary to historical data and standards, turbidity levels of the reservoirs typically were not greater than peak values of turbidity in the streams. Rather, notes Lahusen, the historical weekly sampling schedule did not effectively measure ephemeral turbidity increases that occur during storms. Some of the sediment that is delivered by streams remains in suspension in the reservoirs where it is measured on a daily basis at the headworks (LaHusen, 1994).

During most of the historical water quality monitoring performed within the Bull Run Watershed, streams were sampled at regular time intervals. Such a sampling approach precludes accurate evaluation of stream turbidity caused by stormflows. At the Bull Run River Key Station, turbidity during an average annual peak flow of 6200 cfs is 15 NTUs. Median interstorm turbidity is 0.2 cfs. Therefore, annual peak storm turbidity is 75 times greater than median interstorm turbidity. With respect to time, 90 percent of the time streamflows within the Bull Run Watershed are remarkably clear, with less than 1 NTU (LaHusen, 1994).

The increased turbidity levels in the reservoirs are attributed to a combination of the sampling protocols and processes within the reservoirs.

As sources of higher turbidities in the reservoirs, Lahusen cites: erosion of reservoir shorelines and deltas; and erosion associated with large stormflows that produce streamside landslides or debris jam failures and channel scour.

At extremely low reservoir levels, the shoreline deposits become exposed and eroded by streamflows and early season storms. After such storms, eroded fine particles remain in suspension long enough to become a water supply concern (LaHusen, 1994). Turbidity of streamflows measured above and below reservoir deltas reveal stream turbidity increased an average of 2 to 8 NTUs -- and as much as 25 NTUs where streams were observed cutting into the exposed deltas of the upper reservoirs. This would explain the higher turbidity levels in July through September at the Headworks Key Station (Chart 4-32), as well as the wider variation in turbidity associated at this same station during this time.

Another example of this process is the high levels of turbidity associated with an inner gorge failure in the North Fork River. Coinciding with a major landslide on Jan. 20, 1972 (Beaulieu, 1974), the estimated surge flow on the North Fork River was 9,800 cfs (Beaulieu, 1974). This was nearly 130-fold greater than this site's average flow. The resultant sediment load caused elevated turbidity in the reservoirs for weeks after the event (LaHusen, 1994).

Chart 4-35 -- Turbidity Levels: February 1996

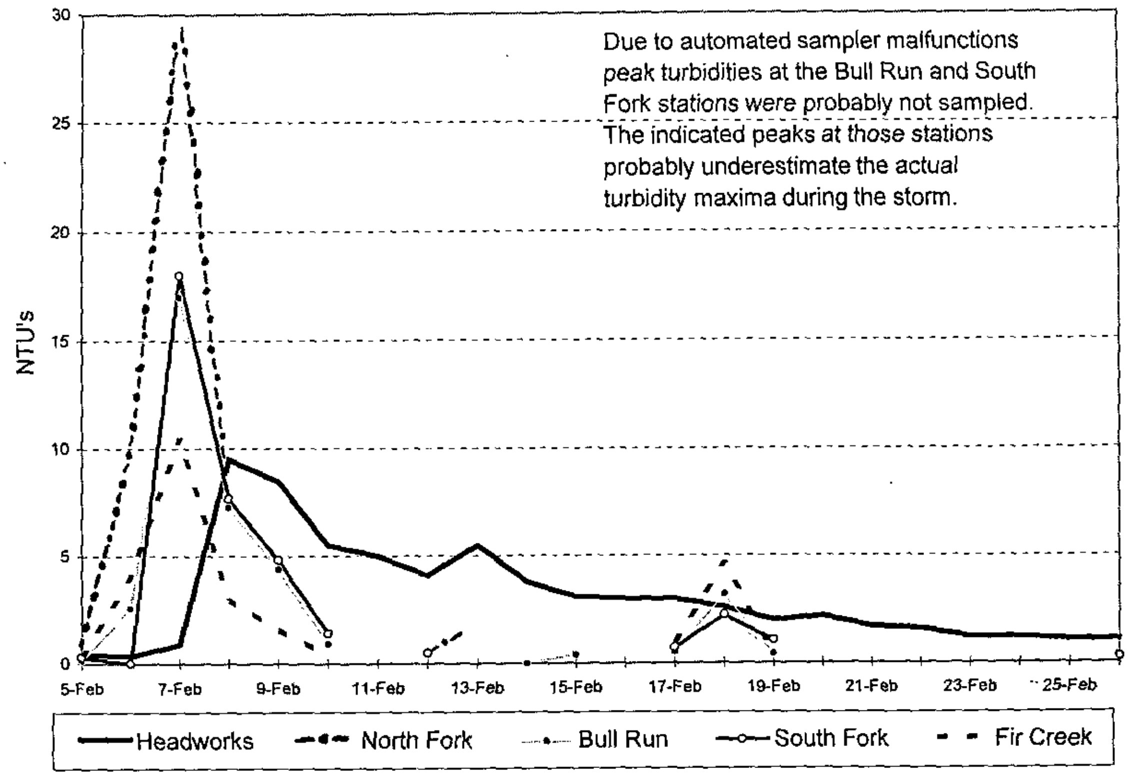


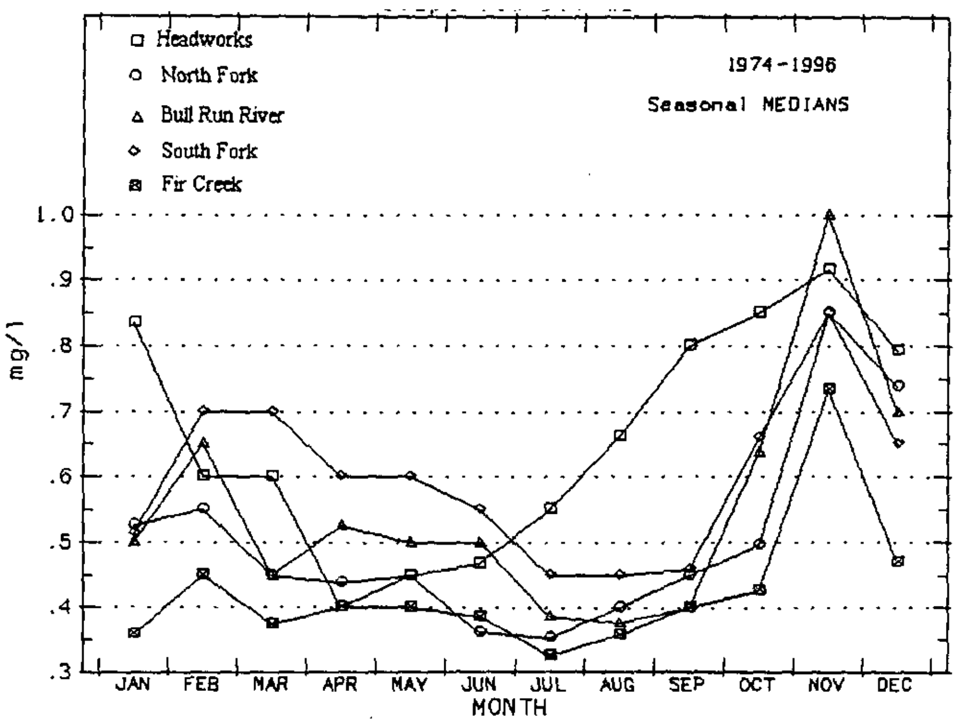
Chart 4-35, displaying the daily average instream turbidities for the February 1996 storm event, demonstrates the persistence of higher turbidity levels within the reservoirs. Turbidity levels peak higher and earlier at the stream Key Stations, but persist for longer periods of time within the reservoirs. This process would explain the higher median levels of turbidity observed at the headworks (Chart 4-33), and the wider variation and higher maximum levels of turbidity recorded at the stream Key Stations.

Suspended Solids

Based on monthly medians displayed in

Chart 4-36, no pattern appears of one station having higher levels of suspended solids throughout the year. However, in July through October, suspended solids levels are higher at the Headworks Station. During February through June, suspended solid concentrations are higher at the South Fork Station.

Chart 4-36 -- Suspended Solids at Stream Monitoring Stations



Levels of suspended solids for the July through October period from Headworks and Fir Creek were compared to determine if a statistically significant difference exists between them.

The specific objective was to ascertain if levels of suspended solids in the reservoir were different from the natural condition in an unmanaged area's stream.

This same procedure was followed to compare levels of suspended solids from South Fork to Fir Creek for February through May.

Chart 4-37 -- Suspended Solids: Headworks and Fir Creek (July-Oct.)

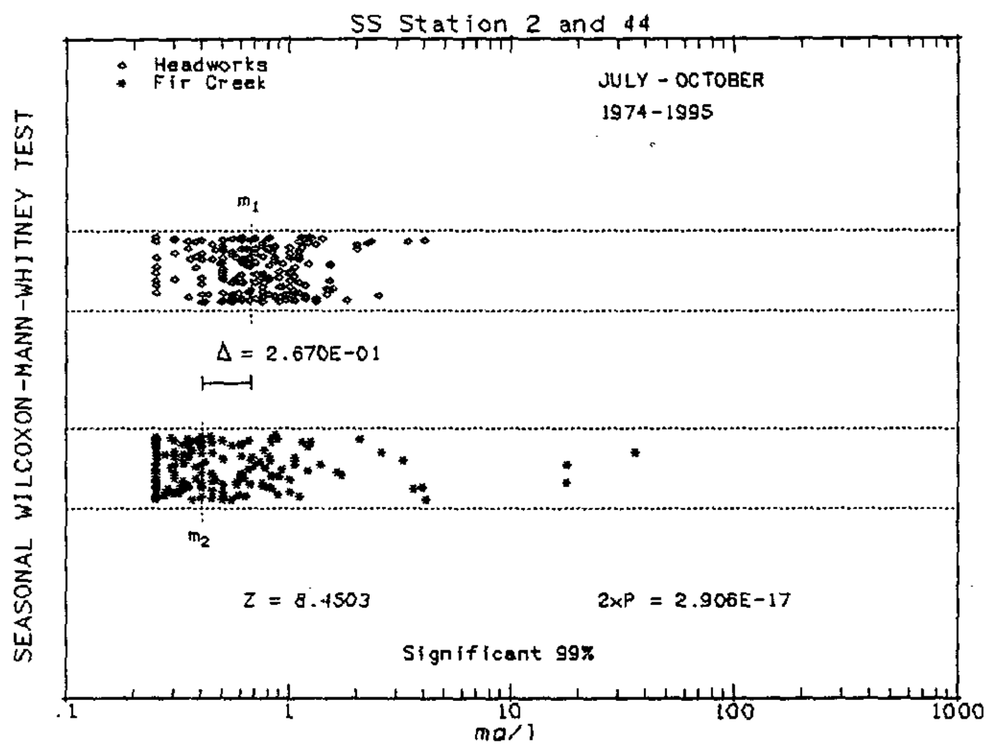
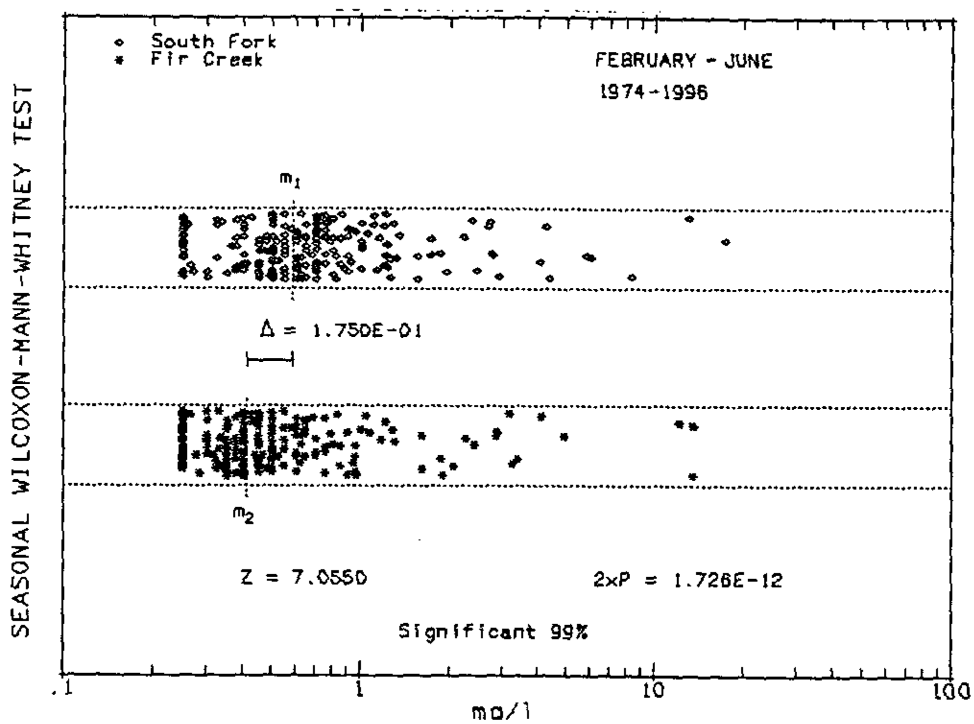


Chart 4-37 illustrates a statistically significant difference between Fir Creek and Headworks of 0.3 mg/l of suspended solids for the period of July through October.

This is attributed to erosion of reservoir shorelines and deltas associated with low flows, and with reservoir recharge in the fall. (This process is detailed in the previous turbidity section.)

Chart 4-38 -- Suspended Solids: Station 35 and 44 (Feb-June)



For the February through June period, a statistically significant difference exists of 0.2 mg/l of suspended solids between South Fork and Fir Creek. The differences in suspended solids levels are attributed to the peak flow regime in the South Fork subwatershed, and associated channel erosion through stream channels in the Rhododendron formation.

The South Fork subwatershed has the highest peakflows per unit area of any subwatershed during January, February, April, and November. In addition, this subwatershed has the lowest average elevation of all the subwatersheds, and the highest flow per unit area --which implies that rain on snow events are driving the peak flow regime in this subwatershed. Higher peak flows per unit area coupled with unstable channel types below the confluence of Cedar Creek and the South Fork, may explain the slightly higher levels of suspended solids.

Nitrogen

Chart 4-39 and Chart 4-40 illustrate higher levels of nitrate nitrogen in Fir Creek than the other stream Key Station and the Headworks Station.

Chart 4-39 -- Nitrate Nitrogen

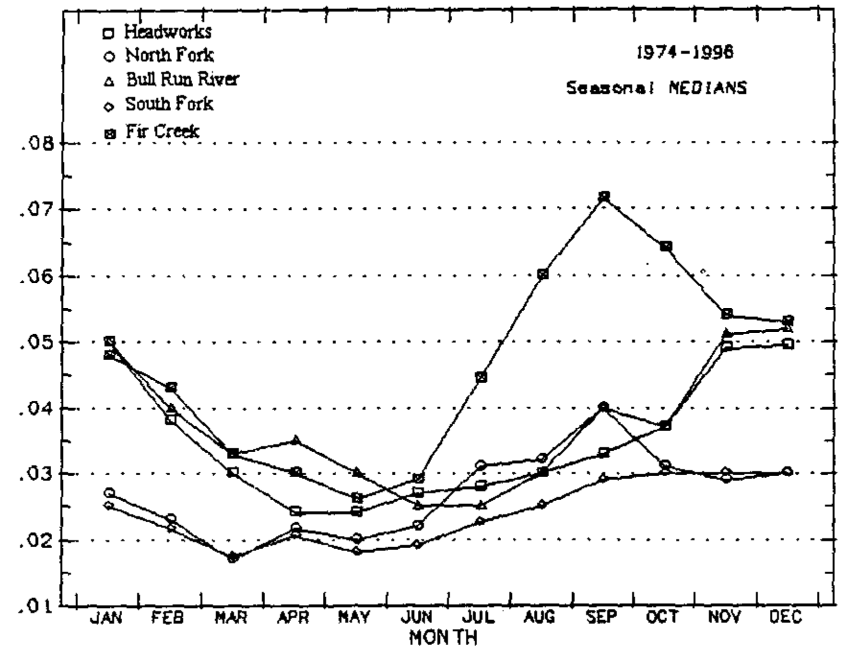
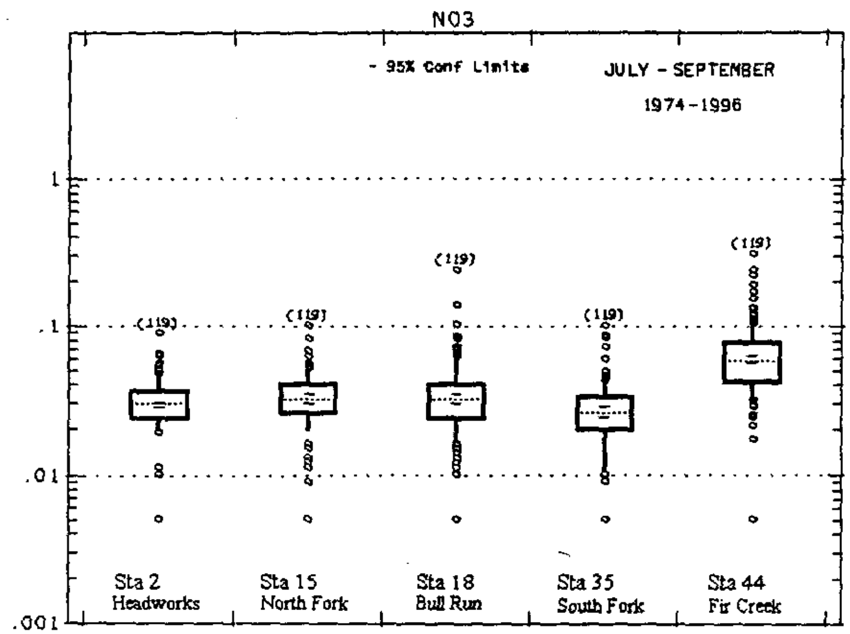
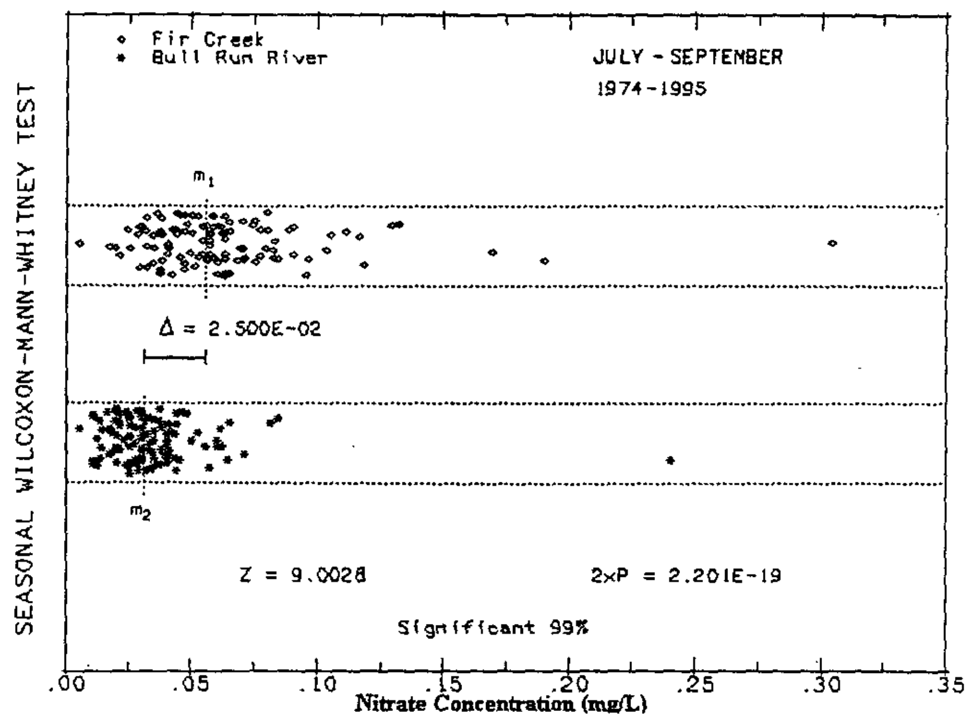


Chart 4-40 -- Nitrate Nitrogen: July-September



For the period of July through September Fir Creek demonstrates statistically significant differences from the other key stations. The magnitude of the differences varies from 0.023 to 0.030 mg/L. Chart 4-41 illustrates the relationship between the Bull Run River and Fir Creek for the period of July through September.

Chart 4-41 Nitrate Nitrogen Bull Run River and Fir Creek



Nitrate concentrations in headwater streams within the Bull Run Watershed are generally much higher than expected for Cascade Mountain streams. High nitrate concentrations in the headwaters do not seem to be related to natural disturbance or management practices because high concentrations were detected in undisturbed, old-growth sites. Concentrations of N, particularly nitrate, decrease dramatically as stream order increases (Aumen, 1987).

Decomposing wood also has some influence on nitrate-nitrogen levels because it may serve as a nitrogen sink, particularly in streams that are limited by nitrogen (Aumen et al. 1985a, 1986b); and all the stream key stations are limited by nitrogen at various times of the year (Bakke, 1993).

Management activities -- including timber harvest -- have the potential to increase nitrate-nitrogen levels in the short-term. In the Fox Creek drainage within the South Fork subwatershed, partial clearcutting caused a four-fold increase in nitrate-nitrogen when slash was broadcast burned, and a six-fold increase when slash was allowed to decompose naturally. Nitrate-nitrogen concentrations returned to pre-logging levels approximately five years after harvest (Harr and Fredrickson, 1988). Because Fir Creek is an unmanaged subwatershed, increases in nitrate-nitrogen cannot be attributed to management activity.

Explanations for the higher levels of nitrate-nitrogen focus on longitudinal (headwaters to mainstem) patterns of dissolved nutrient concentrations in Bull Run Watershed streams.

Nitrate concentrations in headwater streams within the Bull Run Watershed are generally much higher than expected for Cascade Mountain streams. Streams in the Northwest are typically nitrogen limited with sufficient phosphorus available from the soils and substrates. High nitrate concentrations in the headwaters do not seem to be related to natural disturbance or management practices because high concentrations were detected in undisturbed, old-growth sites. Nitrate concentrations decrease from headwaters to larger streams either from removal by streambed processes (biotic uptake, denitrification) or from dilution with water having lower nitrate concentrations (Aumen, 1987).

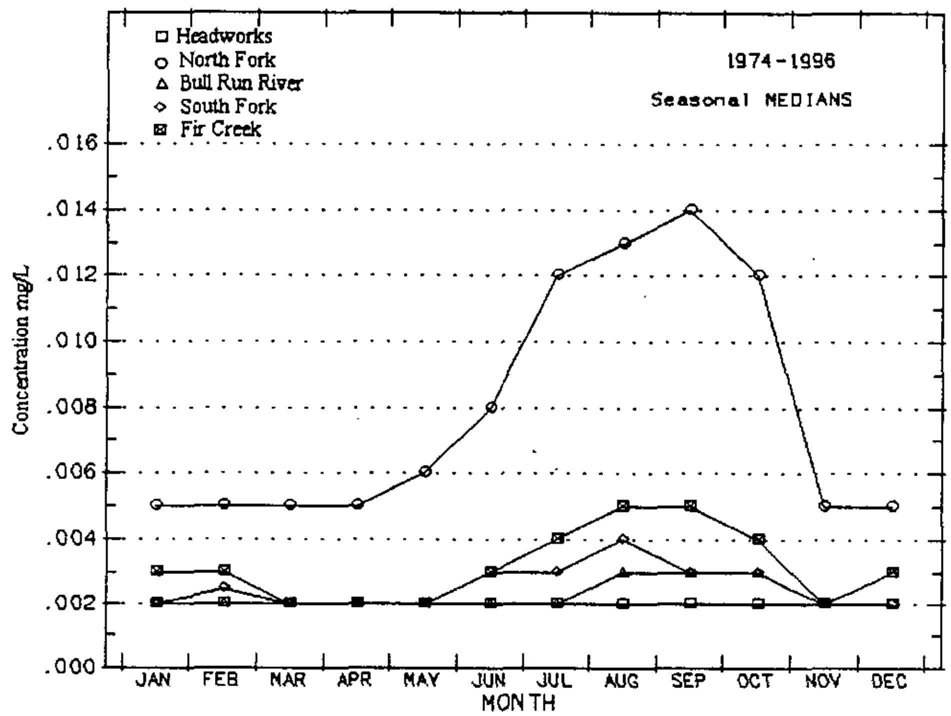
Fir Creek has the smallest drainage area of any of the stream key stations . Since smaller streams have higher nitrate-nitrogen concentrations Fir Creek would be expected to have higher concentrations of nitrate-nitrogen.

Another explanation for the higher concentrations within the Fir Creek subwatershed may be the amount of alder in the riparian area. Fir Creek is suspected to have a higher percentage of alder in the riparian area that is fixing atmospheric nitrogen that is leaching nitrogen into the stream system. The concentration of alders within the riparian area in Fir Creek could not be confirmed with vegetation databases (MOMs or ISAT) or stream survey data.

Phosphorus

Phosphorus levels measured as ortho-phosphorus are very low and near the detection limits for all Key Stations but North Fork, which exhibits higher levels (yet very small concentrations) of phosphorus.

Chart 4-42 – Phosphorus Levels



Concentrations of phosphorus, higher within the North Fork the entire year, are most pronounced from June through November.

Chart 4-43 -- Phosphorus Levels at Key Stations: July-September

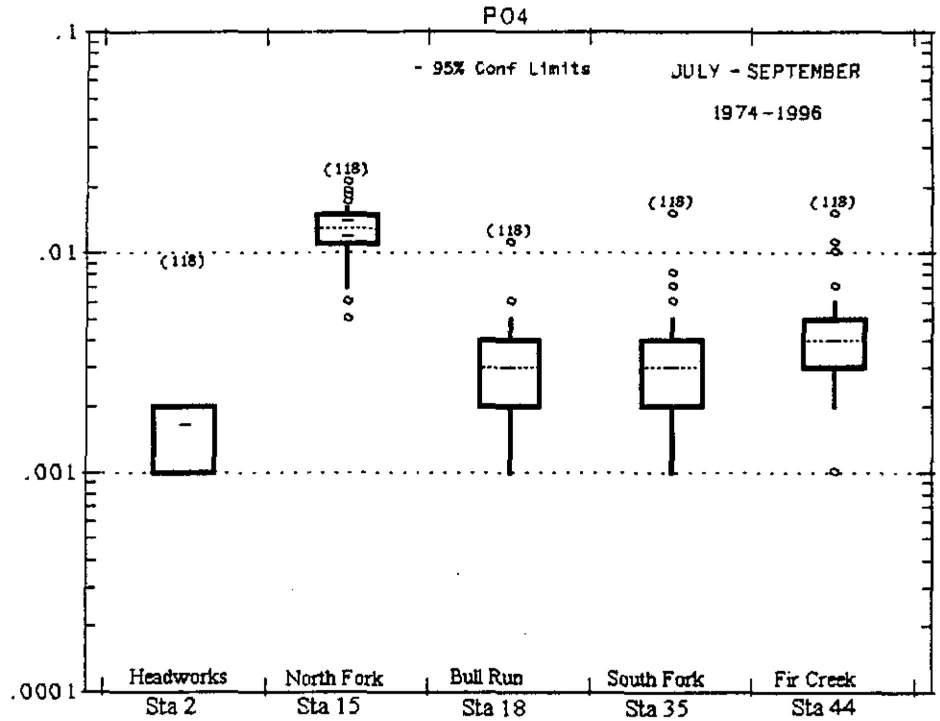


Chart 4-44 -- Phosphorus Levels North Fork and Fir Creek: July-September

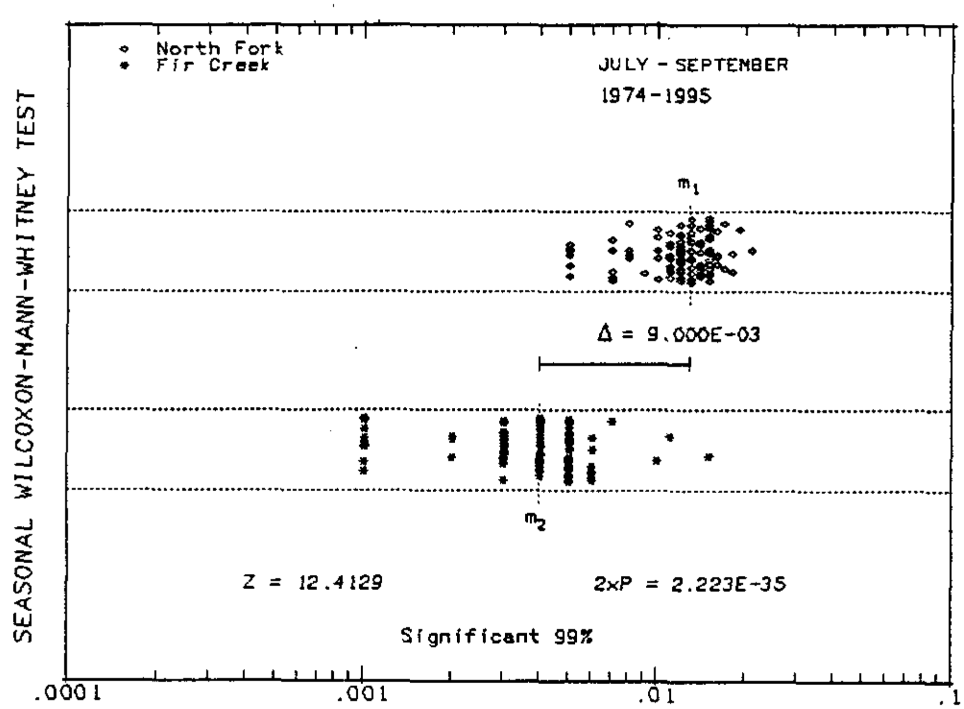
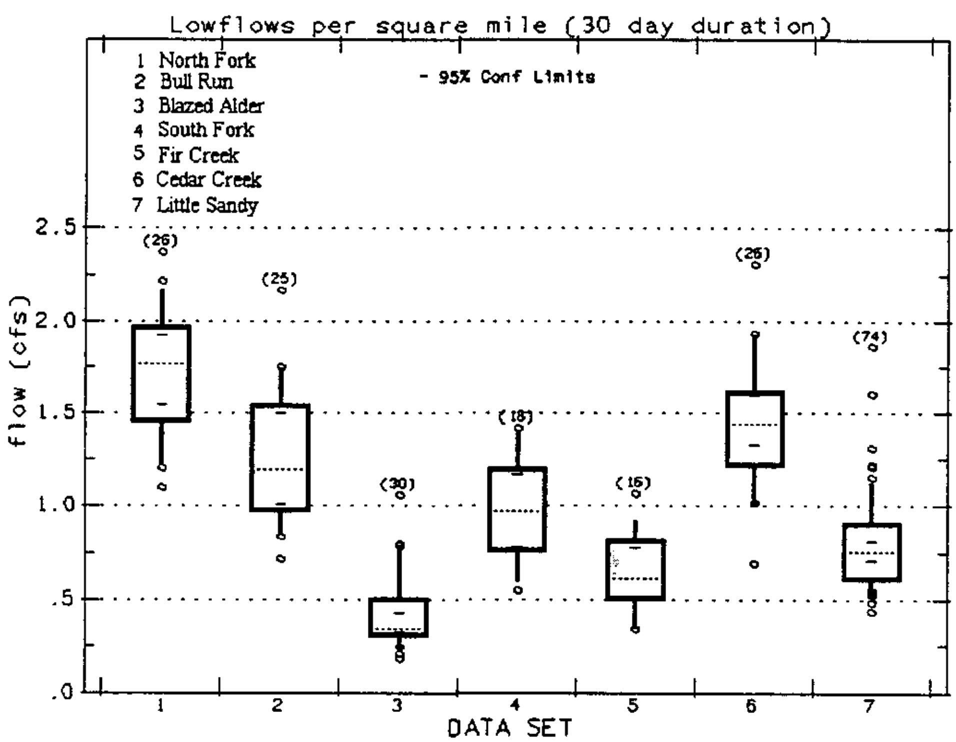


Chart 4-43 illustrates that phosphorus levels differ -- concentrations are higher and variation within season is lower – at the North Fork Key Station. Chart 4-44 demonstrates that this difference is minimal (0.009 mg/l), yet statistically significant. Higher phosphorus levels in the North Fork River have been attributed to the greater influence of groundwater within this subwatershed (1994, AAS).

Particulate inorganic phosphorus is mineral in origin and enters the stream channel primarily by soil erosion and sediment transport. Particulate organic phosphorus comes from a variety of sources and can enter the stream channel through fluvial transport or direct deposition (MacDonald, 1991).

Chart 4-45 – Low Flows per Square Mile



The North Fork was impacted by a 1972 dam-break flood and debris flow which accelerated erosion of unconsolidated and unprotected banks. Effects from this event have persisted in this area for prolonged periods. With low flows that are highest per unit area in the North Fork, and are the potential for erosion associated with the stream channel, a potential exists for increased levels of phosphorus in this area.

This same process appears to have been present in Big Bend Creek. Total phosphorus concentrations were slightly higher (0.002 mg/L) at the station below the disturbed area where a stream channel was impacted by the 1983 blowdown event (1989, AAS).

To prevent eutrophication, where streams enter reservoirs, "total phosphates as phosphorus" should not exceed 0.050 mg/L $^{-1}$ (MacDonald, 1991). ("Total phosphates as phosphorus" refers to the mass of phosphorus atoms per liter; phosphorus atoms represent only 32.6% of the total phosphates per liter.) Maximum levels of ortho-phosphates at North Fork are below 0.03 mg/L $^{-1}$; the monthly median for September is 0.016 mg/L $^{-1}$. Thus, increased trophic levels are not a concern.

Stream Temperature

While stream temperatures vary to some degree by stream Key Station, they are noticeably higher in July and August in both the Bull Run River and South Fork Bull Run River.

Chart 4-46 -- Stream Temperatures

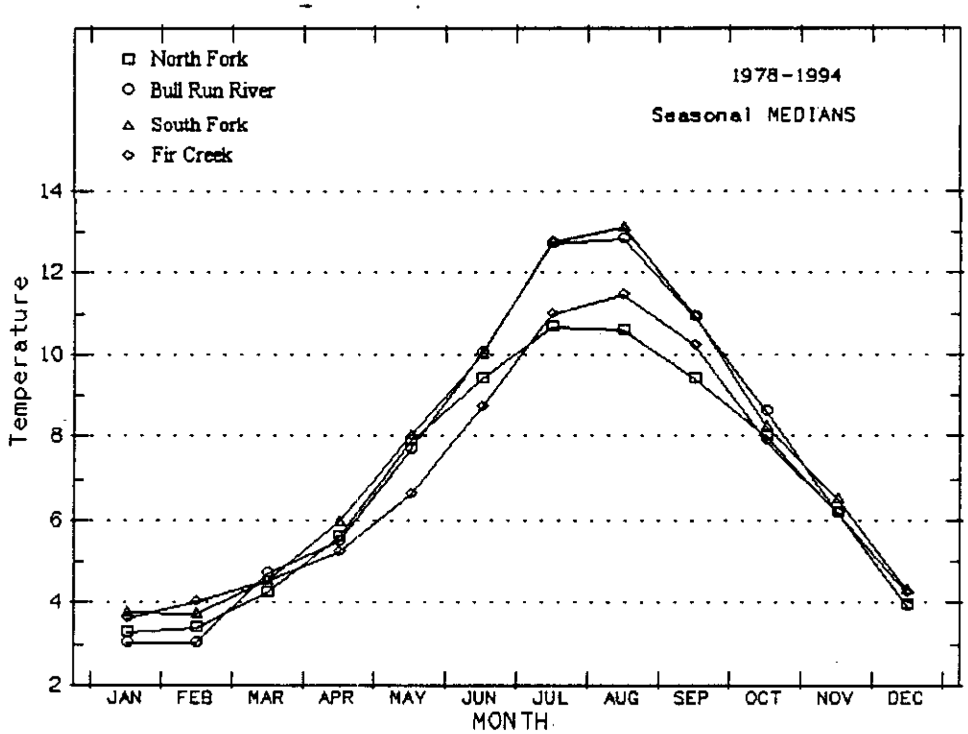


Chart 4-47 further illustrates the higher stream temperatures in the Bull Run and South Fork rivers. Temperatures in these two rivers also have a wider range of variation. The Bull Run River maintains higher maximum temperatures than South Fork.

The July through September mean monthly temperatures from the two rivers were compared to Fir Creek to determine the magnitude and statistical significance of the higher temperatures at these stations.

Chart 4-47 -- Stream Temperatures: Box and Whisker Plot

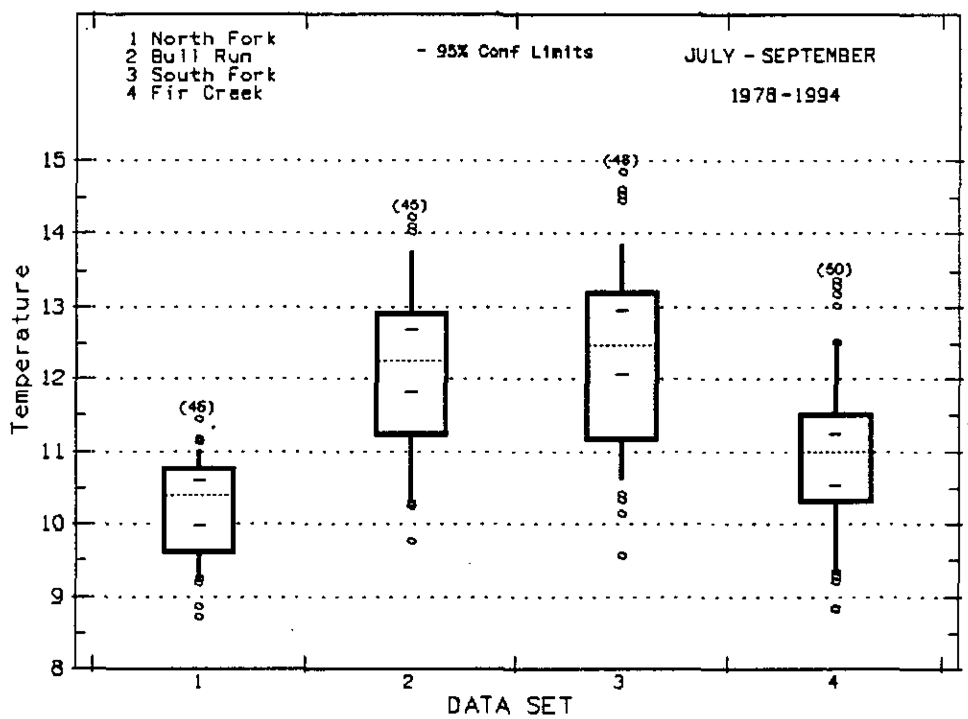


Chart 4-48 -- Bull Run River and Fir Creek Stream Temperatures

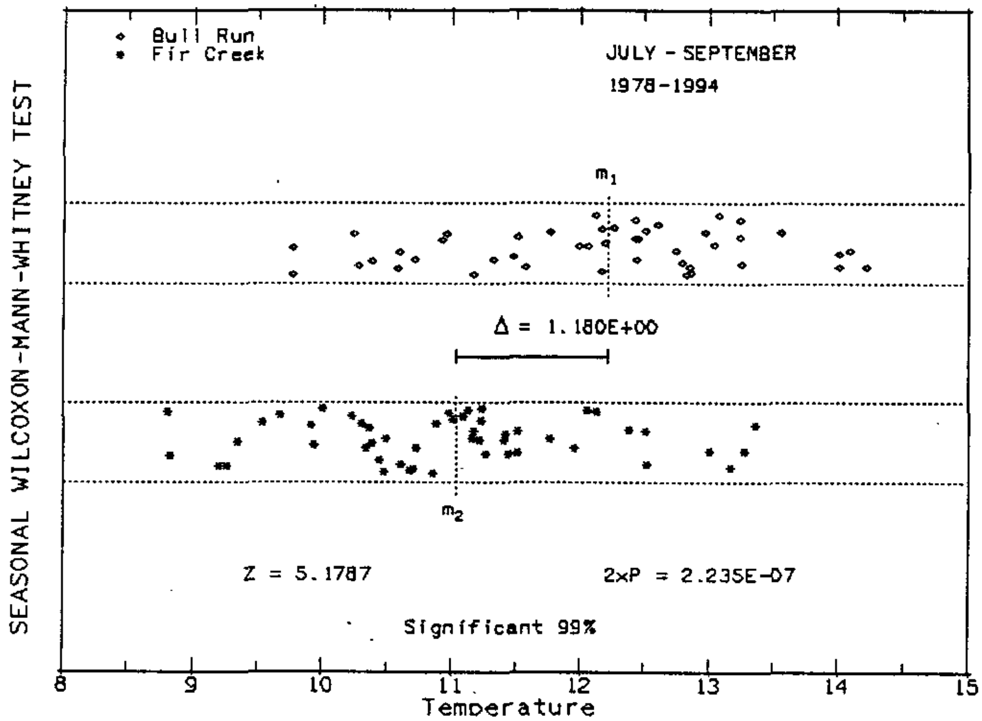
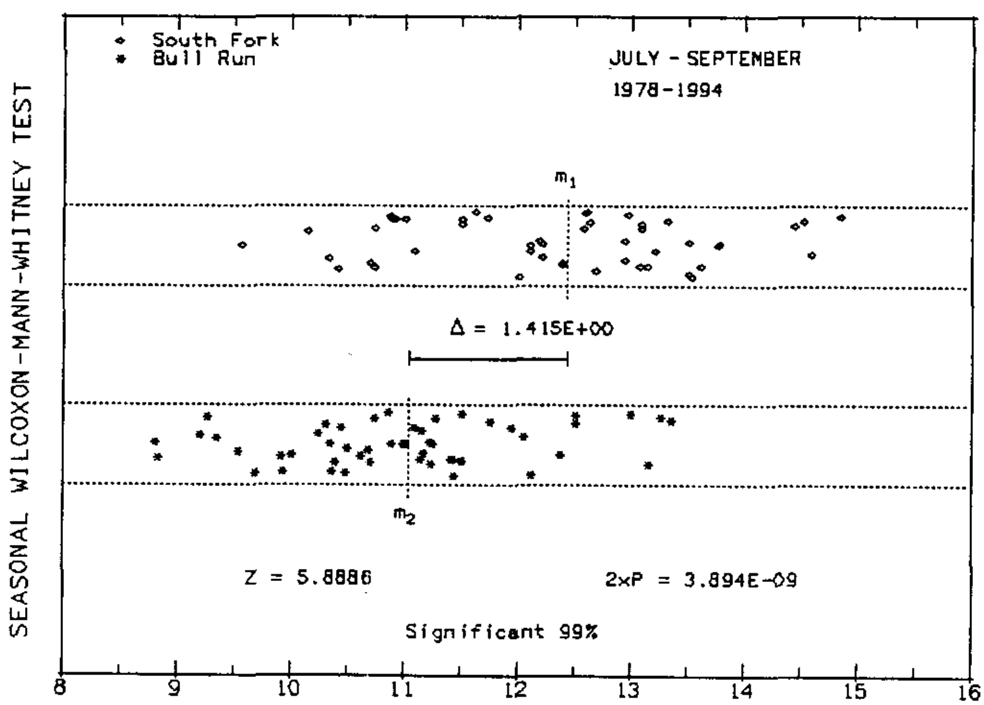


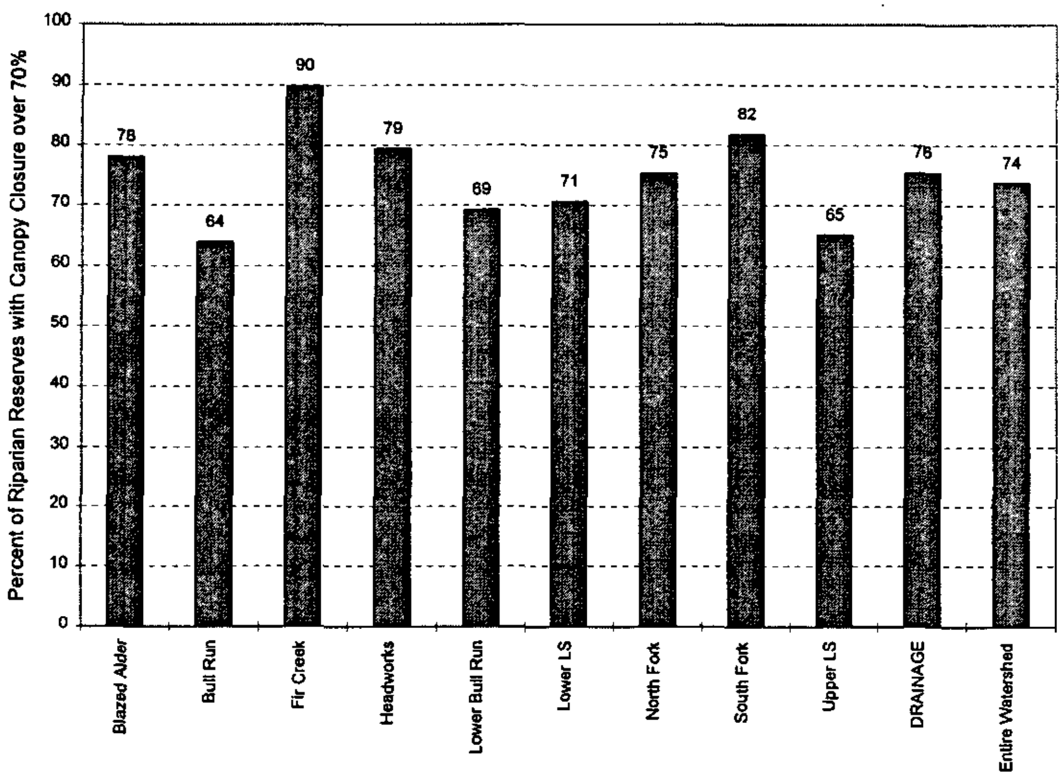
Chart 4-49 -- South Fork and Fir Creek Stream Temperature



Differences between Fir Creek and the Bull Run and South Fork Rivers proved statistically significant and of some practical significance-- over 1^{0}C at both stations, 1.2^{0}C for Bull Run River, and 1.4^{0}C for South Fork River.

Stream shade is one of the primary factors influencing stream temperature. Chart 4-50 displays canopy closure levels within the Riparian Reserves. All the subwatersheds have less area in the 71-100% canopy closure class than Fir Creek.

Chart 4-50 -- Riparian Reserve Canopy Closure



Because all the subwatersheds have less stream shade than Fir Creek (the control basin), daily average stream temperatures were plotted for all the stream Key Stations for the summer of 1992 -- based on canopy closure within the Riparian Reserves. Because of the extreme stream temperatures associated with the low flows and warm air temperatures in 1992, this was used as the reference year (1993 AAS).

Stream temperatures were compared to the State Water Quality Standards (1996 revision). None of the stream Key Stations exceed the absolute numeric criterion (seven day average high of 17.8^{0}C), however all stations but North Fork exceed the absolute numeric criterion for: salmonid spawning, egg incubation, and fry emergence (seven day average high of 12.8^{0}C).

For the majority of the Bull Run Watershed, timing for salmonid spawning would be tied to resident cutthroat and rainbow trout. Rainbow trout, for the most part, spawn from mid-April to late June. When spawning occurs in April or May, fry are usually seen emerging from their nests from mid-June to mid-August (Scott and Crossman, 1973). For the Bull Run Watershed, the period of spawning, egg incubation, and fry emergence is considered to extend from mid-June to mid-September.

The unmanaged (no roads or timber harvest) Fir Creek subbasin has maximum summer stream temperatures (seven-day average) of approximately 15 ^{0}C. This is assumed to approximate the natural condition for this watershed. North Fork River has lower summer stream temperatures -- attributed to the groundwater influence in this area. Both the Bull Run River and South Fork River summer stream temperatures are approximately 2 ^{0}C higher than Fir Creek.

Chart 4-51 -- Stream Temperatures: North Fork

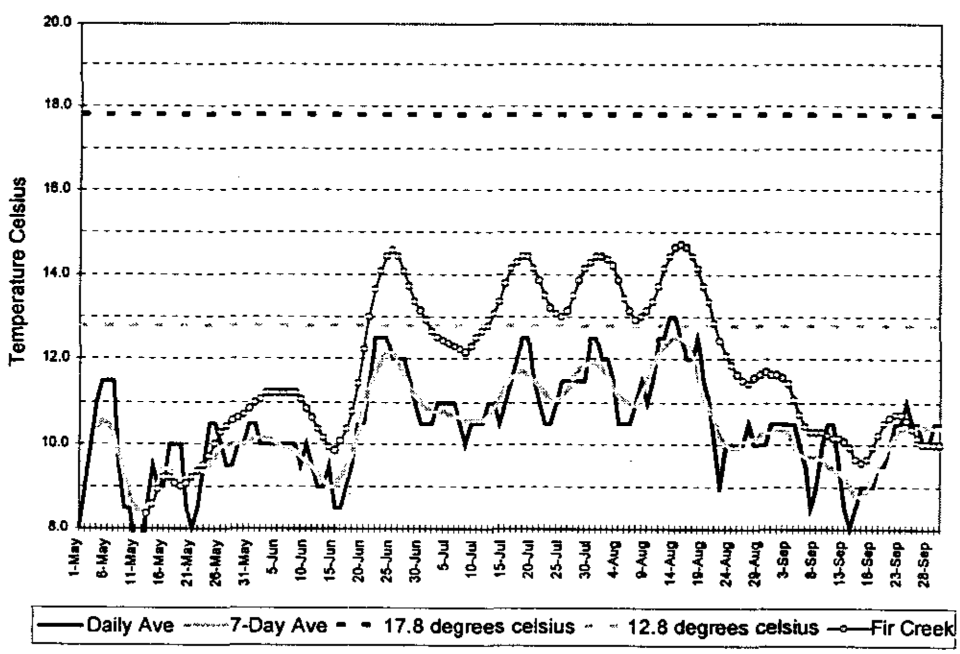


Chart 4-52 -- Stream Temperatures: Bull Run

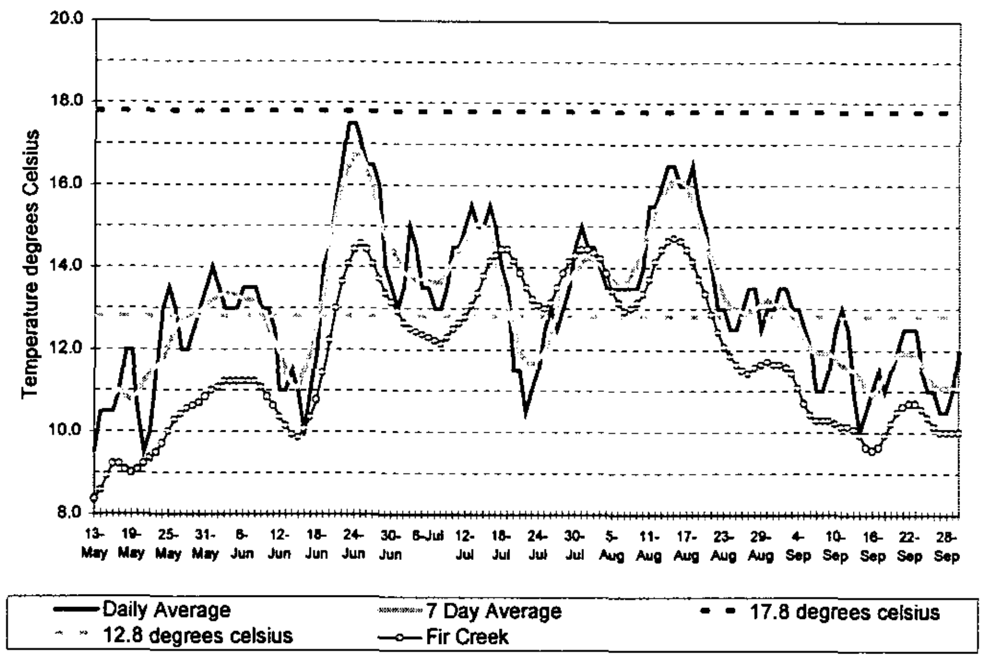


Chart 4-53 -- Stream Temperatures: South Fork

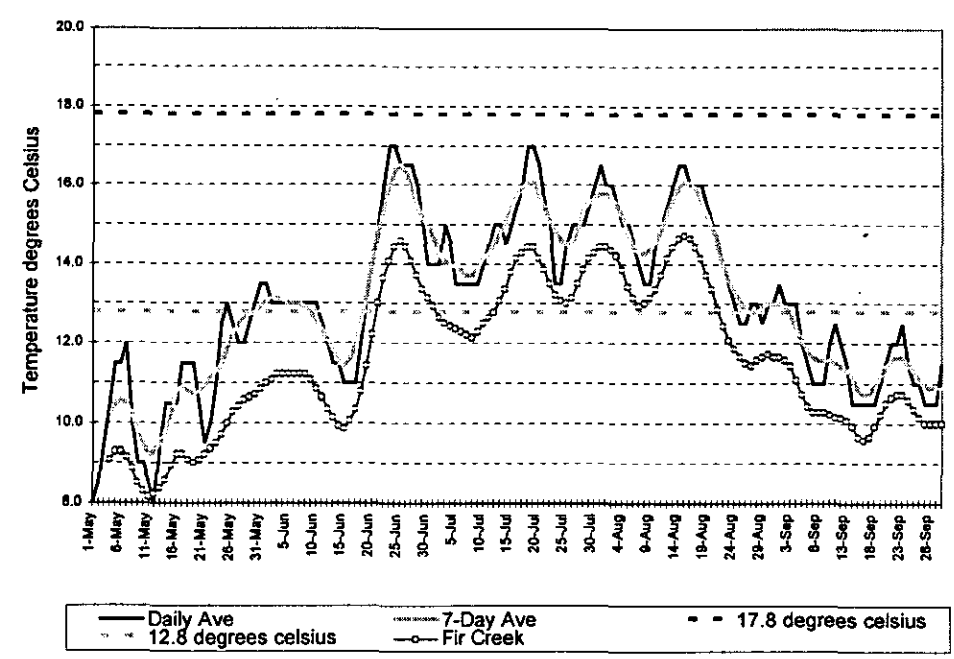
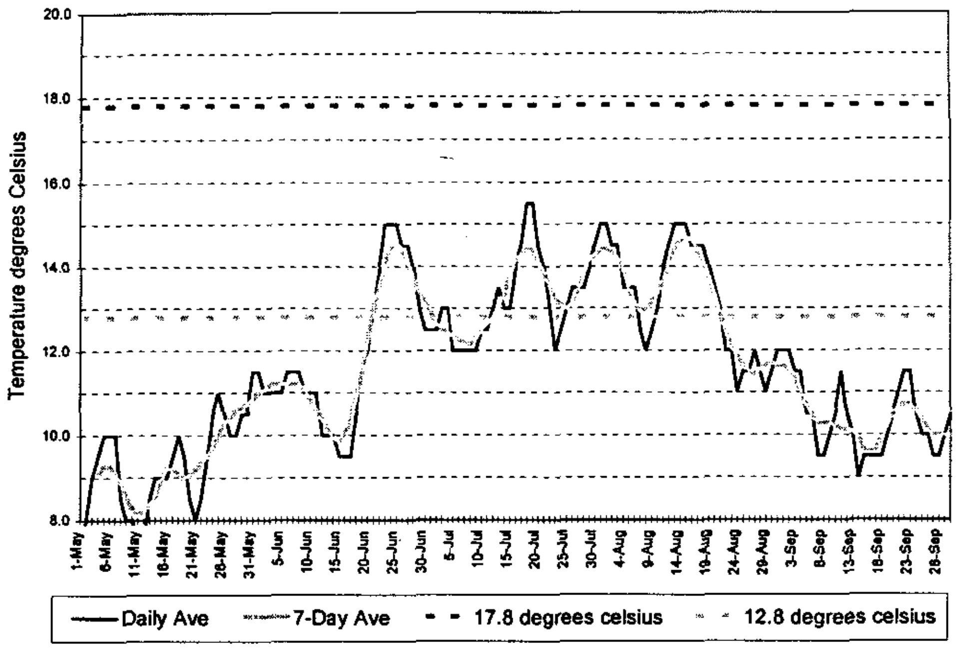


Chart 4-54 -- Stream Temperatures: Fir Creek



Stream temperature can be affected by a number of natural and management factors. Stream orientation, channel geometry, and goundwater influence are natural factors that can influence stream temperatures. Temperature can be affected by management activities that remove stream shade, alter channel structure, or alter the flow regime.

Releases from Bull Run Lake and loss of stream shade associated with the 1983 blowdown event and associated salvage activities may have influenced stream temperatures in the Bull Run River.

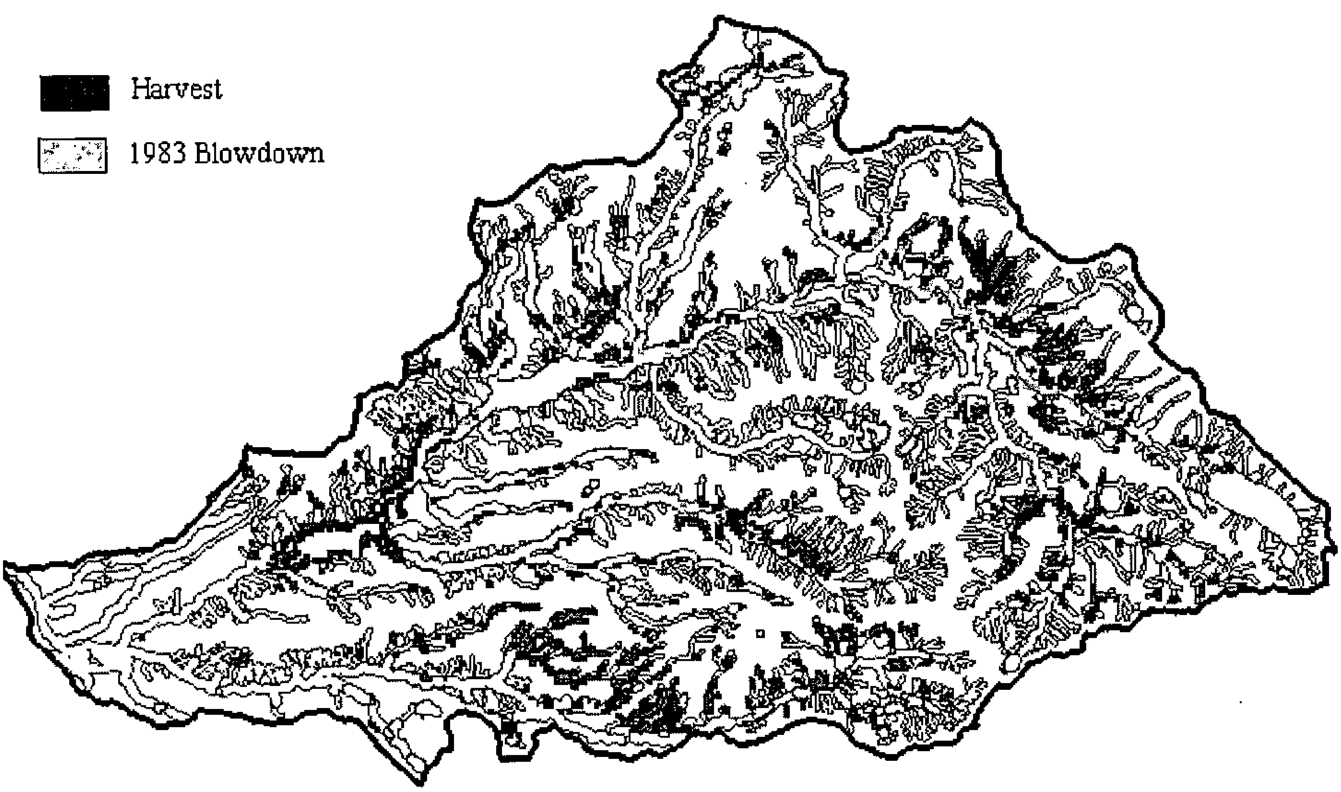
Past releases from Bull Run Lake have increased stream temperatures in the upper Bull Run River by 7^{0}C and in the Bull Run River at the confluence with Blazed Alder by 3^{0}C (PWA Bull Run Lake, 1995). However, based on monitoring results of lake releases from 1985 through 1989 at station 18 past releases of water from Bull Run Lake have decreased stream temperatures at station 18. Although past releases have been shown to increase temperature at the springs below Bull Run Lake, this water is still colder than that of the tributaries to the Bull Run River, and this increased flow of cooler water dilutes and cools the water coming in from the tributaries. The temperature decreases produced no observable effect in Reservoir #1 (BRL EA, 1995). The current management plan for Bull Run Lake releases does not allow for temperature increases at the downstream stations.

Within the Bull Run and Blazed Alder subwatersheds there are 793 acres of unharvested blowdown and 1912 acres of historical timber harvest which equates to approximately 23% of the Riparian Reserves. Stream shade is one of the primary factors influencing the amount of solar radiation intercepted by the stream surface so the openings created by blowdown and timber harvest have the potential to increase stream temperatures.

Table 4-37 -- Harvest and Blowdown in Riparian Reserves

Subwatershed	Acres Harvest	Acres Blowdown But Not Harvested	Total Harvest Plus Blowdown	% of Riparian Reserves Harvested or Blowndown
Blazed Alder	620	161	781	18
Bull Run	1292	632	1924	25
Bull Run and Blazed Alder	1912	793	2705	23
Fir Creek	22	30	52	3
Headworks	1193	269	1462	20
North Fork	262	25	287	14
South Fork	573	77	650	17

Figure 4-35 -- Blowdown and Harvest within Riparian Reserves



South Fork has less timber harvest and blowdown within Riparian Reserves than the Bull Run, Blazed Alder, and Headworks subwatersheds. However, in the mid-1970s a large area along Cedar Creek was clearcut down to the streams for future reservoir construction. (The reservoir was never built and is not referenced in the Regional Water Supply Plan.) Cedar Creek in this area was intercepting 85% of the available solar radiation during July 1990. This contrasts to an undisturbed site immediately downstream that was intercepting 23% of the available solar radiation (Parker, 1990).

Based on aerial photograph interpretation, this area along Cedar Creek exposed to direct solar radiation is at least 2000 feet long. Combined with other openings from timber harvest and blowdown, it would appear the potential exists for increased stream temperatures associated with increased interception of solar radiation. To adequately predict increases in stream temperatures associated with created openings, however, a stream temperature model such as SHADOW (Park, 1993) would be necessary.

It is noteworthy that -- based on seasonal Kendall trends analysis of the monthly mean stream temperature from October 1978 to September 1994 -- a statistically significant trend (increasing or decreasing) for temperature within the South Fork River does not exist. Therefore, there does not appear to be a detectable increase in stream temperatures associated with this subwatershed's 1983 blowdown event.

There is an increasing trend for stream temperature within the Bull Run River. At the current rate of change, however, it would take 15 years to increase stream temperatures 1.0 ^{0}C.

Stream Temperatures: Little Sandy River

Summer stream temperatures have been monitored in the upper Little Sandy River since 1987. In 1992, temperatures exceeded current state water quality standards (1996 revision) for absolute numeric criterion for salmonid spawning, egg incubation, and fry emergence (seven day average of 12.8^{0}C) at both monitoring sites and for absolute numeric criterion (seven day average of 17.8^{0}C) (at the lower monitoring site only). 1992 was used as a reference year because of the high stream temperatures recorded that were associated with low flows and warm air temperatures (1993, AAS).

Chart 4-55 -- Instantaneous Stream Temperatures:Upper Little Sandy River 1992

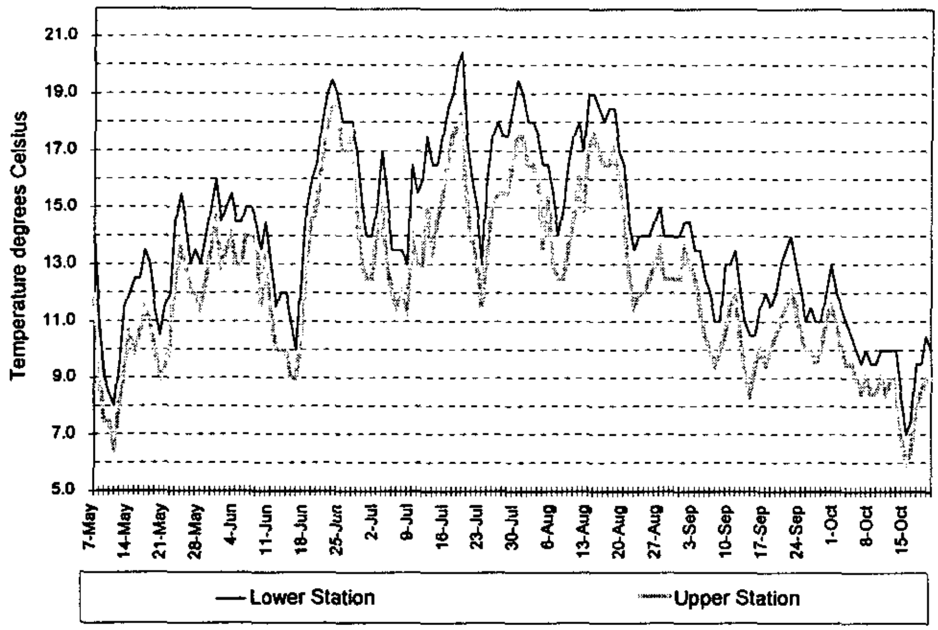


Chart 4-56 -- Stream Temperatures:Little Sandy 7-Day Moving Average 1992

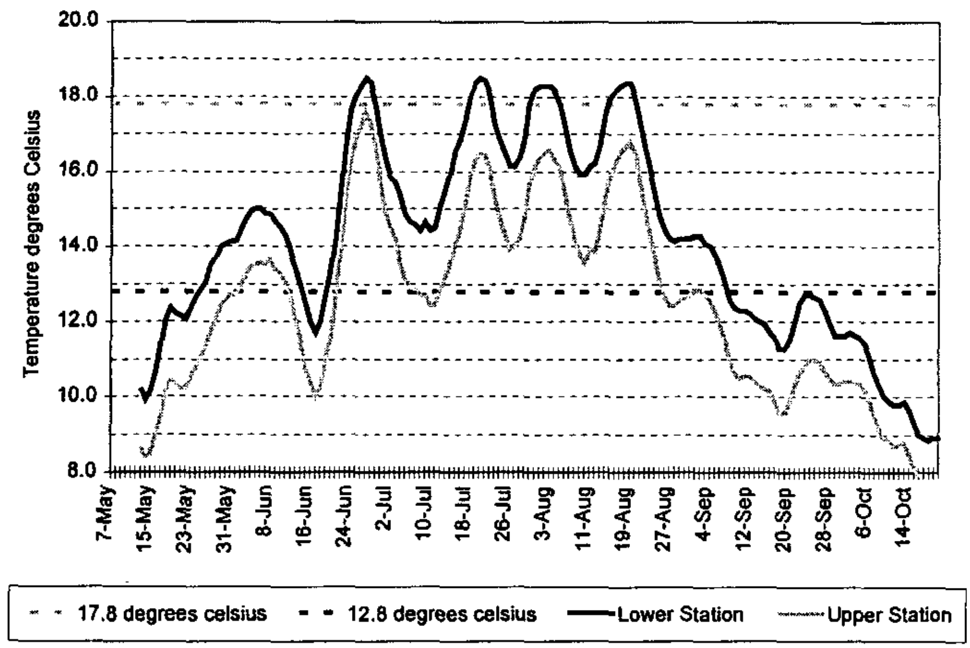
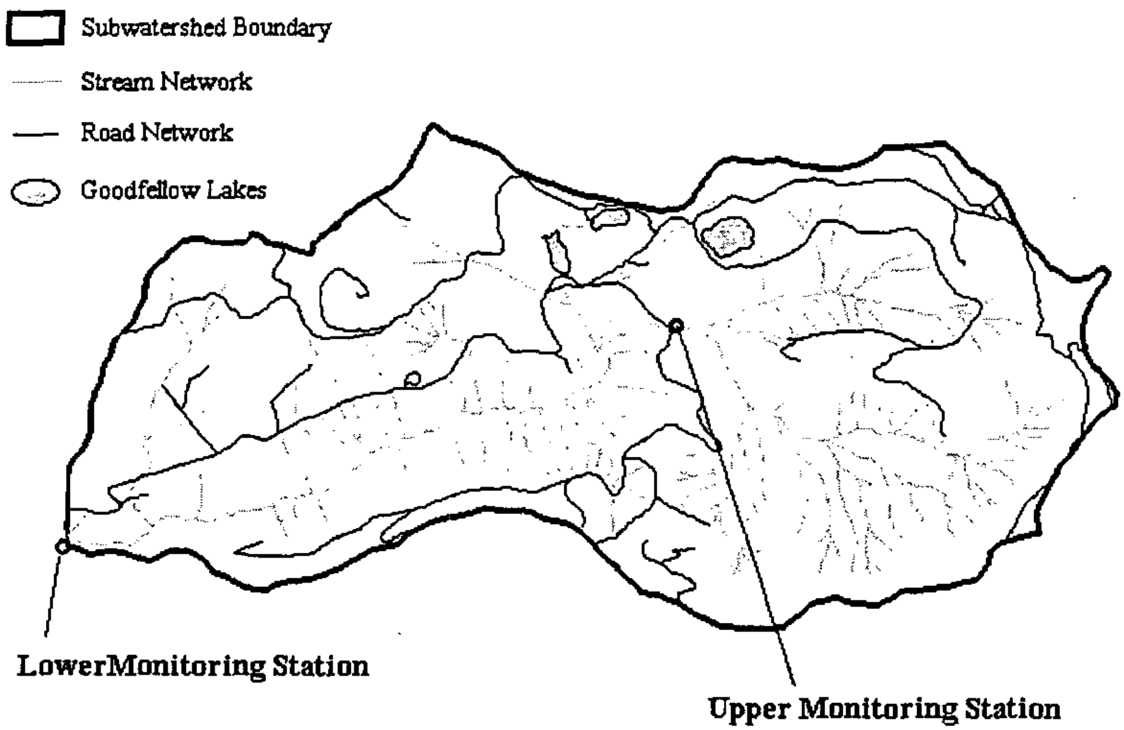


Figure 4-36 -- Upper Little Sandy Subwatershed



Management activities that could potentially influence stream temperature in this area include: created openings associated with timber harvest, and Goodfellow Lakes.

In 1970, a proposal was developed by the City of Portland Water Bureau to expand Goodfellow's west and middle lakes for water storage. Large areas surrounding the west and middle lakes were clearcut in 1973, at which time the middle lake's area was enlarged.

These lakes and associated impoundments are very shallow with created openings -- associated with planned reservoirs -- located around their edges that expose these areas to solar radiation with the potential to raise stream temperatures.

Figure 4-37 -- Goodfellow Lakes 1972

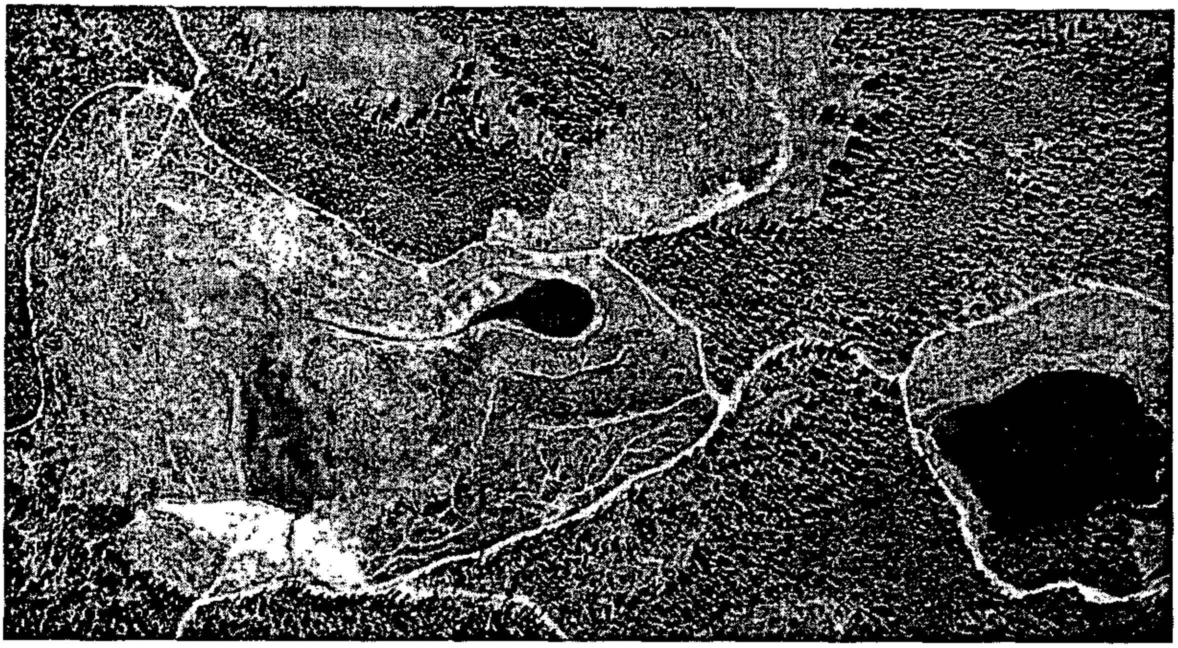


Figure 4-38 -- Goodfellow Lakes 1995

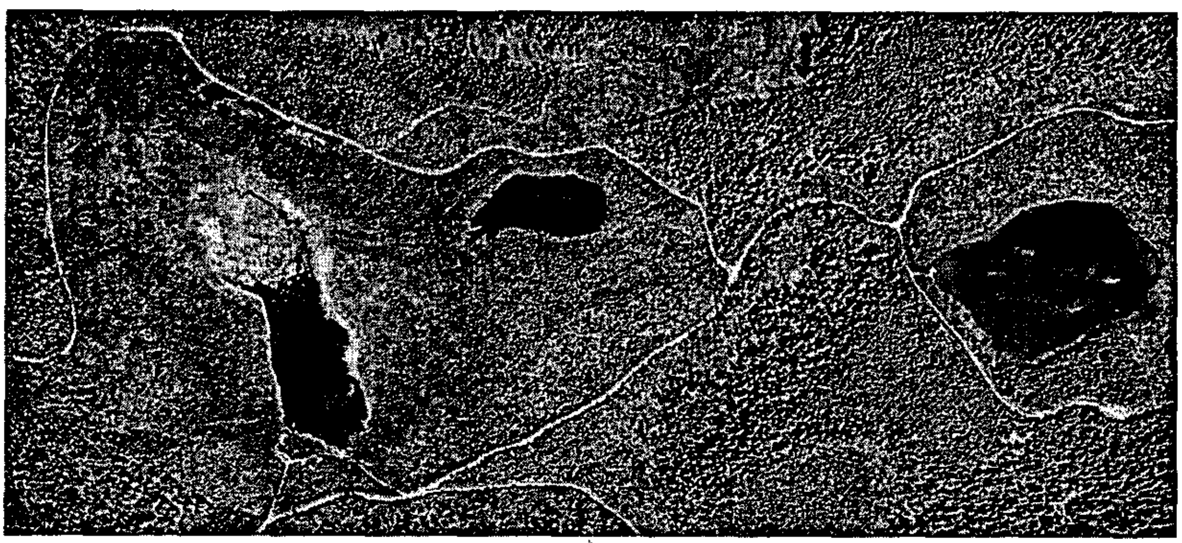
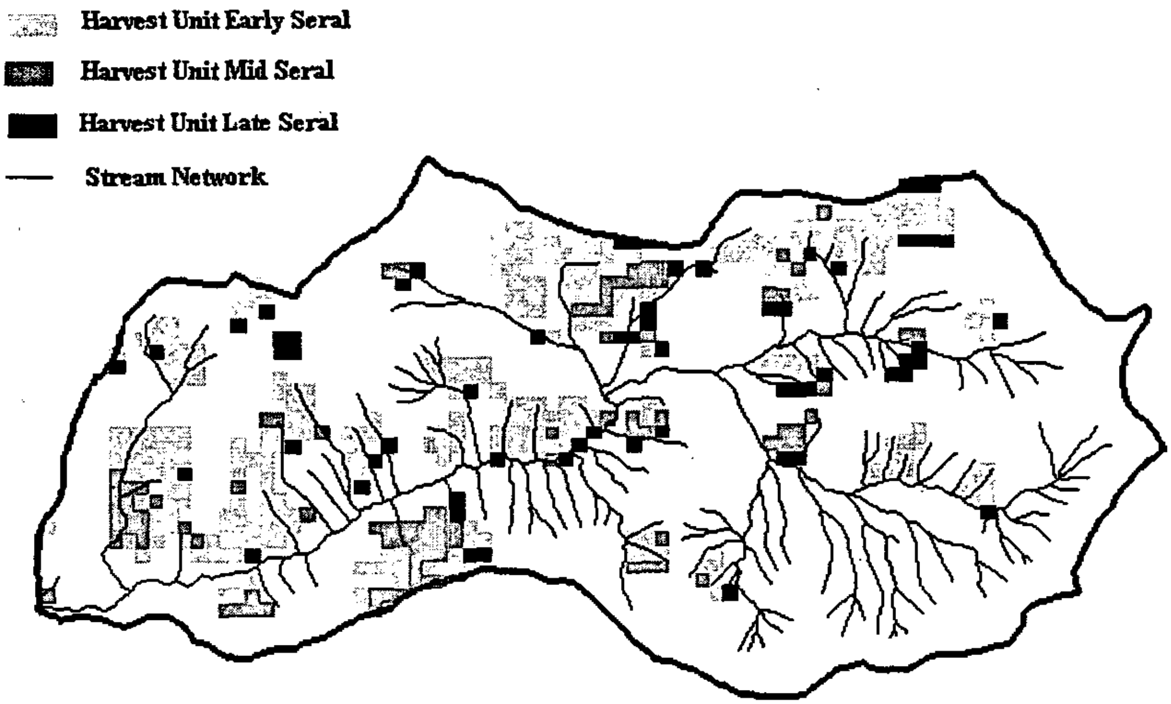


Figure 4-39 -- Harvest Activity with Current Seral Stage Upper Little Sandy Subwatershed



The other major management factor influencing stream shade is timber harvest. As Figure 4-39 illustrates, some harvest activity has occurred adjacent to the Little Sandy and its tributaries in early-seral stands. A result: the potential for increased interception of solar radiation and associated increases in stream temperature.

Stream survey data on stand structure within the floodplain was examined from the 1989 stream survey of the upper Little Sandy River to quantify vegetation structure adjacent to the Little Sandy River.

Table 4-38 -- Vegetation Structure Upper Little Sandy River

Stand Structure	% of Total
Grass/Forb	2
Shrub/Seedling (2-5 feet high)	6
Shrub/Seedling (5-10 feet high)	12
Shrub/Seedling (>10 feet high)	4
Hardwoods	55
Mature Stand	22

Table 4-38 illustrates that 24% of the upper Little Sandy River's surveyed stream length, in the grass/forb or shrub/seedling stage, appears to have been influenced by timber harvest. Table 4-38 also reveals that a large percentage of the area along the upper Little Sandy River is comprised of hardwoods. Examination of low elevation photos at the scale of 1:4000 (inch equals 333 feet), shows large natural openings associated with talus slopes along the upper Little Sandy River. Within these openings, the potential exists for increased solar radiation interception and associated increased in stream temperatures.

Examining the canopy closure data within the Riparian Reserves from the ISAT database: 65% of the Riparian Reserves have over 70% canopy closure, and only 7% of the area shows less than 40% canopy closure. However, due to the 100 meter pixel size which does not appear to have the resolution required to assess stream shade, it appears stream shade doesn't respond well to queries from the ISAT database.

A number of natural and management influences on stream temperature have been identified. While these factors were not quantified in this analysis, it would be possible to quantify them with a stream temperature model such as SHADOW (Park, 1993).

Even though no stream temperature data exists for the Little Sandy River's lower section, stream temperatures are of concern in this area due to: increased stream temperatures in the Little Sandy's upper portion, the lack of additional sources of cool water to dilute and cool the lower Little Sandy's waters, and management influences in vegetation adjacent to the Little Sandy and its tributaries.

The Lower Little Sandy subwatershed has the highest percentage of timber harvest within Riparian Reserves on federal ownership (29%) of any of the Bull Run Watershed's subwatersheds. Canopy closure levels within this subwatershed also appear to be low. In addition, percent of the riparian area in the 71-100% canopy closure class is well below that of an unmanaged watershed. (70% in Lower Little Sandy subwatershed compared to 90% in Fir Creek subwatershed.)

Conclusions: Water Quality

By any objective standard, the water quality of the Bull Run Watershed's streams can only be described as extraordinary. From the earliest days of using the basin as Portland's water supply, its purity has been lauded. At present, chemical measurement of dissolved species in the water require the utmost in analytical skill because of the minimal amounts of their concentrations – generally at or near the limits of detection for accepted analytical methodologies (Aumen, Hawkins and Grizzard, 1989).

Although the minor ions in the watershed are derived largely from atmospheric deposition, approximately 90% of the solutes in the reservoirs originate from ... reactions in the watershed. This finding highlights the importance of both natural processes and, to a lesser extent, anthropogenic activities in controlling surface water chemistry in Bull Run Watershed (Eilers et al 1994).

- Stream temperatures appear to be higher than the current state water quality standards in the Upper Little Sandy River. This is attributed to Goodfellow Lakes, unvegetated talus, and harvest activities.
- Stream temperatures are slightly higher in the Bull Run and South Fork[14] rivers during the period of July-September than in Fir Creek.
- Levels of turbidity and suspended sediment are higher in the reservoirs (as measured at station 2) than in the stream key stations[15]. This is attributed to:
    1. A weekly sampling schedule for the stream key stations that did not effectively measure ephemeral turbidity increases during storms.
    2. Erosion of reservoir shorelines and deltas at extremely low reservoir pool levels.

[14] For the period of July-September stream temperatures are 1.2^{0}C higher in the Bull Run River and 1.4^{0}C higher in the South Fork than Fir Creek.

[15] For the period of July-September turbidity levels are 0.22 NTU's higher at headworks than Fir Creek and for the period of July-October suspended sediment levels are 0.3 mg/L higher at headworks than Fir Creek.

- Based on the Seasonal Kendall Trends Test there statistically significant (P-level less than 0.10) trends for turbidity, suspended solids, nitrogen, and stream temperature, ***however, the magnitude of the trends are less than the laboratoy detection limit and cannot be measured on an annual basis.***

- Nitrate nitrogen levels are higher in Fir Creek than the other stream key stations[16]. This is attributed to smaller watershed size.

---

[16] For the period of July-September nitrate nitrogen concentrations are from 0.023 to 0.030 mg/L higher in Fir Creek than the other stream key stations.

Fisheries and Key Aquatic Macroinvertebrates

Introduction

The Mt. Hood National Forest uses salmonids (salmon, trout and char) as management indicator species for aquatic habitats. Because of their value as game fish and their sensitivity to habitat changes and water quality degradation, salmonids have been selected to monitor trends within Mt. Hood National Forest's streams and lakes.

Although other fish species are present in the watershed, (sculpins and dace, for example), population trends are unknown. Because more information exists on salmonids, this group serves as a more optimum choice for monitoring aquatic environments.

The Bull Run Watershed supports both anadromous (sea-run forms) and resident species of salmonids. Within these species are distinct stocks, some native to the Sandy Basin and some introduced. Native stocks, as defined in this analysis, are those stocks found historically in the Sandy River Subbasin that have maintained a high degree of genetic integrity and have little genetic influence from other introduced stocks. The native stocks are uniquely adapted to the special conditions found within the Bull Run River and its tributaries.

Wild spawners originated from hatchery stocks, have persisted and now produce generations of young. Hatchery stocks are defined as first generation fish outplanted from hatchery facilities.

Current fish distribution within the Bull Run Watershed is displayed in Figure 4-40. This information is from the Mt. Hood National Forest streams layer. The information for this map was compiled by fisheries biologists across the forest. Information used to determine fish species presence or absence includes stream inventory data, Oregon Department of Fish and Wildlife records, documentation from other agencies, tribes, or archived literature, and personal communications with other agencies and tribes (Streams coverage data dictionary).

Figure 4-40 includes presence or absence codes present, suspected, and potential. The definations for these codes are:

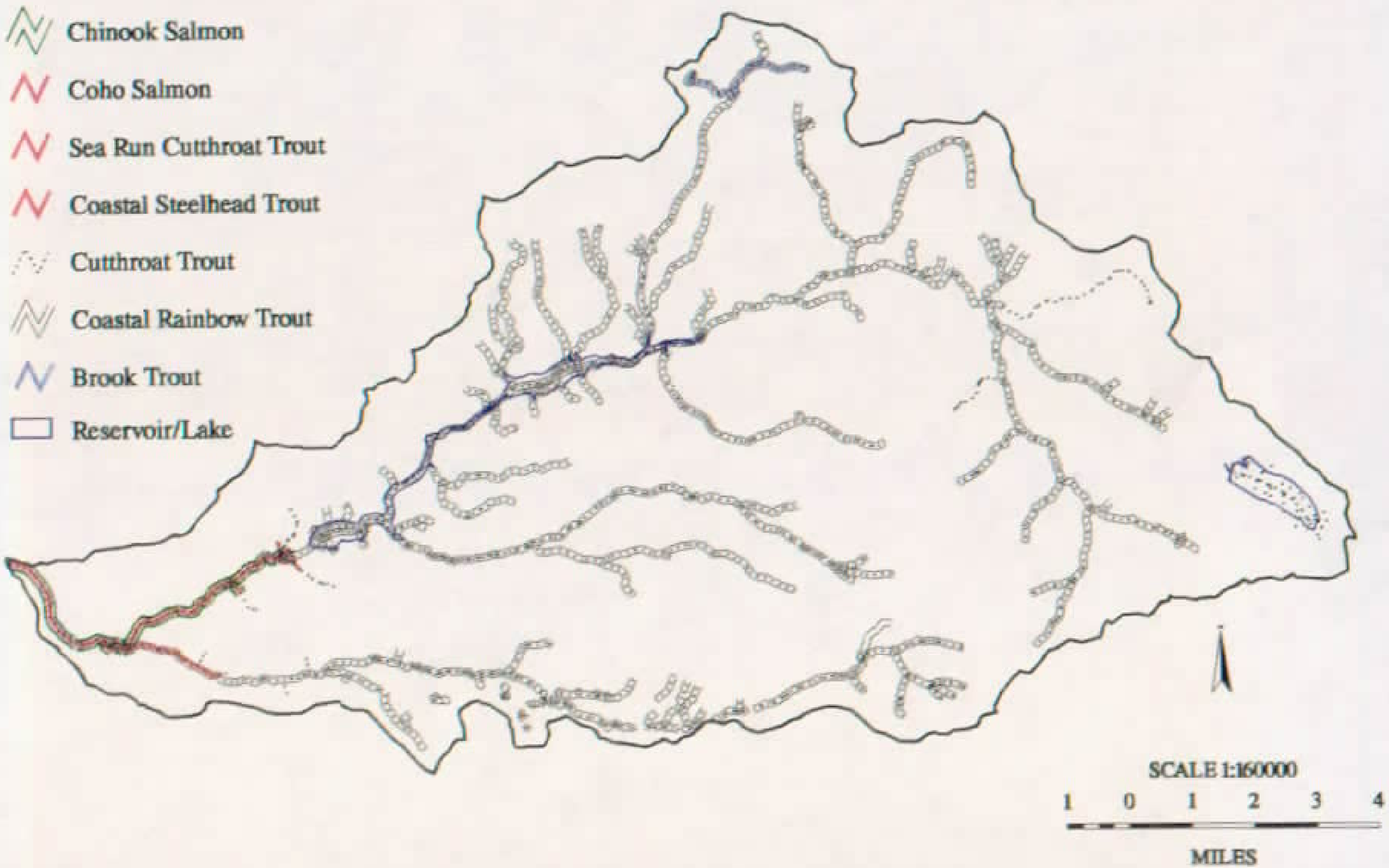
- Present - Species using habitats (spawning, rearing, or migratory routes) within given stream reach as documented by snorkeling surveys, visual surveys , historical records, electrofishing, and other methods.

- Unknown but suspected - Fish biologists have reason to believe that fish habitat and fish may exist within these stream sections but stream surveys have not be conducted nor has the fish use been otherwise documented.

- Potential - This category refers to stream segments that were historically occupied by the species of interest, are not currently occupied, and have reasonable potential for future occupancy following restoration or alteration of management practices. Definitions of historical range may be a judgement call based on knowledge of natural migration barriers, sinces written or oral records may not indicate past use.

More detailed information for individual species presence (including maps detailing each presence or absence code) is presented with the summary of that species.

Bull Run Watershed
Fish Distribution by Species



Historical Trends -- Sandy Subbasin

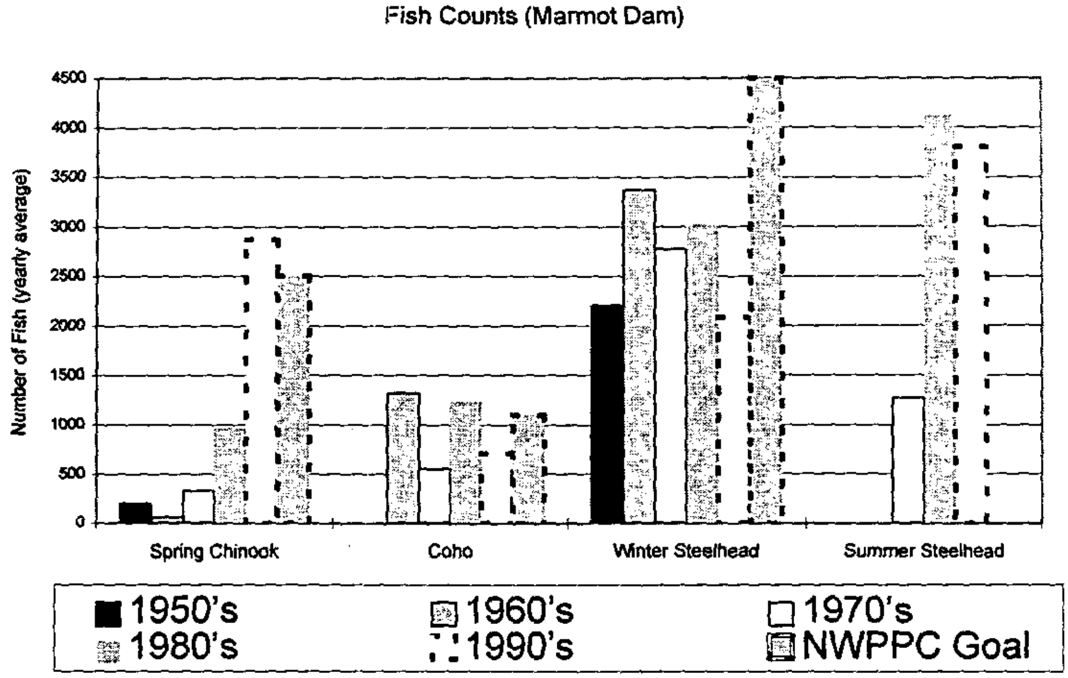
Population information specific to the Bull Run watershed is limited. For this reason fish population data from sources in the upper Sandy basin have been used to assess historical trends. Information from Salmon River and Still Creek are used as indicators of conditions in the Upper Sandy Subbasin(which includes Bull Run, Upper Sandy, Zigzag, and Salmon River watersheds). Salmon and steelhead counts passing into the upper Sandy Basin appear to be greatly reduced from the levels present before the 1850s. Scant information is available on historical run size, but comparisons of records from an old hatchery within the Salmon River Watershed, along with recent spawning surveys in the Salmon and Zigzag watersheds, indicate that current spawning returns are only 10-25% of 1890s' levels (which were already reduced by decades of heavy fishing on the Columbia River).

Recent returns to the upper Sandy Basin (counts at Marmot Dam) illustrate these recent trends in returns. To indicate the drastic relative change in fish numbers in upper Sandy tributaries from 1890-1950, historical Salmon River hatchery records are also included. (Note: historical data is extrapolated.)

Information sources for this fish stock discussion include: Oregon Department of Fish and Wildlife's (ODFW) *Sandy River Subbasin Salmon and Steelhead Plan*, (1990); draft Sandy River Subbasin Fish Management Plan sections (1995/96); Portland General Electric's (PGE) *Hydroelectric Development and Fisheries Resources on the Clackamas, Sandy and Deschutes Rivers*, (1995); Mt. Hood National Forest habitat and population inventories; NWPPC and Biennial Report on the Status of Wild Fish in Oregon (ODFW, 1995).

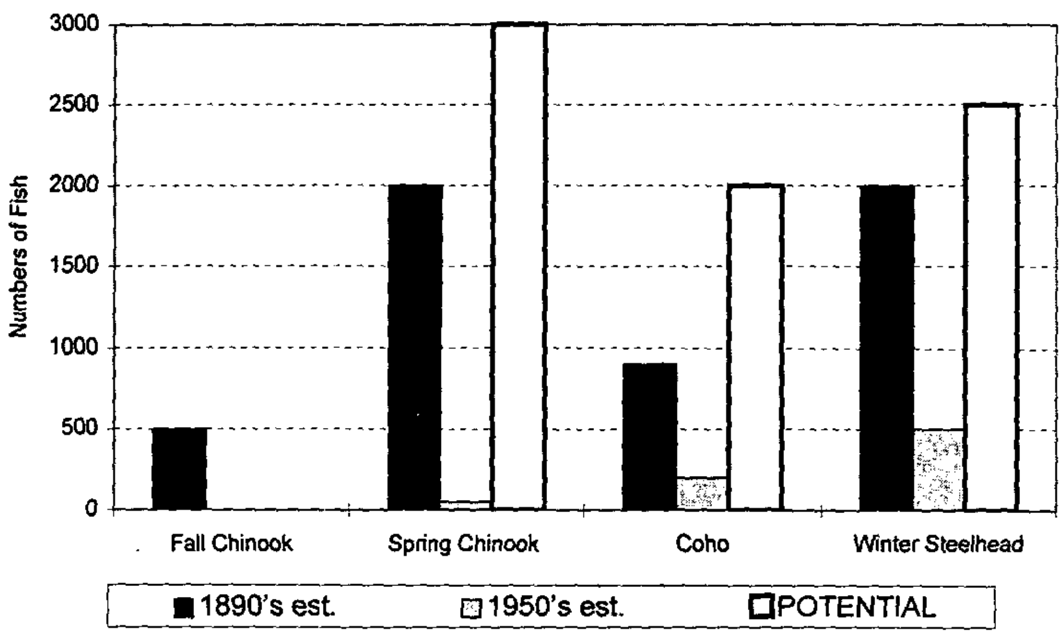
Trends for counts at Marmot Dam from the 1950's to present and escapement goals for anadromous salmonid species in the Upper Sandy River are displayed in Chart 0-2. Chart 0-2 does not represent the time period prior to the 1950's. Impacts had already occurred by 1950. Chart 0-3 presents estimated population and potential for the Salmon River and includes estimates from the 1890's. The information suggests that current anadromous fish production in the Salmon River (which could be used as an index for the upper Sandy) is substantially less than the historic production. Chart 0-3 also indicates that current production is below potential.

Chart 4-41 -- Fish Counts and Existing Escapement Goals, Upper Sandy River



NWPPC-Northwest Power Planning Council

Figure 4-42 – Estimated Population and Potential, Salmon River (Mattson, 1955)



Historical trends in anadromous fish numbers are, in a large part, related to the history of dams within the Sandy Subbasin. Hydropower development in the Sandy Subbasin began in the early 1900s. Construction of the Little Sandy Diversion Dam began in 1906 and was in operation by 1912 (Figure 4-43).

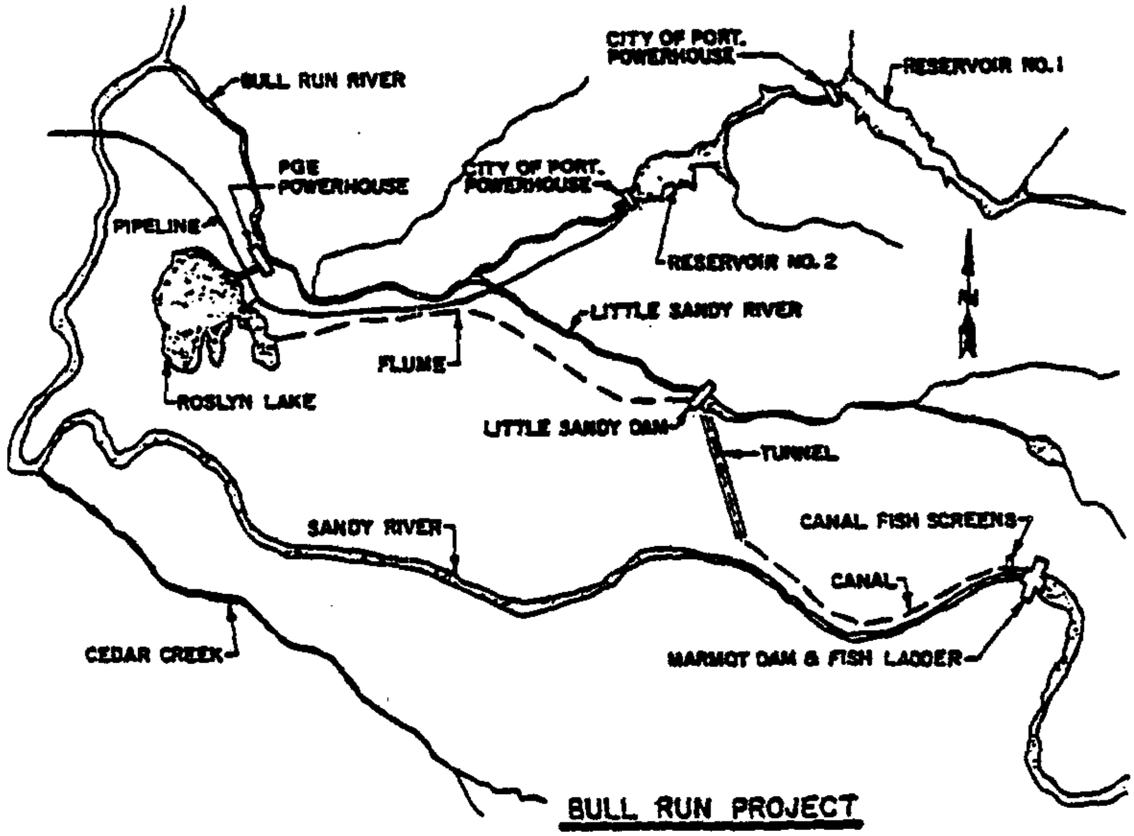
There has been an operating fish ladder in service on the Sandy River since Marmot Dam's construction in 1912 (PGE, 1995). In its early years of operation, the Marmot Dam fish ladder was used as a trap to obtain adults for egg-taking. For an extended number of years, apparently few fish, if any, were allowed to proceed upstream to spawn naturally (Exhibit S - Project No. 477, Bull Run Project). Problems with fish passage with the fish ladder at Marmot Dam were documented as late as 1970 (Oregon State Game Commission, 1970).

The diversion canal at Marmot Dam was unscreened from 1912-1951. During this period, much of the smolt production was diverted and killed by the Bull Run power generating facilities. In 1951, the diversion at Marmot Dam was screened to prevent smolt mortality associated with hydropower generation.

There were no minimum streamflow requirements for the Sandy River below Marmot dam until 1972. Through 1973, water withdrawal associated with hydropower developments on the Sandy River de-watered long reaches of the river below Marmot Dam. In 1974 minimum flows were established on the Sandy River below Marmot Dam to provide fish passage and increase rearing areas (PGE 1995).

Anadromous fish passage on the Bull Run River was blocked in 1921 by a 40 foot headworks diversion dam at River Mile 6.2 (personal communication, Dick Robbins, City of Portland, May, 1996). Dam 1 was constructed in 1929 and Dam 2 was built just above the headworks dam in 1962.

Figure 4-43 – Dams Upper Sandy Subbasin



Fish Distribution and Habitat

Fish distribution and miles of available habitat in the Upper Sandy Subbasin and the Bull Run Watershed are summarized in the following pages. The miles of habitat summarized in these figures and the table are estimates to be used for comparison purposes only. These estimates are not complete because the portion of the Sandy River between the Bull Run River and Cedar Creek is not accounted for in the database and there is the potential for fish presence on streams that were not surveyed.

Available historical habitat was assessed by calculating stream miles accessable to anadromous fish below falls assumed to be barriers to fish passage. Although fish habitat may have been available, actual use is unknown.

Figure 4-44 -- Historical Habitat Available to Anadromous Fish Passage - Bull Run Watershed

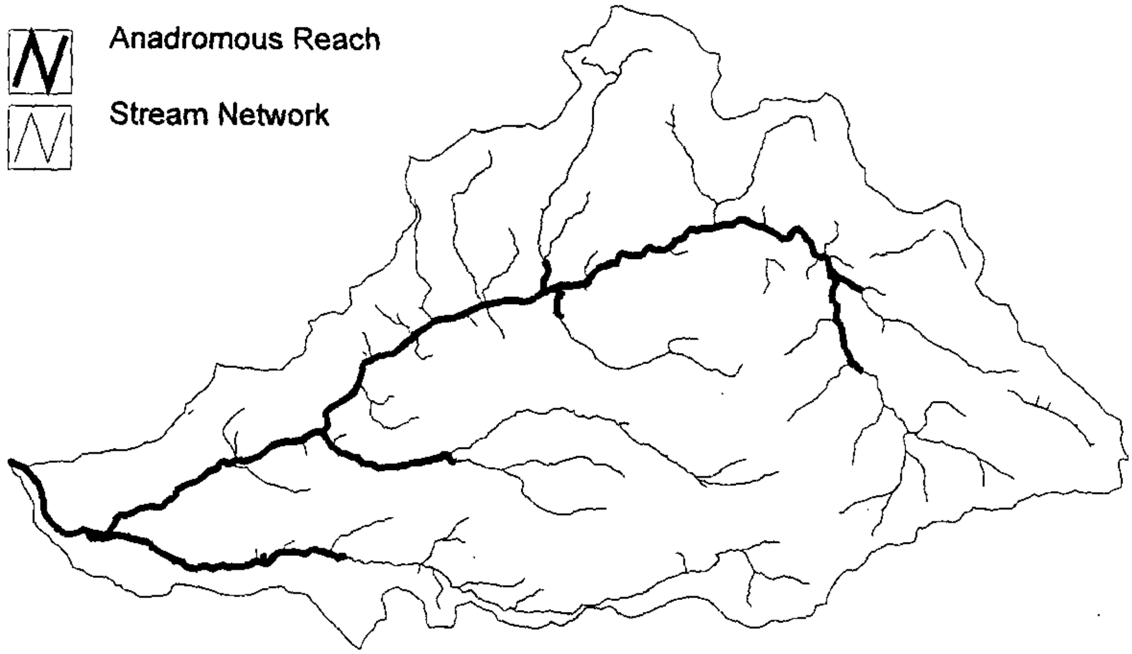


Figure 4-45 -- Anadromous Fish Distribution 1921-Present - Bull Run Watershed

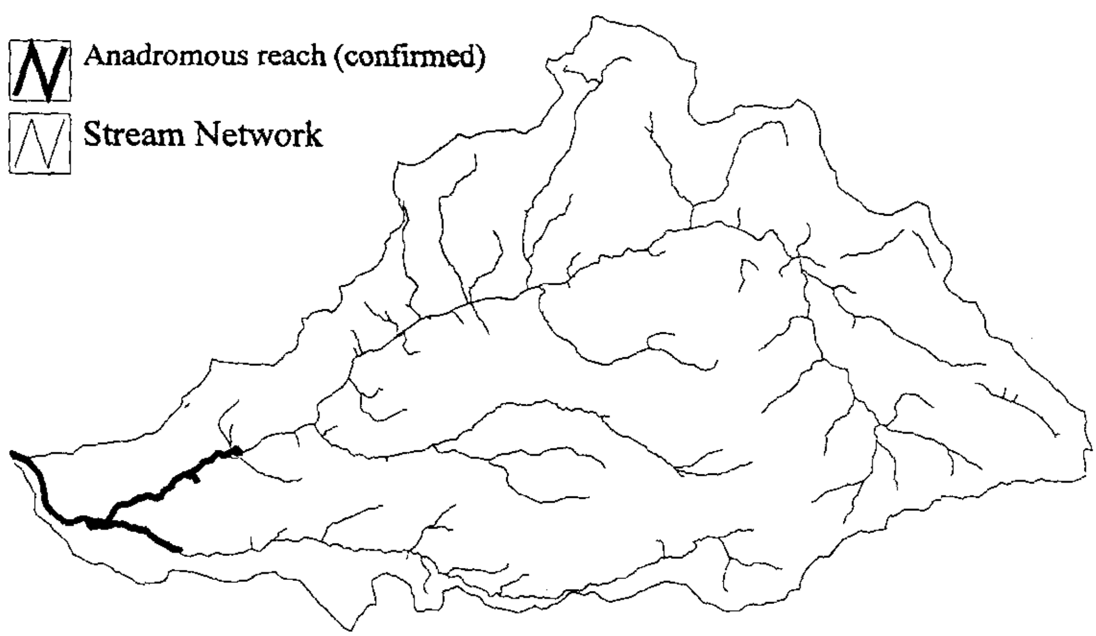


Table 4-39 -- Miles of Anadromous Fish Habitat Upper Sandy Basin

Period	Miles of Available Anadromous Habitat Upper Sandy Subbasin[17]	Miles of Available Anadromous Habitat Bull Run Watershed[18]	Percent of Historical Habitat Available in the Upper Sandy Subbasin	Percent of Sandy River Basin Habitat Available in the Bull Run Watershed
Prior to 1912	167.4	40.2	100	24
1912-1921	44.0	40.2	26	91
1921-1951	11.5	7.7	7	67
1951-Present	135.3	7.7	81	6

Mile of historical habibat were based on summaries completed by the Oregon Department of Fish and Wildlife that are summarized below.

Miles presently available below dams:

Bull Run mainstem	6.0 miles
Little Sandy River	1.7 miles
Total	7.7 miles

Historical Miles above dams

Bull Run mainstem	15.0 miles
Tributaries to Bull Run above dams	11.0 miles
Little Sandy River	6.5 miles
Total	32.5

Summing the miles of habitat below the dams with the miles of habitat above the dams gives a total of 40.2 miles of historical habitat available.

Prior to 1912, the Bull Run watershed provided 24 percent of the total anadromous fish habitat by miles of stream in the Sandy River basin. Between 1912 and 1951, the Bull Run watershed was a major contributor to total anadromous fish production for the entire Sandy Basin.

[17] Based GIS streams coverage (PSTMTH)
[18] From Oregon Department of Fish and Wildlife

During this period, few adults were allowed to escape upstream from Marmot dam and the diversion canal was unscreened, causing smolts to pass through the PGE turbines. Also, a large section of the Sandy River was dewatered below Marmot dam. Currently, the Bull Run watershed provides 7 percent of the total habitat in miles available to anadromous fish in the Sandy River basin. Twenty-two percent of the historical habitat for anadromous fisheries in the Bull Run Watershed is currently available.

Table 4-40 -- Habitat affected or disconnected by municipal water supply and hydropower development in the Bull Run River (Whitt 1975, Collins 1974, USFS Stream Surveys).

From	To	River Miles	Comments/Fish Related Concerns
Confluence Sandy River	PGE Powerhouse	0.0-1.5	Temperature and turbidity changes associated with diverted Sandy River water Periodic flow fluctuations due to water releases from Roslyn Lake.
PGE Powerhouse	Headworks Dam	1.5-6.0	Extremely low flows from late spring to early fall. Fish entering this reach in the spring may become stranded in isolated pools in summer and early fall. Woody debris and besload intercepted and trapped by dam and reservoir..
Headworks Dam	Top of Reservoirs	6.0-14.5	Historical channel is inundated by reservoirs. No anadromous fish passage
Top of reservoirs	First major falls	14.5-21.0	Free flowing - used by resident and probably adfluval trout from reservoirs (rainbow and cutthroat)
Falls	*Origin of river below* Bull Run Lake	21.0-24.1	*No historic anadromy. Genetically unique stock of cutthroat trout present*
Bull Run Lake	Tributaries to Bull Run Lake		Lake drawdown and lack of surface water connection to tributaries. Genetically unique stock of cutthroat trout present

Table 4-41 --Habitat affected or disconnected by municipal water supply and hydropower development in the Little Sandy Watershed (Whitt 1975, Collins 1974, USFS Stream Surveys).

From	To	River Miles	Comments/Fish Related Concerns
Confluence Bull Run River	Diversion Dam	0.0-1.7	Extremely low flows. Possible stranding of fish.
Diversion Dam	First major falls	1.7-8.2	No anadromous fish passage at diversion dam.
Falls	Top of Reservoirs	8.2-14.9	Genetically pure rainbow trout present. This stock is suspected to be redband trout. Extent of distribution unknown

Fish Stocks

Native stocks, as defined in this analysis, are those stocks found historically in the Sandy River Subbasin that have maintained a high degree of genetic integrity and have little genetic influence from other introduced stocks. The native stocks are uniquely adapted to the special conditions found within the Bull Run River and its tributaries.

Wild stocks are self-sustaining populations that originated from or have been significantly altered genetically by hatchery introductions. Hatchery stocks are defined as first generation fish outplanted from hatchery facilities.

Populations of native stocks of salmonids (which include spring and fall chinook, coho salmon, and resident and anadromous forms of rainbow and cutthroat trout) are much reduced from historical levels due to: habitat degradation, hydroelectric dam operation, overfishing, and ocean- rearing conditions.

The Oregon Department of Fish and Wildlife (ODFW) has developed a Wild Fish Policy and angling regulations to protect these stocks. High quality habitat is critical for maintaining these stocks. The Bull Run and Little Sandy rivers and their tributaries formerly provided large amounts of this high quality and diverse fish habitat for anadromous fish. Currently, however, anadromous fish are limited to the lower rivers below the dams where adverse habitat conditions are frequently encountered. Yet, within the upper watersheds, where human intrusion has been restricted, the Bull Run Watershed contains some of the highest quality trout habitat within the entire Sandy Subbasin.

The dams in the Bull Run watershed effectively disconnected resident trout populations and trapped anadromous forms in the river and tributaries above the headworks dam. The dams also created a distinct boundary of fish distribution patterns, restricting anadromous production to below dams and reserving the areas above for resident fish. For this reason, this fish stock analysis is divided by dam location into upper and lower watersheds.

Historic angling reports indicate that, prior to dam construction, large numbers of salmon and steelhead entered the Bull Run River for spawning. Chinook, coho, summer and winter steelhead were all known to have used the system.

The city of Portland and PGE are required to mitiate for the loss of anadromous production in the Bull Run and Little Sandy Rivers as part of their FERC (Federal Energy Regulatory Commission) license. In a 1979 memo, ODFW estimated that 846 adult coho and 706 adult steelhead could have been naturally produced in the

Little Sandy River. In 1974, Collins stated that therre could have been an adult return of 500 coho and 600 stelhead to the Little Sandy River. To mitigate for this it was agreed that PGE would fund the production of 100,000 spring chinook smolts (considered an aquitable amount). At the time ODFW thought the coho and winter steelhead hatchery programs were successful and it would be better to enhance the spring chinook program.

The city of Portland has mitigated for the loss of salmonid fish production in the Bull Run by funding the production of 60,000 hatchery winter steelhead smolts and 200,000 hatchery spring chinook smolts. Due to a lack of records for the Bull Run, ODFW used historic records from the Boulder Creek hatchery on the Salmon River to estimate pre-dam run size on the Bull Run River. From this estimate it was determined that 1,530 spring chinook, 725 steelhead, and 1,050 coho could have been naturally produced in the Bull Run River. All mitigation fish are released below Marmot Dam.

PGE's Little Sandy and Marmot diversion dams come up for relicensing in 2004. During this time, FERC license agreements and mitigations will be revisited.

Lower Bull Run and Little Sandy Rivers

The following fish stocks are limited to the lower Bull Run and the Little Sandy rivers. Little data exist on the numbers of anadromous fish that historically or currently use the Bull Run Watershed. Most of the information that follows is based on fish runs of the Sandy River.

Steelhead Trout

Steelhead are an anadromous form of rainbow trout.

Figure 4-46 -- Steelhead Trout Distribution

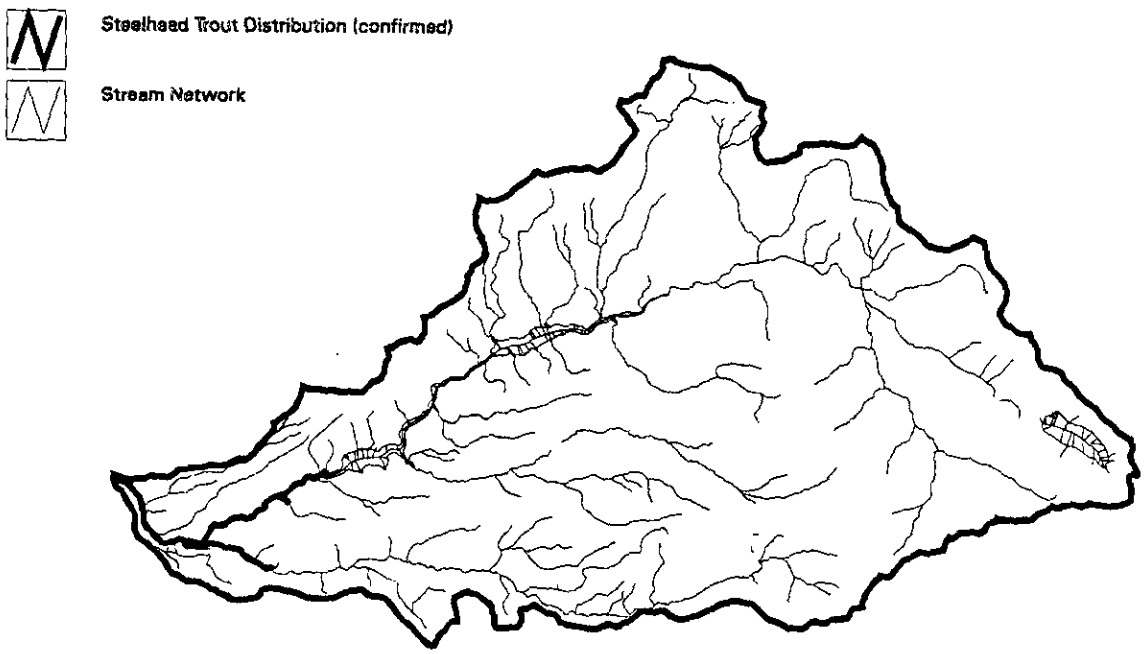
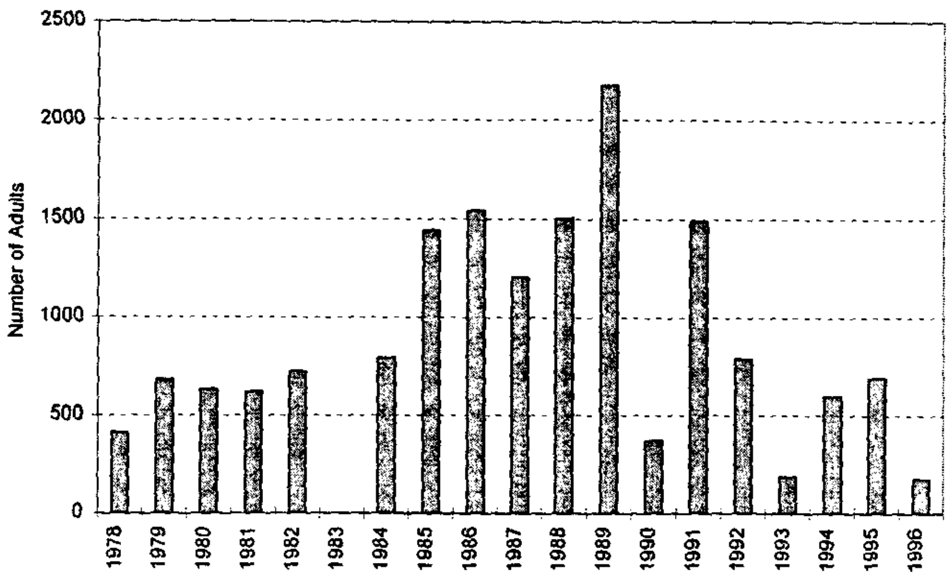


Chart 4-57 Population Trends Steelhead Trout - Count at Marmot Dam (ODFW, 1997)



Steelhead Status

On August 9, 1996, the National Marine Fisheries Service (NMFS) proposed steelhead ion the Lower Columbia River Evolutionarily Significant Unit (ESU) for listing under the federal Endangered Species Act as "Threatened." This ESU includes the Sandy River and tributaries.

Summer Steelhead

Summer Steelhead enter the lower Sandy River as early as late February. Peak migration past Marmot Dam occurs in June; most spawning is complete by the end of August. Straying of summer steelhead into the Bull Run River occurs due to the false attraction created by the release of Sandy River water into the lower Bull Run River at the PGE powerhouse facilities. Fish entering the Bull Run or Little Sandy rivers in spring and early summer may become isolated in pools as upstream water storage substantially decreases the amount of flow coming through the system below the dams. These fish trapped in isolated pools typically encounter high mortality rates due to decreases in water quality. Increased water temperatures and exposure to avian predation are also commonly observed in this type of situation.

Native Stock

Speculation exists that a summer race of steelhead once returned to the Sandy Subbasin. If a native run was supported, however, it is believed to have been very small (pers comm Tom Murtagh). Any possible evaluation of this stock through the ODFW Sandy Subbasin Management Plan (in progress) could help provide the needed information on the potential existence of this stock.

Introduced Stock

Hatchery summer steelhead were introduced into the Sandy Subbasin in 1975. The Foster/Skamania stock from the South Santiam Hatchery is currently used. This stock was developed from eggs taken at the Skamania Hatchery on the Washougal River. Although it was once assumed that this hatchery stock would not naturally reproduce or compete with indigenous steelhead and juvenile coho, natural production is known to occur -- as evidenced by sport catch in the upper Sandy Basin and in Marmot Dam counts. Additionally, residualization (holdover) of smolts is suspected.

Winter Steelhead

Current ODFW guidelines give management direction to protect the late-run natives. Under these guidelines, only 10% of the naturally spawning winter steelhead should consist of hatchery stock. Since 1989, hatchery stocking has occurred below Marmot Dam in an effort to concentrate the sport fishery to the lower Sandy Subbasin and to reduce juvenile competition in the upper subbasin.

Native Stock

Late-run winter steelhead, native to the Sandy Subbasin, pass Marmot Dam from April through May. From the early 1980s to the early 1990s, the percentage of natives comprising the winter steelhead run declined from 28% to only 18% (ODFW; May 3, 1994). This decline could be related to poor ocean rearing conditions and incidental by-catch by commercial ocean harvest operations.

Historically, native winter steelhead spawned throughout the Sandy River Subbasin. Currently, the majority of winter steelhead spawning occurs in the upper Sandy River watershed.

Introduced Stock

Big Creek stock, an early winter spawner , are released into the Sandy River. Since 1989, all winter steelhead smolts have been and are released below Marmot Dam.

Chinook Salmon

Chinook Salmon Status

Chinook stocks in the coastal basins of Oregon, California, and Washington are currently under review by NMFS for listing as threatened or endangered.

Figure 4-47 – Chinook Salmon Distribution

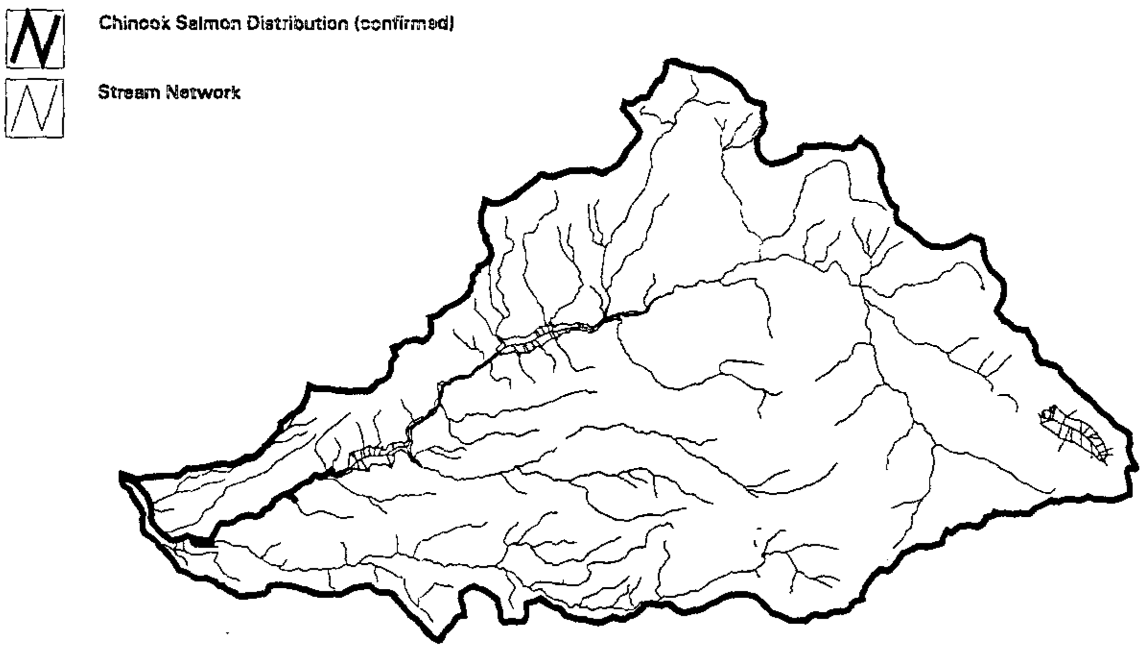
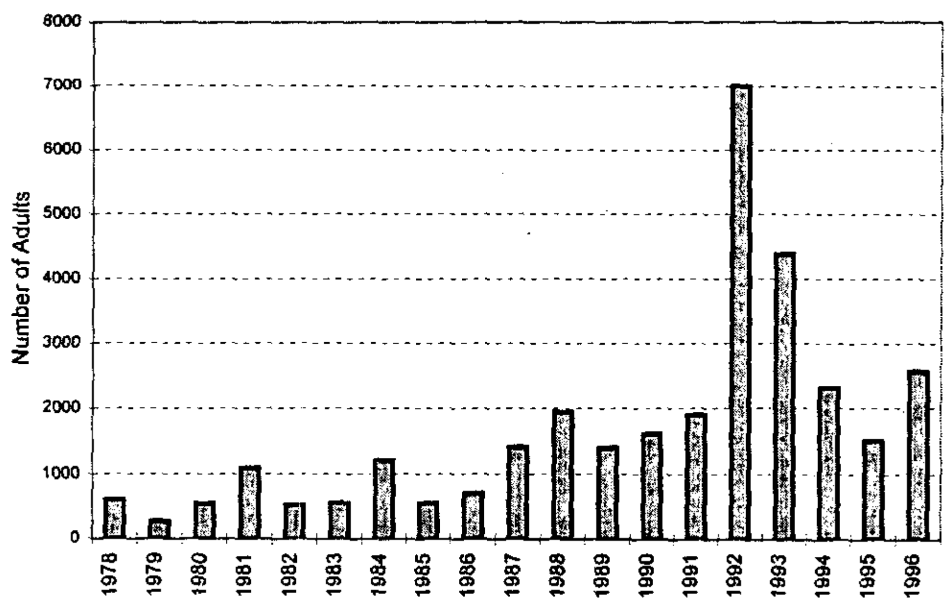


Chart 4-58 – Populations Trends Spring Chinook Salmon - Sandy River at Marmot Dam (ODFW, 1997)



Fall Chinook

From spawning ground surveys conducted in the mainstem Sandy River since 1984, estimated fall chinook escapement (both native and hatchery stock) has ranged from 500 to 2,200 fish. From 1983 to 1993, Sandy River sport harvest averaged approximately 390 fish.

Native Stock

Late maturing Sandy stock is indigenous to the Sandy Subbasin. Recent studies reveal this stock has similar genetic characteristics and run-timing to Lewis and Cowlitz river Washington stocks (collectively known as the Lower River Wild Stock). The late maturing Sandy population consists of a group that returns to spawn from October to early December and a late returning group that spawns December to early February (sometimes referred to as "winter" or "bright" chinook). Previously, the "winter" chinook were described separately. However, the decision to combine the two groups was made due to the lack of genetic information describing stock differences, the possibility that the "winter" stock may be a later returning segment of the same run, and to facilitate stock management (draft Sandy River subbasin management plan, 1996).

The numbers of native fall chinook have been drastically reduced from historic numbers. This reduction is believed to be a result of: fishing pressures, extended periods of low mainstem flows below dams, poor upstream passage conditions, and high smolt mortality at Marmot Dam from 1912-1951.

Introduced Stock

Until 1977, hatchery fall chinook originating from stocks inside and outside the Sandy Basin were released intermittently into the Sandy River. The early maturing tule fall chinook are believed to be a mix of wild spawning fish from early hatchery releases and stray hatchery tule chinook from the large releases below Bonneville Dam. It is unclear if a native tule stock historically returned to the Sandy River in great numbers. Currently, no fall chinook hatchery programs exist.

Spring Chinook

Currently, spring chinook entering the Bull Run and Little Sandy rivers to spawn become isolated in pools as areas below dams become dewatered in summer. Even though the area below the Little Sandy Dam receives some seepage of groundwater and spring flows during the summer, water quality and habitat conditions are considered poor.

Native Stock

Large runs of native spring chinook once returned to the Sandy and Bull Run rivers. This run may now be extinct in the Sandy River Subbasin. It is unknown if the native stock of Sandy River spring chinook has sustained itself as a separate subpopulation from the introduced Willamette stock. Though actual data is lacking, a 1955 report by the Fish Commission of Oregon estimates 5000 spring chinook once used the Bull Run for spawning (Mattson, 1955). The decline of Sandy River spring chinook salmon populations is most likely due to: the early Marmot Dam operations, decreased access to historical spawning grounds above the Headworks and the Little Sandy Dam, influences of hatchery practices, timber harvest practices, and high harvest levels in commercial and recreational fisheries. Between 1912 (when Sandy River water withdrawal at Marmot Dam began) and 1974, long reaches of the Sandy were dewatered. Additionally, high smolt mortality occurred on the Sandy River between 1912 and 1951 when the diversion canal was unscreened and smolts were diverted into the PGE power generating facilities at Bull Run.

Introduced Stock

Nearly all spring chinook salmon currently present in the basin are a result of hatchery production. The hatchery stock of spring chinook are derived from the Willamette stock produced at the Clackamas hatchery. Since 1993, smolts have only been released below Marmot dam.

Coho Salmon

Coho Status

Currently, the lower Columbia River coho salmon are designated as a candidate species under review by NMFS to determine if they warrant consideration for listing.

Coho are listed by the State of Oregon and the USDA Forest Service as a sensitive species. Factors contributing to the decline of coho populations include: habitat degradation, overfishing, poor ocean rearing conditions, competition and genetic dilution with hatchery stock, and hydroelectric dam operations.

Figure 4-48 -- Coho Salmon Distribution

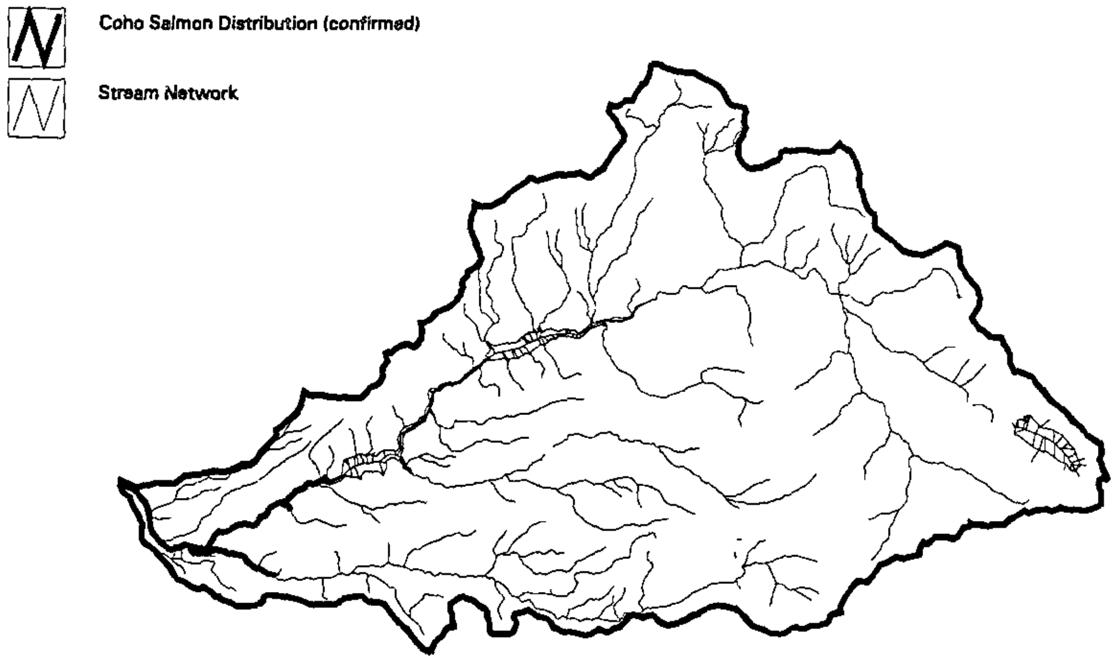
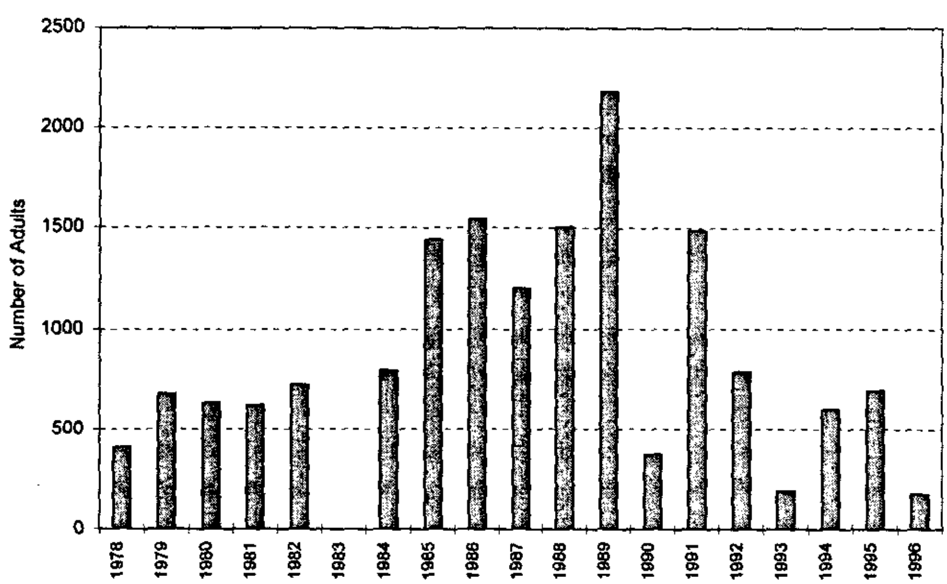


Chart 4-59 -- Population Trends Coho Salmon - Sandy River at Marmot Dam (ODFW, 1997)



Native Stock

Coho salmon are native to the Sandy River Subbasin. Although geneflow may occur between native coho and hatchery coho, the hatchery stocks on the Sandy River originated "almost entirely" from native Sandy River coho salmon. The lower Columbia coho hatcheries are often mistakenly reported to be rearing Toutle River coho from southwestern Washington. However, investigations by ODFW have shown little evidence that Toutle River fish were used for broodstock (ODFW, 1990).

Introduced Stock

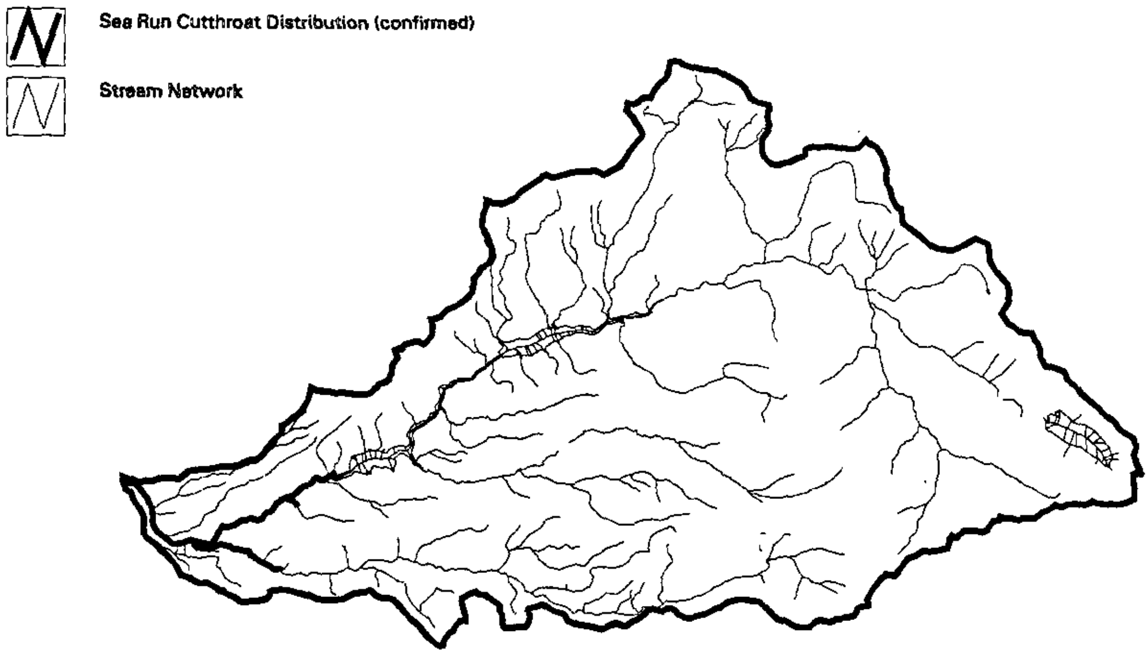
Hatchery broodstocks of coho salmon have a direct lineage back to native Sandy Basin coho (ODFW, 1990) In 1896, the first hatchery in the Sandy Basin began operation on Boulder Creek, a tributary to the Salmon River (Collins, 1974). After completion of Marmot Dam in 1912, hatchery operations moved below the dam to Cedar Creek and operated intermittently until 1955 (Wallis, 1966). In 1965, hatchery operations accelerated with the supplementation of fry, pre-smolt, and adults. The Sandy Hatchery coho population originated almost entirely from Sandy stock coho produced at the Sandy Hatchery (ODFW, 1990). Since 1990, all stocking of coho has been limited to below Marmot Dam.

Cutthroat Trout

Cutthroat Status

The anadromous sea-run cutthroat trout are currently under review by NMFS for listing as threatened or endangered. This review is expected to be completed by late fall of 1997 (pers comm - Jim Lynch, NMFS, Portland Office, May, 1996). Populations of sea-run cutthroat trout are in severe decline throughout their range and are considered sensitive by ODFW.

Figure 4-49 -- Sea-run Cutthroat Trout Distribution



Native Stock

Sea-run cutthroat trout are native to the Sandy Basin. The Bull Run River habitat above Headworks was most utilized by sea-run cutthroat trout prior to the construction of Headworks Dam.. While very few sea-run cutthroat now return to the lower Sandy River hatchery each fall, two to three dozen sea-run cutthroat once returned there (ODFW, 1995).

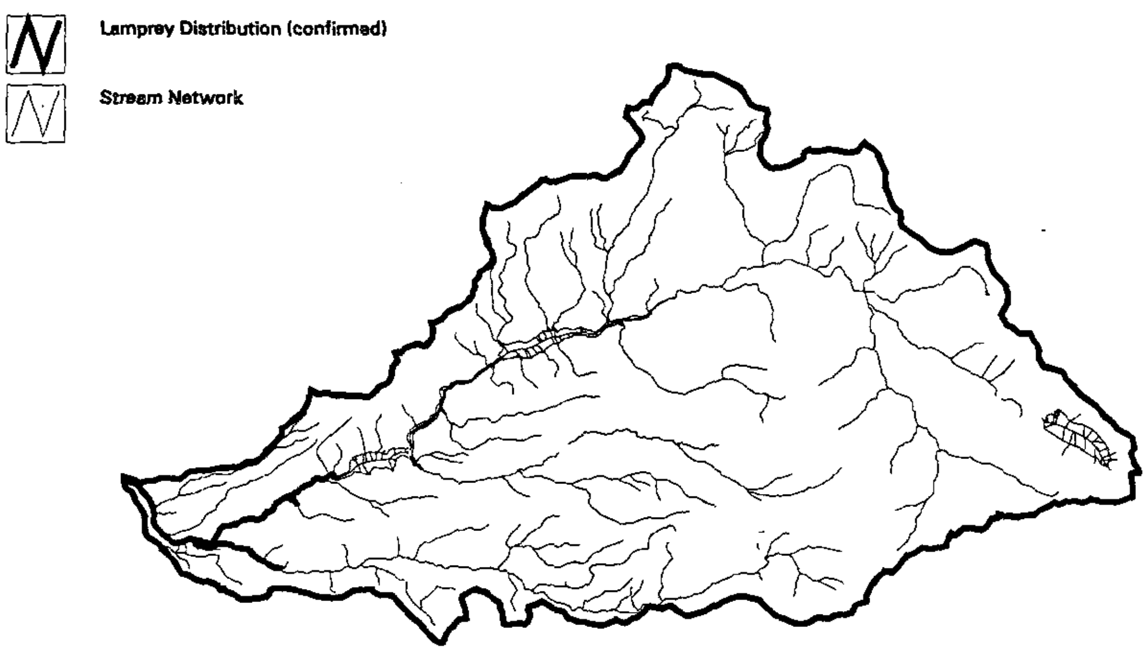
Resident forms may be present in the lower Bull Run and Little Sandy watersheds, however, little information is available on their abundance within these sections. (The resident forms present in the upper watershed will be discussed later in this section.)

Pacific Lamprey

Pacific lamprey, a primitive eel-like fish, is native to the Sandy Basin. The adult form of this anadromous fish is parasitic. The larvae (ammocoetes) may spend 3 to 8 years in gravel and fine sediment substrates in shallow backwaters. Because of this characteristic, they are especially susceptible to the deleterious effects of dewatering below the dams.

Pacific lamprey are very effective at navigating barriers. Thus, in 1965, the City of Portland Water Bureau installed two electric fences (currently not in operation) on the Bull Run River at river miles 5.25 and 6.0. Because this method was not completely effective, the water bureau used selective larvicide which virtually eliminated the lamprey from this system. Currently, a velocity barrier to lamprey exists in the pool below the lower reservoir (Reservoir #2) spillway. In a 1973 Forest Service electrofishing survey, "a few larval and a few adult lampreys" below the Headworks Dam in the Bull Run River were recorded.

Figure 4-50 Pacific Lamprey Distribution



Pacific Lamprey Status

Pacific Lamprey are listed as a sensitive species by the State of Oregon and are considered a species of concern by the Oregon Natural Heritage database.

While survey information is lacking for this species, a widespread perception exists that population numbers have notably declined during the last several decades. Likely threats or factors contributing to this decline include: rapid or prolonged water withdrawal, high water temperatures, impacts to water quality, a declining prey base, and passage barriers such as high dams.

Bull Trout

Data is lacking regarding the historical and current presence of bull trout. Bull trout are presently identified in the Hood River drainage and were historically known to inhabit the Clackamas River drainage. While the presence of Bull trout in the Sandy Basin is uncertain, there is a possible reference to this species in the Sandy Subbasin by Leonards (1960). Mary Hanson of ODFW is preparing a bull trout status review. She acknowledges that there is a data gap for the Bull Run watershed regarding presence/absence of bull trout (personal communication 1996). Suitable habitat for bull trout exists in the upper Bull Run watershed.

Upper Bull Run and Little Sandy River

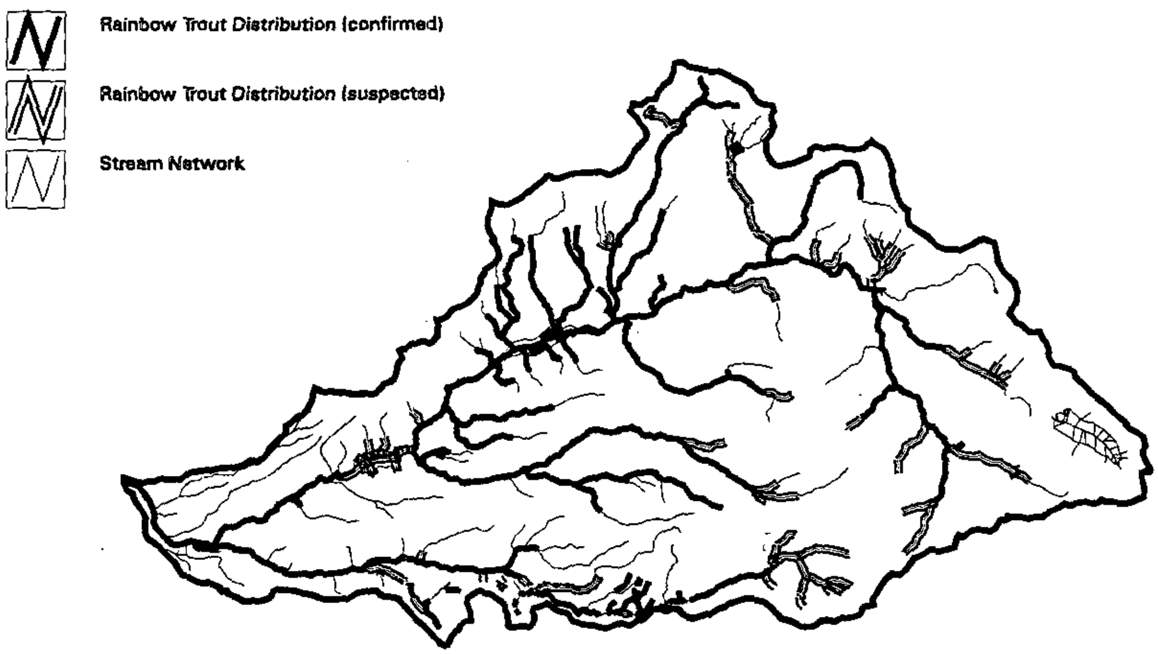
Anadromous fish are not able to migrate past the Headworks Dam at river mile 6.2 on the Bull Run River, nor the Little Sandy Dam at river mile 1.5. The following fish stocks are limited to the upper Bull Run and the Little Sandy rivers.

Resident Fish

Recreational fishing has been prohibited in the Bull Run waershed since the late 1800's. Without fishing pressure and competition from anadromous fish, resident populations above the dams have done very well.

Rainbow Trout

Figure 4-51 -- Resident Rainbow Trout Distribution



Rainbow trout are native to the Sandy River Basin. They are present in the upper watershed above the dams in the Bull Run and Little Sandy. Some of these fish may have formerly migrated to the ocean but became trapped after dam construction. In the Bull Run, rainbow have been collected from Reservoir #1.

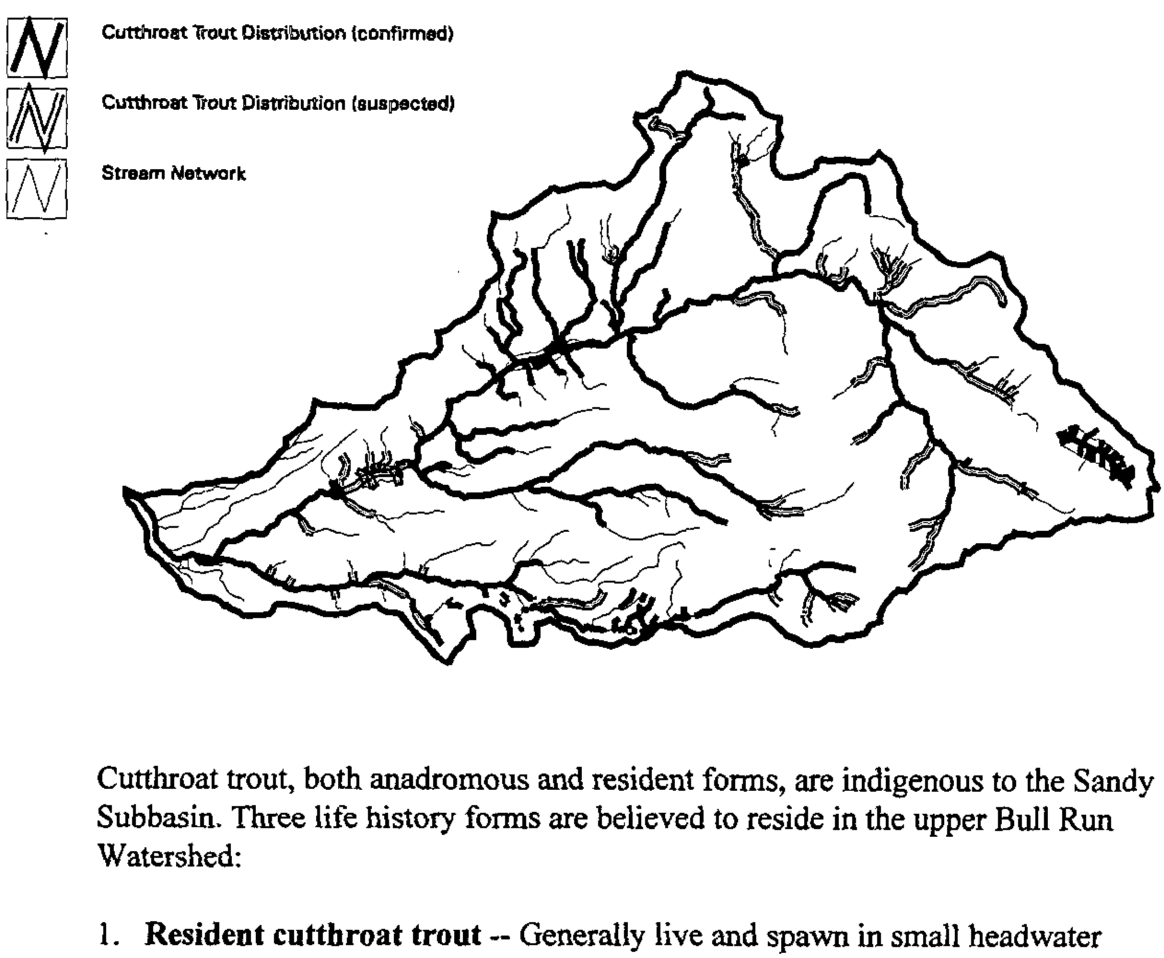
They are believed to be steelhead that have residualized and now live in the reservoirs and migrate to tributaries to spawn (adfluvial form). It is not known what percentage of these fish are the true resident form (pers comm, Kathryn Kostow, Geneticist, ODFW, May, 1996).

While hybridization between cutthroat and rainbow does occur, the upper Little Sandy has a unique stock of rainbow shown by electrophoretic studies to be pure rainbow trout. Current information indicates this stock may be the ancient inland redband trout. Further studies are needed to make this determination (pers comm, Kathryn Kostow, Geneticist, ODFW, March, 1996).

Stocking of rainbow with the Cape Cod stock (Leaburg, Roaring River Hatchery) has occurred in the upper Sandy River tributaries. Stocking was discontinued in 1994. However, there has been no known stocking of rainbow trout within the Bull Run watershed (pers. comm. Jay Massey, ODFW, May 1996).

Cutthroat Trout

Figure 4-52 -- Resident Cutthroat Trout Distribution



Cutthroat trout, both anadromous and resident forms, are indigenous to the Sandy Subbasin. Three life history forms are believed to reside in the upper Bull Run Watershed:

1. **Resident cutthroat trout** -- Generally live and spawn in small headwater streams.

2. **Fluvial cutthroat trout** -- Live in main rivers and migrate to upstream tributaries to spawn.

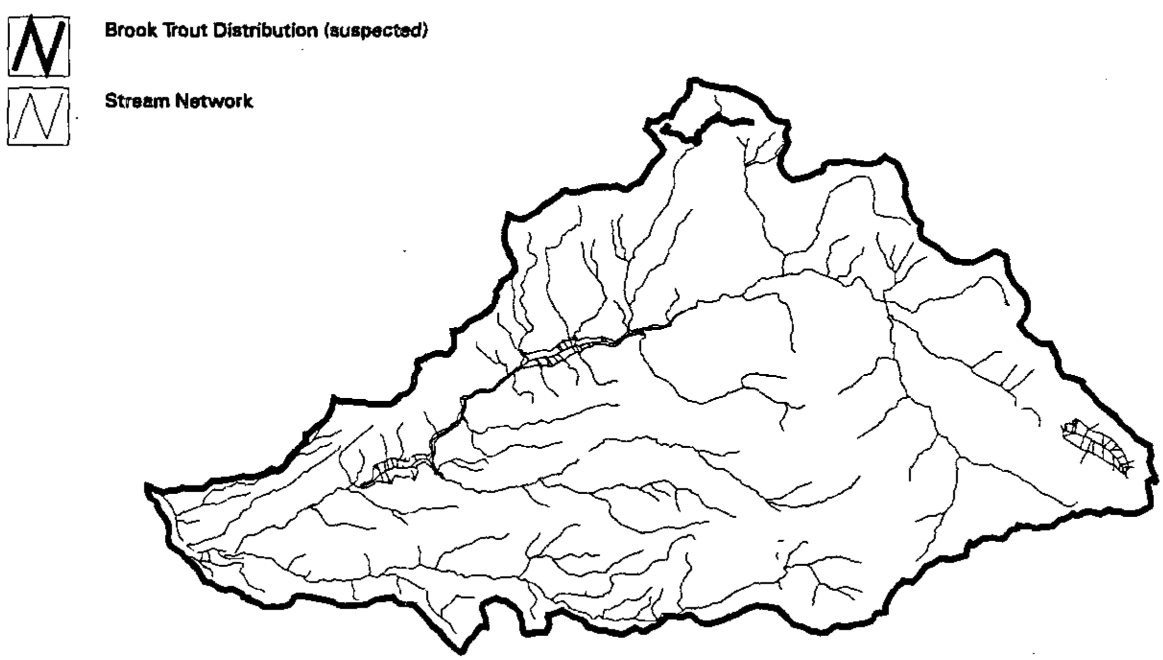
3. **Adfluvial cutthroat trout** -- Reside in lakes and spawn in lake tributaries.

While hybridization with rainbow trout commonly occurs, preliminary morphology and electrophoretic evidence indicates genetically pure cutthrout trout are present in Bull Run Reservoir #2, Bull Run Lake, and the Bull Run River.

Fish samples from Bull Run Reservoir #1 were largely cutthroat with some introgression of rainbow trout alleles (Gregg and Allendorf, 1995). A genetically unique population of cutthroat trout has been identified in Bull Run Lake and in the Bull Run River above the falls at river mile 21 (personal communication, Kathryn Kostow, Geneticist, ODFW, March, 1996). Further study is needed to determine if genetically unique cutthroat trout sub-populations exist above natural barriers within the Bull Run watershed.

Brook Trout

Figure 4-53 Brook Trout Distribution



Brook trout are a competitive non-native introduced into several Sandy Subbasin high mountain lakes during the late 1800s to provide angling opportunities in a wilderness setting. Within the Bull Run Watershed, brook trout were introduced into the upper North Fork. They persist there today. A 1982 Forest Service trout sampling study confirmed brook trout presence above river mile 13.3 on the Little Sandy River. These trout may have entered the Little Sandy River from historical releases made in Goodfellow Lakes (ODFW, 1995 draft). Snorkeling efforts by the Forest Service in 1993 and 1994, however, did not reveal brook trout presence in the Little Sandy River. Further information is needed to determine whether brook trout still persist in this area of the Little Sandy.

Other Species

Longnose dace, mountain whitefish, and torrent and shortnose sculpin are native to the Bull Run Watershed. Complete distribution information on these species is lacking. During surveys, mountain whitefish have been observed in Reservoir #2 and in the Bull Run River just above this reservoir. A 1950-era National Geographic reported that Bull Run Lake was stocked with whitefish around the turn of the century. While Forest Service gill net sampling has not confirmed this report, it is possible that the whitefish were located farther down into the depths of the water column -- below the nets. Within the Bull Run Watershed, sculpin are typically found throughout the range of cutthroat trout.

Fish Stock Summary

Species/Run	Origin/Hatchery Stock	Trends	Status	Typical Spawning and Rearing Habitat	Spawning Time	Freshwater Rearing	Percent of Sandy Subbasin Smolt Capacity*
Summer Steelhead	Possibly Native (further evaluation needed) Hatchery- Foster/Skamania	Extinct ? Current stocking		Fast Water Riffles	Winter	1-4 yrs	0
Winter Steelhead	Native Hatchery- Big Creek	Decline Current Stocking	Potential Listing	Fast Water Riffles	Late Winter/Spring	1-4 yrs	3
Fall Chinook	Native Wild Spawning from previous hatchery stocking	Decline No current stocking	Under Review by NMFS/State Sensitive	Low gradient mainstem spawniers (LWD and pools)	Fall/Winter	3-6 months	8
Spring Chinook	Native Hatchery- Willamette	Extinct? Current stocking	Under Review by NMFS and State	Low gradient mainstem spawniers (LWD and pools	Early Fall	Up to 1 yr	6
Coho	Native Hatchery- Sandy	Decline Current stocking	Under Review by NFMS. FS and State Sensitive	Low gradient, small to medium sized streams and side channels. LWD	Late Fall	1 yr +	7

Species/Run	Origin/Hatchery Stock	Trends	Status	Typical Spawning and Rearing Habitat	Spawning Time	Freshwater Rearing	Percent of Sandy Subbasin Smolt Capacity*
Sea-run Cutthroat	Native	Decline	Under Review by NFMS. State Sensitive	Small tributaries. Juveniles use pools and large channels with LWD	Winter/Early Spring	1-6 yrs	
Resident Cutthroat	Native Genetically unique population upper Bull Run River and Bull Run Lake	Stable		Small first and second order tributaries. Juveniles use pools and side channels with LWD	Spring	N/A	
Pacific Lamprey	Native	Decline	State Sensitive	Clear gravel riffles and runs	Spring/early summer	3-8 yrs	
Bull Trout	Possibly native (lacking data regarding historical or current presence)	Unknown	FS Sensitive	Cold low gradient riffles.	Fall	N/A	
Resident Rainbow	Native	Unknown		Tributaries margins of mainstems and side channels	Spring	N/A	
Redband Rainbow	Possibly native (further evaluation needed)	Unknown	FS and State Sensitive. Federal T&E candidate	Not well documented, probably similar to resident rainbow	Spring	N/A	
Brook Trout	Wild spawning	Unknown		Clear cold water small streams	Fall	N/A	

*This value represents the current percent contribution from the Bull Run and Little Sandy watersheds, utilizing the entire Sandy watershed anadromous fish production as 100 percent.

Macroinvertebrate Species

The following findings were noted during a single USFS spot check for macroinvertebrates. The possibility of wider distribution within the watershed exists and warrants further investigation.

Columbia Dusky Snail *(Lyrogyrus sp.)*

The Columbia dusky snail has been documented in the Bull Run Watershed in the springs below Bull Run Lake. Columbia dusky snail habitat requirements are springs and spring outflows, from low to high elevations in cold, pure, well-oxygenated water. This species is often found in very small springs or channel margins of larger springs, and is most common on soft substrates in shallow slow flows. It prefers oligotrophic pristine water sources with no macrophytes (Frest, 1993). The Northwest Forest Plan lists the Columbia dusky snail as a survey and manage species.

Cascades apatanian caddisfly (*Apatania tavala*)

Habitat for *Apatania tavala* is present in the springs (weir locations) below Bull Run Lake. A single specimen was collected at the springs in October 1994. This species is listed as sensitive by the Forest Service and is a USFWS candidate Category 2 species. It is adapted to cold water spring areas with stable substrates and low amounts of sedimentation.

Lake Habitat

The lakes in the Bull Run watershed are unique as a result of the strictly limited access, semi-pristine conditions, and high water quality. Also, records indicate that fish stocking within the watershed has been very limited. There is a small population of brook trout in the upper North Fork that was probably introduced during the late 1800's.

There may also be a small population of brook trout just below Goodfellows Lakes. However, further information is needed to confirm this. The only other stocking recorded occurred in Goodfellows Lakes. Goodfellows Lakes were not fish bearing in the past and were stocked several times between 1983 and 1992 with rainbow and some cutthroat trout (USFS 1994).

Stocking no longer occurs there. Compared to other high elevation lake systems, this is a minimal stocking history. Stocking of formerly fishless lakes can change their trophic structure and may affect amphibian populations.

Big Bend and Hickman lakes are oligotrophic (pure and nutrient poor) lakes identified during USFS surveys as fishless and in their natural state. Because many high mountain lakes have been stocked for recreational fishing, these lakes may have particular value by providing baseline conditions.

Bull Run Lake is a natural lake at the head of the Bull Run River and has been dammed for municipal water use. The lake was previously dammed by natural processes, including a large landslide from Preacher's Peak. Water from the lake percolates down through porous rock before it resurfaces approximately one-half mile downstream. There it forms the Bull Run River.

Bull Run Lake is oligotrophic and studies indicate that biological and chemical conditions are simlar to conditions of the past several thousand years. It is a glacial cirque with a maximum depth of 273 feet. The lake is fed by numerous non-glacial tributaries.

Five of the tributaries to Bull Run lake provide important spawning habitat to the lake's unique genetic stock of cutthroat trout. During drawdown of the lake, the tributaries become disconnected from the lake and affect fish movement between the two. This has the potential to affect the overall spawning success. Drawdown may also decrease macroinvertebrate prey base available to the lake fish. Effects of drawdown on downstream populations of *Apatania* and *Lyrogyrus* are poorly monitored. For more information on Bull Run Lake, refer to the Bull Run Lake Environmental Assessment, Mt. Hood National Forest, February 1995.

Fish Habitat

Introduction

In the previous fish stock discussion, several critical habitat components were identified, including: streamflow, stream substrate, aquatic habitat types, and in-channel large woody debris. Within this section of the document, these will be discussed by the appropriate stratification unit (stream system, subwatershed, species of concern) for habitat component and associated data.

For this analysis the stratification unit for fish stocks was focused on habitat for species of concern as outlined in Table 4-42.

Table 4-42 Fish Species of Concern Stratification Units.

Species	Concern	Habitat Location
Coho salmon	Forest Service and State sensitive species; high risk of extinction; under review for Federal T & E listing.	Lower Bull Run and Little Sandy rivers
Spring chinook salmon	High risk of extinction; status under review by State.	Lower Bull Run and Little Sandy rivers
Winter steelhead	Moderate risk of extinction; proposed for Federal T & E listing.	Lower Bull Run and Little Sandy rivers
Sea-run cutthroat trout	Forest Service and State sensitive species; moderate risk of extinction.	Lower Bull Run and Little Sandy rivers
Pacific lamprey Entosphenus tridentatus	State sensitive species	Lower Bull Run and Little Sandy rivers
Resident cutthroat trout	Unique genetic stock in upper Bull Run River and Bull Run Lake	Upper Bull Run River and Bull Run Lake
Rainbow trout	Pure rainbow trout suspected to be inland redband trout	Upper Little Sandy River

All anadromous fish within the watershed were grouped in this assessment due to similar habitat requirements and range of distribution within the watershed.

Stream Survey Data

Data for aquatic habitat types, pool levels, and large woody debris were compiled from Level II stream surveys in the Bull Run watershed. A Level II survey is an extensive stream channel, riparian vegetation and aquatic habitat condition inventory on a watershed-wide scale. Level II surveys are designed to determine the "pulse" or condition of a system. Level II surveys meet assumptions for standard statistical analysis and result in estimates with known bounds of error for habitat dimensions. They follow a stratified random sampling design, and permit extrapolation of known, measured attributes throughout the watershed. Level II stream surveys contain the "Core Data Standards" developed by the inter-agency team for implementation of the Northwest Forest Plan.

Data from the Level II surveys is stored in the Stream Management, Analysis, Reporting and Tracking (SMART) database. The SMART database is an ORACLE application that was developed to facilitate the sharing of information between units and to support Regional efforts to integrate Level II inventory information into the GIS environment.

Range of Natural Variation (RNV)[19]

The range of natural variation (RNV) was approximated for in-channel woody debris and pools from unmanaged stream reaches by stream order across the Sandy Basin. Stream reaches from unmanaged areas (Wilderness and Fir Creek subwatershed) in the Sandy Subbasin were selected from the SMART database and stratified by stream order[20].

Table 4-43 Streams in Unmanaged Areas[21]

Stream	Area
Boulder Creek	Salmon Huckleberry Wilderness
Cast Creek	Mt. Hood Wilderness
Cheeney Creek	Salmon Huckleberry Wilderness
Cool Creek	Salmon Huckleberry Roadless Area
Devil Canyon	Mt. Hood Wilderness
Fir Creek	Fir Creek subwatershed
Lady Creek	Mt. Hood Wilderness
Mack Hall Creek	Salmon Huckleberry Wilderness
Muddy Fork Sandy	Mt. Hood Wilderness
South Fork Salmon River	Salmon Huckleberry Wilderness
Salmon River	Salmon Huckleberry Wilderness
Wind Creek	Wind Creek Roadless Area

[19] Range of Variability (Natural Variability, Historic Variability) - The spectrum of conditions possible in ecosystem composition, structure, and function considering both temporal and spatial factors.

[20] Stream Order - A method of numbering streams as part of a drainage basin network. The smallest unbranched mapped tributary is called first order, the stream receiving the tributary is called second order, and so on

[21] If a stream survey included a stream that was both in a managed and unmanaged area an attempt was made to only inlcude those stream reaches in the unmanaged area

For this analysis the RNV was determined as the median of the unmanaged stream reaches plus one standard deviation on either side of the median. This was done to eliminate outliers with the potential to bring the RNV from 0-100%.

Streamflows

Bull Run River

The flow regime in the lower Bull Run River is severely altered due to the Little Sandy Diversion Dam, the Bull Run Reservoirs, and the Portland General Electric (PGE) power plant. PGE also diverts up to 600 cfs from the Sandy River into the Bull Run River for the Bull Run power plant.

High flows and low flows were quantified on the Bull Run River at the lower gage (river mile 4.7) below the PGE powerhouse (river mile 1.5), and on the Little Sandy River at its confluence with the Bull Run River. Monthly averages and the year 1994 were used, because they were the only flows available from the Bull Run power plant. Both existing and natural flows were quantified. See the hydrology section for a complete description of the analysis.

Chart 4-60 -- Flows: Bull Run River Below PGE Power plant 1994 (Monthly Mean)

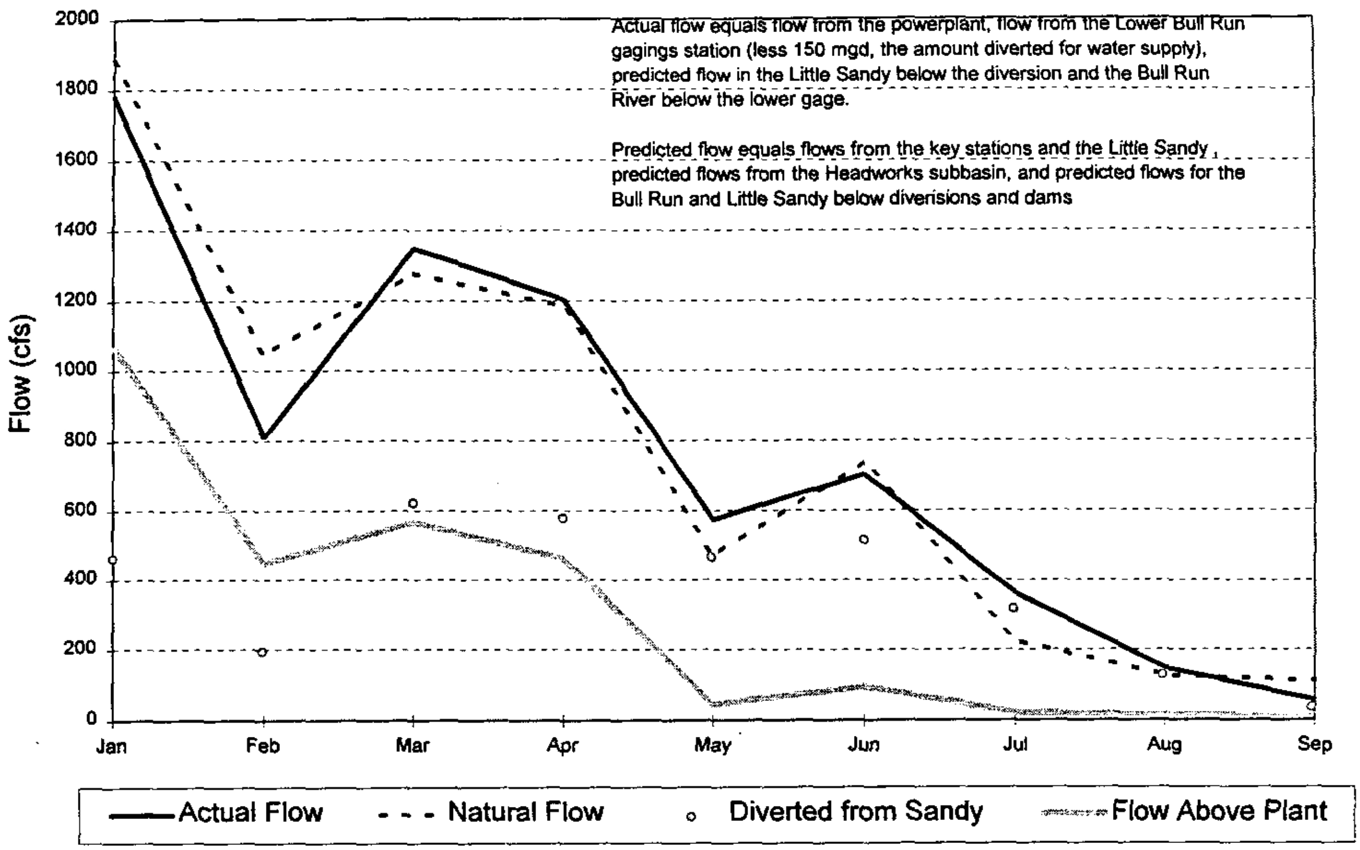
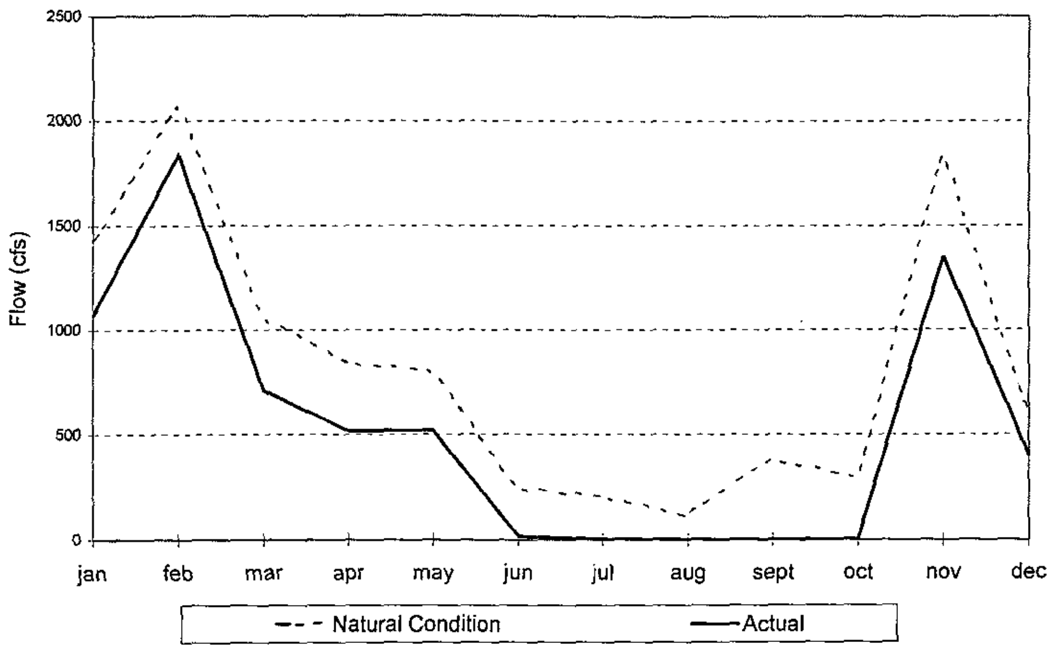


Chart 4-61 illustrates streamflows at the lower Bull Run Rivers streamflow gage for water year 1986. The year 1986 was used because data was available for the lower Bull Run streamflow gage without flow diverted from Reservoir 2 for City of Portland use added to the streamflow figures as is the standard practice in later years. Predicted flows were calculated by adding flows from the key stations with a per unit contribution for ungaged areas. Actual streamflow is from the USGS data.

Chart 4-61 -- Flows: Lower Bull Run River 1986 (Hydroshpere CD)



Low Flows

Table 4-44 -- Typical Low Flows (Monthly Means)

Site	Natural Condition	Current Condition	Difference
Bull Run River at Lower Gage (July mean 1986)	202	5	-197
Bull Run River Below PGE Powerhouse (July 1994)	225	361	+136

The low-flow regime in the lower Bull Run River exhibits two extremes. Current flows from the confluence with the Sandy River to the PGE powerhouse are 136% of the natural condition (due to water imported from the Sandy River). Above the PGE powerhouse, flows are minimal with 2% of the natural condition at the lower Bull Run gage. In July 1994, the flows above the powerhouse are predicted at 21 cfs, and, below the powerhouse, 361 cfs.

Peaking Operations

Portland General Electric has instituted a program of passing natural flows through the Bull Run powerplant during low flow periods to minimize impacts to fish and other aquatic resources (Exhibit S - Project No. 477). Based on data for the summer low flow periods of 1995 and 1996 it appears that every effort is made to approximate the natural lowflow regime, however, in the past two years non-routine major equipment repair has required periods where the powerplant has to be operated in a manner that caused wide flucuations in streamflow (variations of approximately 200 cfs in a one hour period). **Chart 4-25, Chart 4-26**, and Chart 4-64 detail streamflows during the low flow periods of 1995 and 1996.

Chart 4-62 Streamflow (cfs) Sandy River July 1995

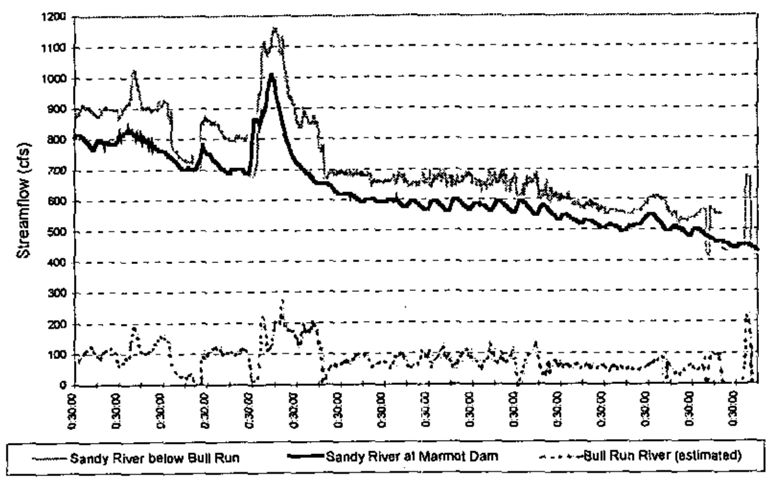


Chart 4-63 Streamflow (cfs) Sandy River August 1995

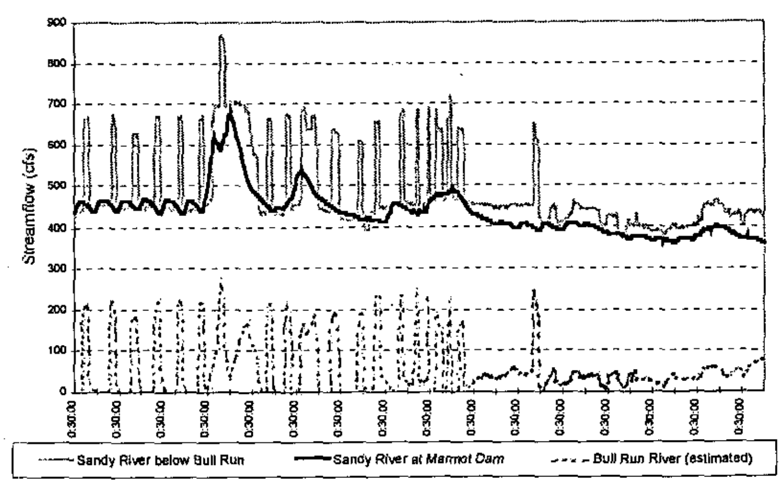
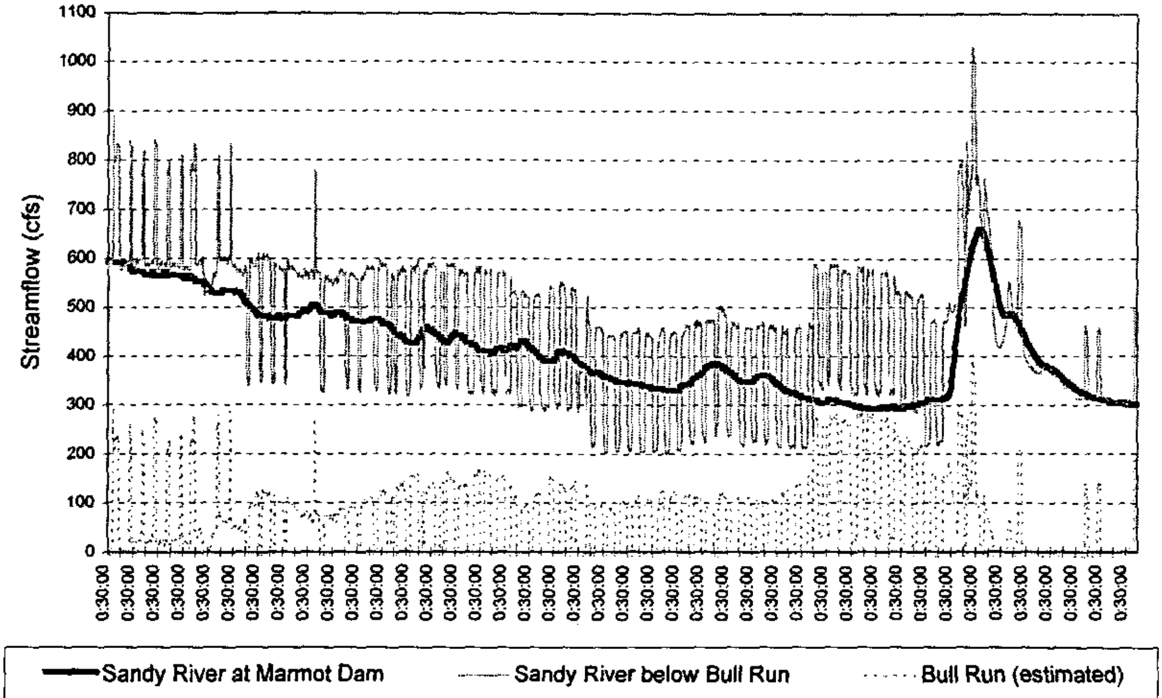


Chart 4-64 Streamflow (cfs) Sandy River July 9-September 29, 1996



PGE's policy of passing natural flows though the Bull Run powerplant should provide habitat conditions with respect to streamflow that are within the range of natural variation.

High Flows

Table 4-45 -- Typical High Flows (Monthly Means)[22]

Site	Natural Condition	Current Condition	Difference
Bull Run River at Lower Gage (Nov 86 monthly mean)	1837	1351	-486
Bull Run River Below PGE Powerhouse (Jan 94)	1882	1785	-97

The high-flow regime is altered, but not as severely as the low-flow regime. The Bull Run River at the lower gage is 73% of the natural condition and the Bull Run River -- below the PGE powerhouse -- is 95% of the natural condition. Flow regime at the PGE powerhouse, however, is still in an altered condition. Flow

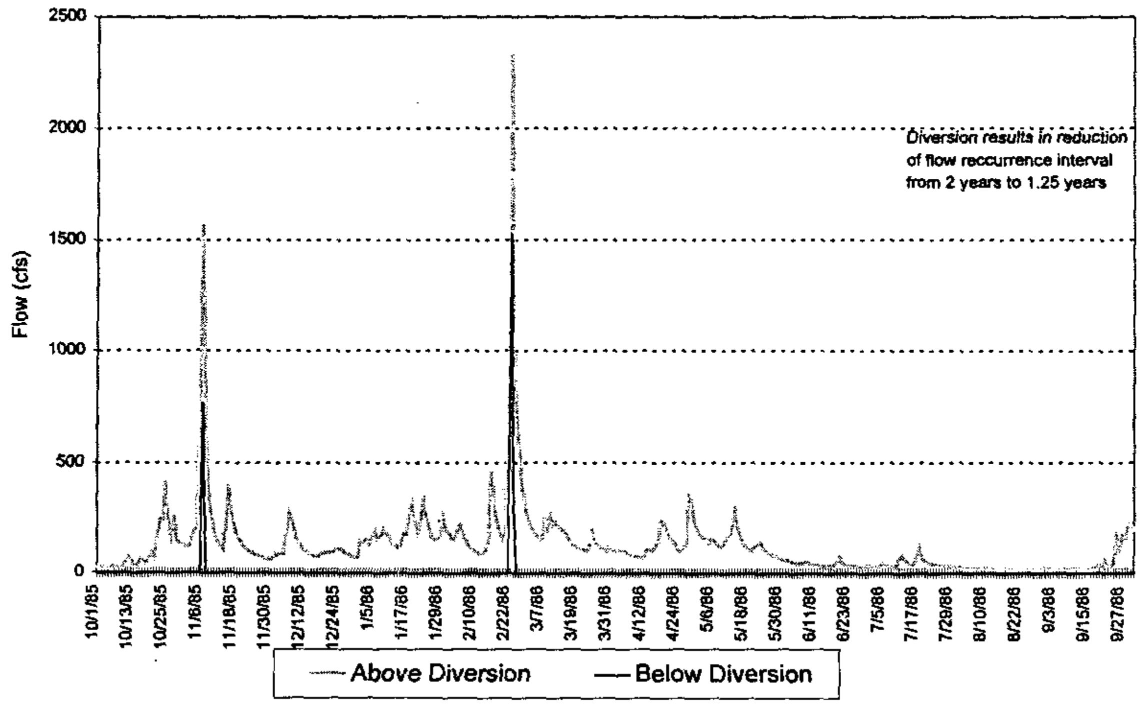
[22] Monthly means were used for comparison purposes because this was the only streamflow data available for the area below the PGE powerplant.

above the PGE powerhouse in January 1994 was 1070 cfs, and below the powerhouse was 1785 cfs.

Little Sandy River

For all but a few days every year, the entire flow of the Little Sandy River is diverted to the PGE power plant on the Bull Run River

Chart 4-65 -- Streamflow Little Sandy River Water Year 1986



Stranding

Variations in flow interrupt spawning, rearing and migration of anadromous fish, and encourages the stranding of fish in isolated pools. During the spring of 1953, 40 steelhead were observed crowded and stranded in an isolated pool below the Little Sandy Dam (Pirtle, 1953). Since that time, PGE has agreed to operating procedures for the Little Sandy dam which minimize the release of water over the dam. Periodic spilling is not desirable as it may attract spawning fish that may be vulnerable to stranding.

However, according to Tom Murtaugh, ODFW, when the Little Sandy exceeds 500 cfs spill does occur and may lead to stranding of winter steelhead and coho salmon. In addition, fish entering the Bull Run River during spring and early summer months are still vulnerable to decreased flow below the dam. Isolated pools offer very poor habitat quality with high mortality from increased temperatures, decreased dissolved oxygen levels, and increased predation.

False Attraction

Anadromous fish returning to the Sandy subbasin may become attracted to Sandy River water being diverted and released into the lower Bull Run River at the PGE Powerhouse. This negatively affects spawning success by luring these fish away from good spawning areas of the Sandy subbasin and into the poor habitat conditions of the Bull Run River below the dams.

Historically, a concrete pool directly below the PGE Powerhouse on the Bull Run River was known to attract summer steelhead and spring chinook. In September of 1994, approximately 20 summer steelhead and 15 spring chinook salmon were observed in the concrete pool. In October, the same pool had several dead summer steelhead and spring chinook. This situation has been mitigated by deterring salmon from entering the concrete pool.

Substrate

Spawning Gravels

Prior to the construction of the new headworks dam in 1962, the Oregon Wildlife Commission conducted a survey that recorded in excess of 247,000 square yards of spawning gravels from headworks dam to Reservoir # 1 -- indicating the river's former importance to anadromous fish production.

Although stored fine-grained sediment is uncommon within the Bull Run Watershed's channels, some streamside deposits do exist. Alluvial flood plains and terraces are located in the wide, relatively low-gradient valley bottoms formed in the watershed by lateral erosion of relatively weak geologic formations. For example, erodible alluvial deposits are present adjacent to the following small stream channels that empty into the north part of the upper reservoir: Five-mile, Bear, Deer, and Cougar creeks. In addition, Cedar Creek, the lower South Fork Bull Run River, and lower segment of Fir Creek, also have relatively wide valley bottoms with erodible deposits. Sediment that has been deposited during high velocity streamflows in the Bull Run Watershed typically consists of sand, gravel, cobbles, boulders and lacks fine particles that may linger in suspension in reservoirs (LaHusen, 1994).

Narrow stream channels that have incised into massive basalt or andesite bedrock contain steep rock banks that are not easily eroded. Examples of these particular stream channels include: the mainstem of the Bull Run River, Blazed Alder Creek, and the lower reaches of Nanny Creek. Sediment within these channels appears to consist primarily of volumes of coarse sediment stored behind ephemeral dams that have been created by logs and other debris (LaHusen, 1994).

The flow of sand, gravel, cobble and boulder size sediment from the upper watershed to the lower Bull Run and Little Sandy Rivers has been interrupted by the reservoirs and the diversion of the Little Sandy. Interrutions of this flow began in 1912 in the Little Sandy and 1921 in the Bull Run River. This interruption may affect the availability of spawning gravels in the lower Bull Run River.

A 1973 survey conducted by the Forest Service below the headworks facility recorded onlyu 215 square yards of good and marginal spawning gravel. This indicates relatively poor quality spawning habitat. A current survey from 1992 classified the dominant substrate as small boulders. However, it is not known how divergent existing conditions are from the natural condition due to the lack of pre-dam data.

Aquatic Habitat Types

Pool, riffle, glide and side channel habitat types provide critical habitat for salmonid species. Different habitat types are preferred by different species at different stages of their life cycle:

- *Fast water habitats (riffles and glides)* -- trout and steelhead
- *Large mainstem glides and pools* -- chinook salmon
- *Side channels* -- coho salmon
- *Small meandering streams with glides and pools* -- resident cutthroat and brook trout

Using habitat type from the Stream Management, Analysis, Reporting and Tracking (SMART) database, habitat types for the Bull Run Watershed were evaluated to assess habitat quality for different anadromous and resident fish.

Chart 4-66 -- Aquatic Habitat Types for Entire Watershed

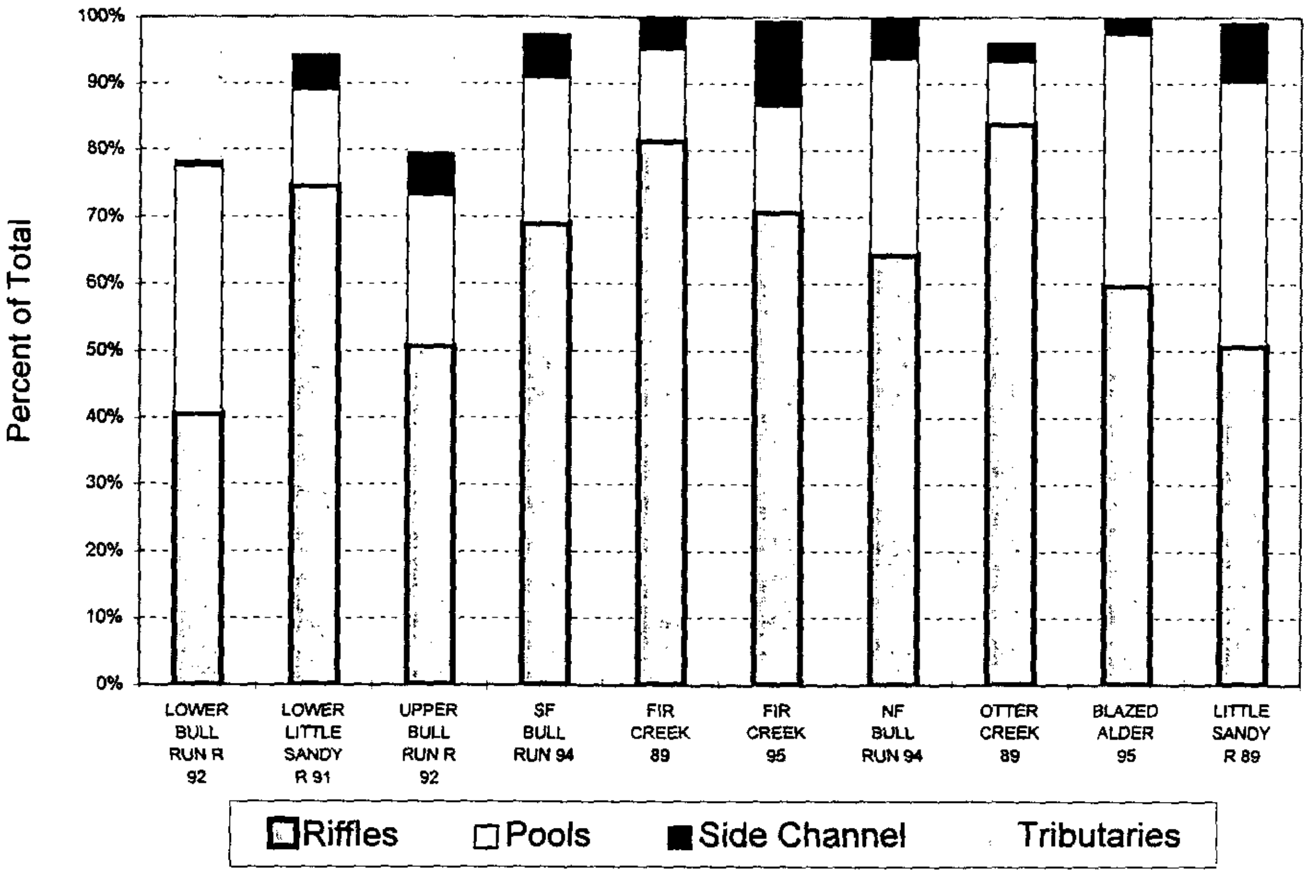


Table 4-46 -- Aquatic Habitat Types by Individual Stream Survey

	Percent of Total			
Stream	Riffles	Pools	Side Channel	Tributaries
Lower Bull Run R 92	41	37	1	22
Lower Little Sandy R 91	74	14	5	6
Upper Bull Run R 92	48	21	6	19
SF Bull Run 94	69	22	7	2
Fir Creek 89	80	14	5	0
Fir Creek 95	69	15	13	0
NF Bull Run 94	63	29	6	0
Otter Creek 89	76	8	3	3
Blazed Alder 95	58	37	2	0
Little Sandy R 89	43	33	8	1

With the exception of the upper Little Sandy River, riffle habitat is the dominant habitat type for the Bull Run Watershed's main channels. Because Fir Creek is an unmanaged basin within the watershed where roading or timber harvest has not occurred, it serves as an indication of the undisturbed condition for a fourth-order stream.

While Fir Creek contains a great amount of area classified as riffles, it also has a significant area of side channel habitat. In fact, Fir Creek has the highest percentage of side channel habitat of all the streams surveyed in the Bull Run Watershed. This indicates that the undisturbed condition for streams with similar channel morphology (flood plain width, entrenchment, and gradient) would have more side channel habitat than is currently available across the watershed.

Aquatic Habitat Types and Fish Stocks

Table 4-47 -- Aquatic Habitat Types by Fish Usage

	Percent of Total				
Fish	Riffle	Pool	Side Channel	Tributary	Glide
Anadromous	54	30	3	14	0
Rainbow Trout	43	33	8	1	15
Cutthroat Trout	78	9	6	7	0

Due to the watershed's high percentage of riffle and large pool habitat, coupled with its limited area of side channel habitat, the streams that support anadromous fish are providing habitat that favors steelhead trout and chinook salmon over coho salmon.

Aquatic habitat types in the portion of the Little Sandy River that may support redband trout appear to meet the habitat needs for that species -- riffles and glides with pool and side channel habitat.

There is a low percentage of pool habitat where resident cutthroat trout are present in the upper Bull Run River.

Pool Levels

Pools provide:

- Resting habitat for adult salmonids on their spawning migrations
- Baseflow thermal refugia
- Protective cover
- Slow water rearing and overwintering habitat for juvenile steelhead and salmon, resident fishes, and amphibians.

The habitat capability of individual pools increases with depth, volume, substrate complexity, and large woody debris for cover and habitat partitioning. The natural range of pool frequencies is highly variable and dependent on gradient, confinement, quantities of large wood debris, and stream width. Habitat complexity and the number of pools per mile increases with decreasing stream order and width.

Pool levels were calculated from queries of the SMART database. The assessment was completed to compare pool quantity to the range of natural variation, and the Columbia River Basin Policy and Implementation Guide (PIG) standards. PIG standards include target levels for pools and large woody debris per mile of stream. The PIG standards are an indication of the desired condition for streams in this area and are used as a "sideboard" for the current condition and the range of natural variation. The range of natural variation (RNV) was approximated from unmanaged stream reaches by stream order across the Sandy Basin.

Chart 4-67 -- Pool Levels: Bull Run Watershed

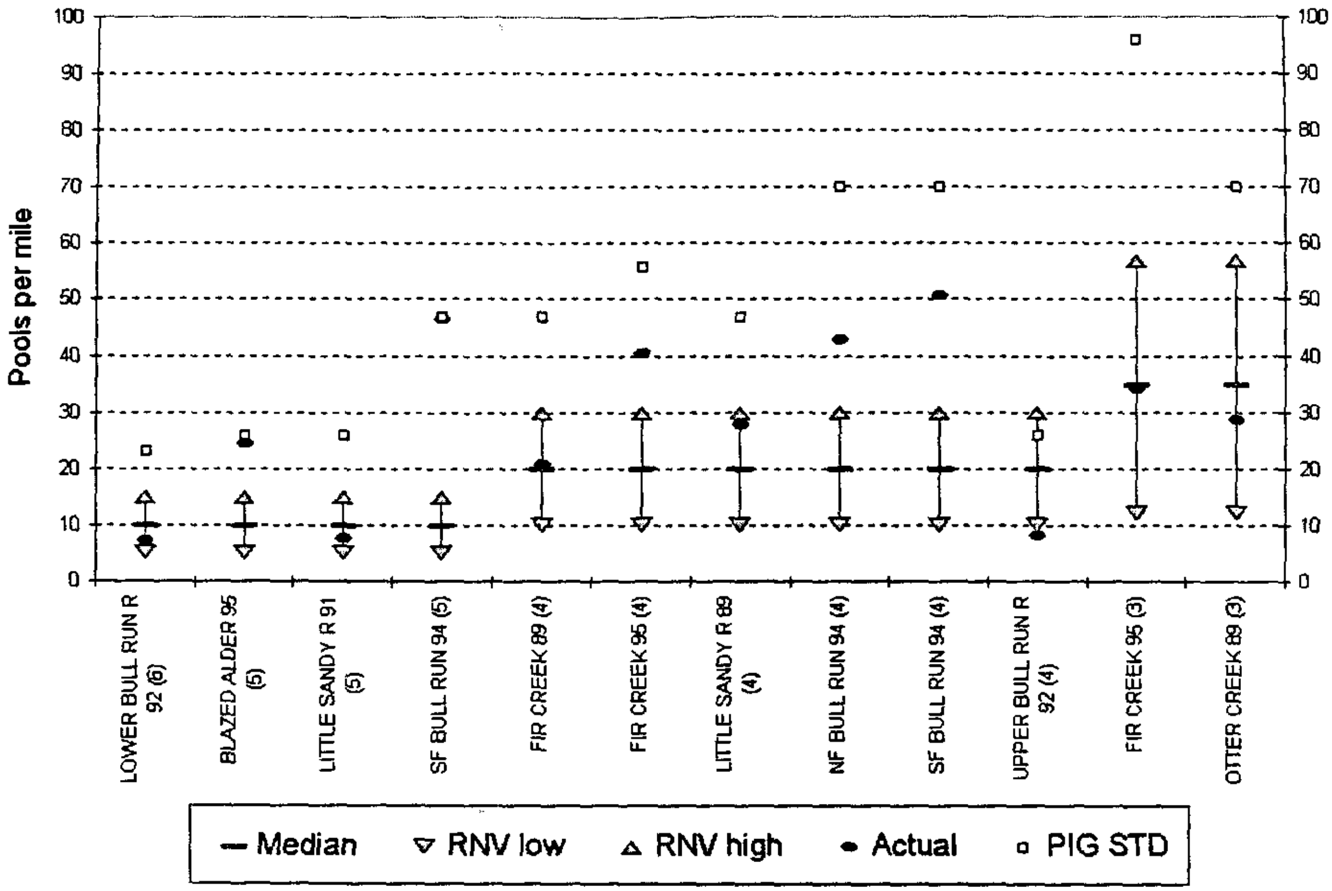


Table 4-48 -- Pools Per Mile

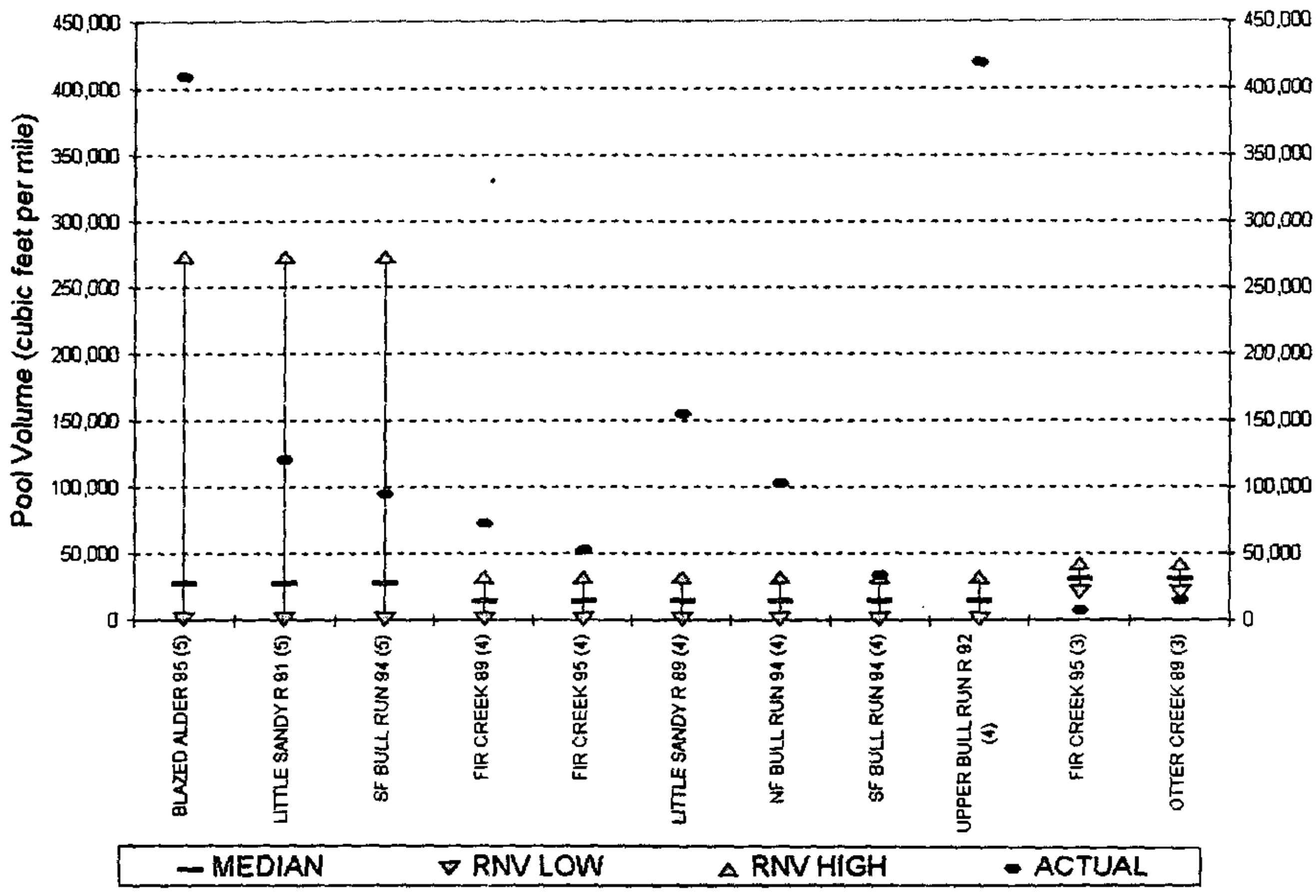
STREAM	Pools per mile	PIG standard
Lower Bull Run R 92 (6)	7	23
Blazed Alder 95 (5)	24	26
Little Sandy R 91 (5)	8	26
SF Bull Run 94 (5)	46	47
Fir Creek 89 (4)	21	47
Fir Creek 95 (4)	40	56
Little Sandy R 89 (4)	28	47
NF Bull Run 94 (4)	43	70
SF Bull Run 94 (4)	51	70
Upper Bull Run R 92 (4)	8	26
Fir Creek 95 (3)	34	96
Otter Creek 89 (3)	29	70

Two of the watershed's eleven streams surveyed (Blazed Alder and South Fork Bull Run River) meet the PIG standards. Additionally, most of the watershed's streams are either within the RNV or are above the median that was determined in establishing the RNV.

Large pools (greater than 25 square yards and greater than 3 feet deep) from a 1940 lower Bull Run River survey, were compared to current large pool levels. Large pools went down from 54 in 1940, to 37 in the 1995 survey. (It should be noted because of the different methodologies utilized in the two surveys, this comparison is subject to some uncertainty.)

Streams at the low end of the RNV (or outside the RNV): lower Bull Run River, lower Little Sandy River, and upper Bull Run River. A comparison was made between the RNV for pool volume (which was determined in the same manner as pool levels) to determine if the number of pools was well correlated with the pool quality as expressed by pool volume.

Chart 4-68 – Pool Volume: Surveyed Streams



The Bull Run River was not portrayed in Chart 4-68 because of the very high pool volume in that area:

Stream	Median	RNV Low	RNV High	Actual
Lower Bull Run R 92 (6)	28,173	0	273,363	1,255,936

This area of the Bull Run River has 44 times the median of pool volume of similar stream orders within the Sandy Basin.

The lower and upper Bull Run River, both at the low end of the RNV for pool numbers, are well above and outside the RNV for pool volume. Because this indicates that pools within the Bull Run River system are large mainstem pools, pool numbers may not be of concern.

In the lower Little Sandy River pool volume is above the median and in the upper area of the RNV for similar stream orders. This would indicate that even though the pool count is low, the pools are large and presumably of high quality.

Pools and Fish Stocks

Chart 4-69 – Pool Levels and Fish Stocks

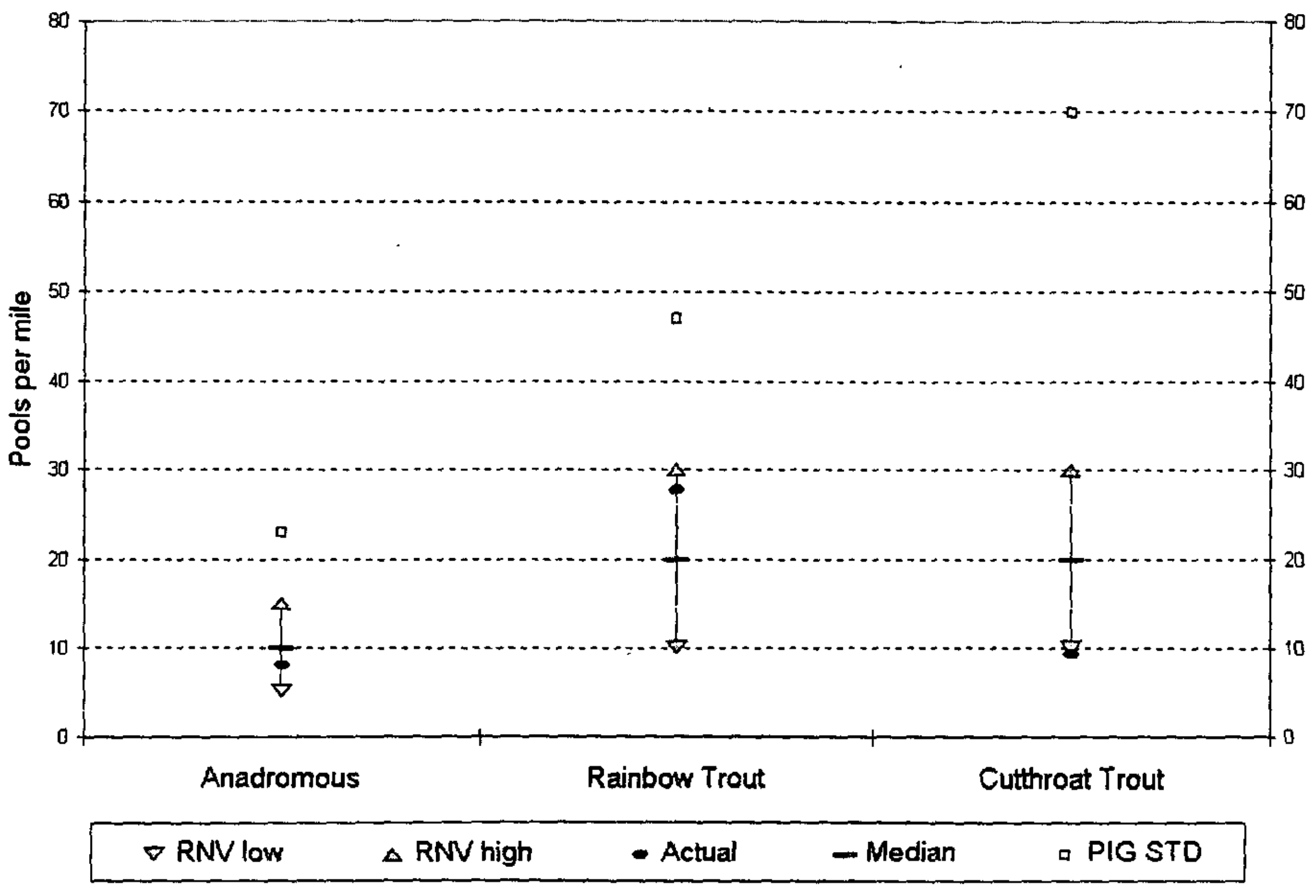
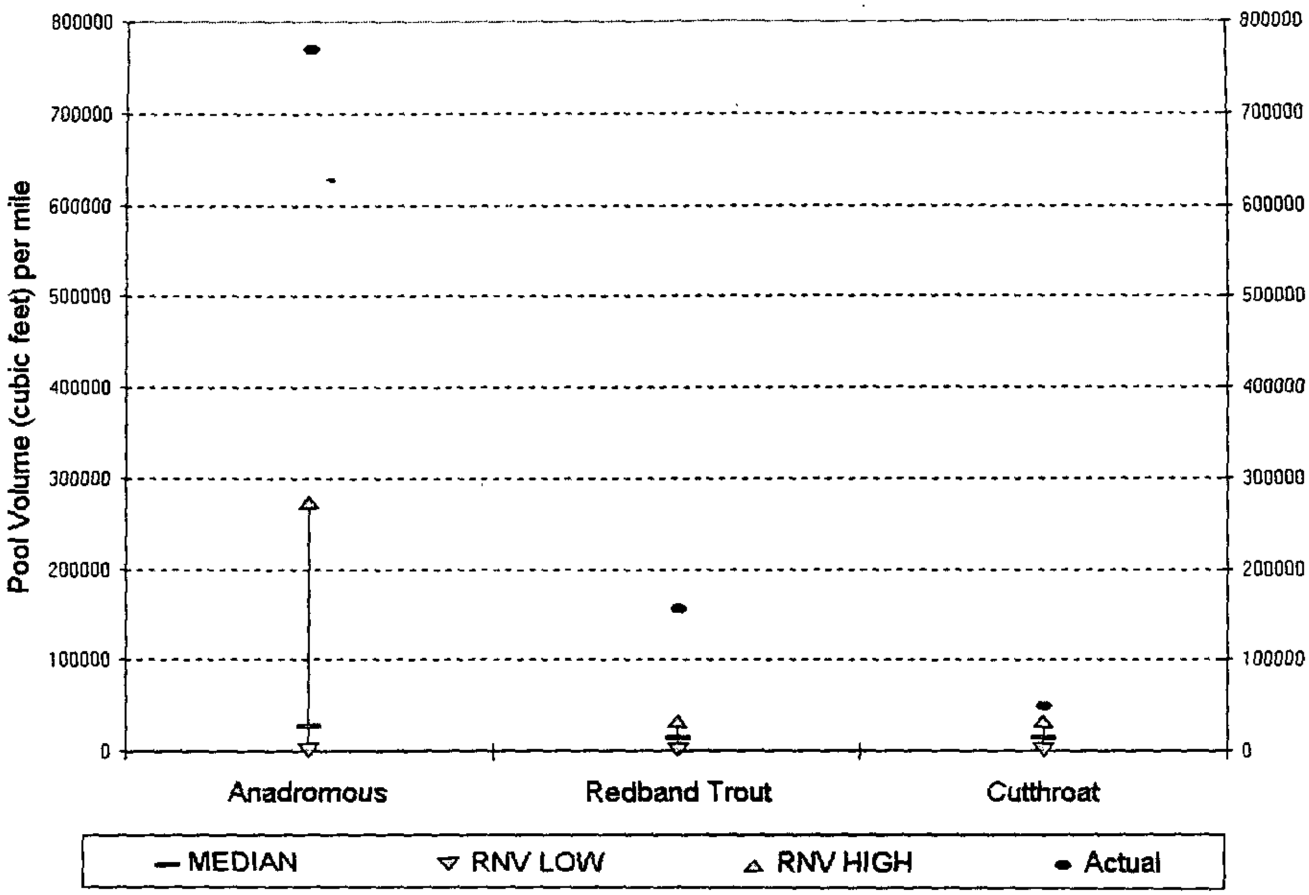


Chart 4-70 -- Pool Volume and Fish Stocks



The sections of the lower Bull Run and Little Sandy rivers utilized by anadromous fish have low pool counts. The pool volumes, however, are outside and above the RNV which would provide good habitat for chinook salmon because of the large mainstem pools.

The portion of the Little Sandy River that is utilized by rainbow trout has pool counts that are above the median and well within the RNV, but below the PIG standard. Pool volumes are well above the median and outside and above the RNV for pool volume. Even though pool counts are below PIG standards, both pool counts and volume are within or above the RNV. Therefore, pool habitat appears adequate for rainbow trout in this area.

In the upper Bull Run River, utilized by cutthroat trout, pool levels are at the very low end of the RNV, but pool volumes are outside the RNV. This indicates fewer larger mainstem pools and should provide adequate pool habitat for cutthroat trout.

In-Channel Large Woody Debris

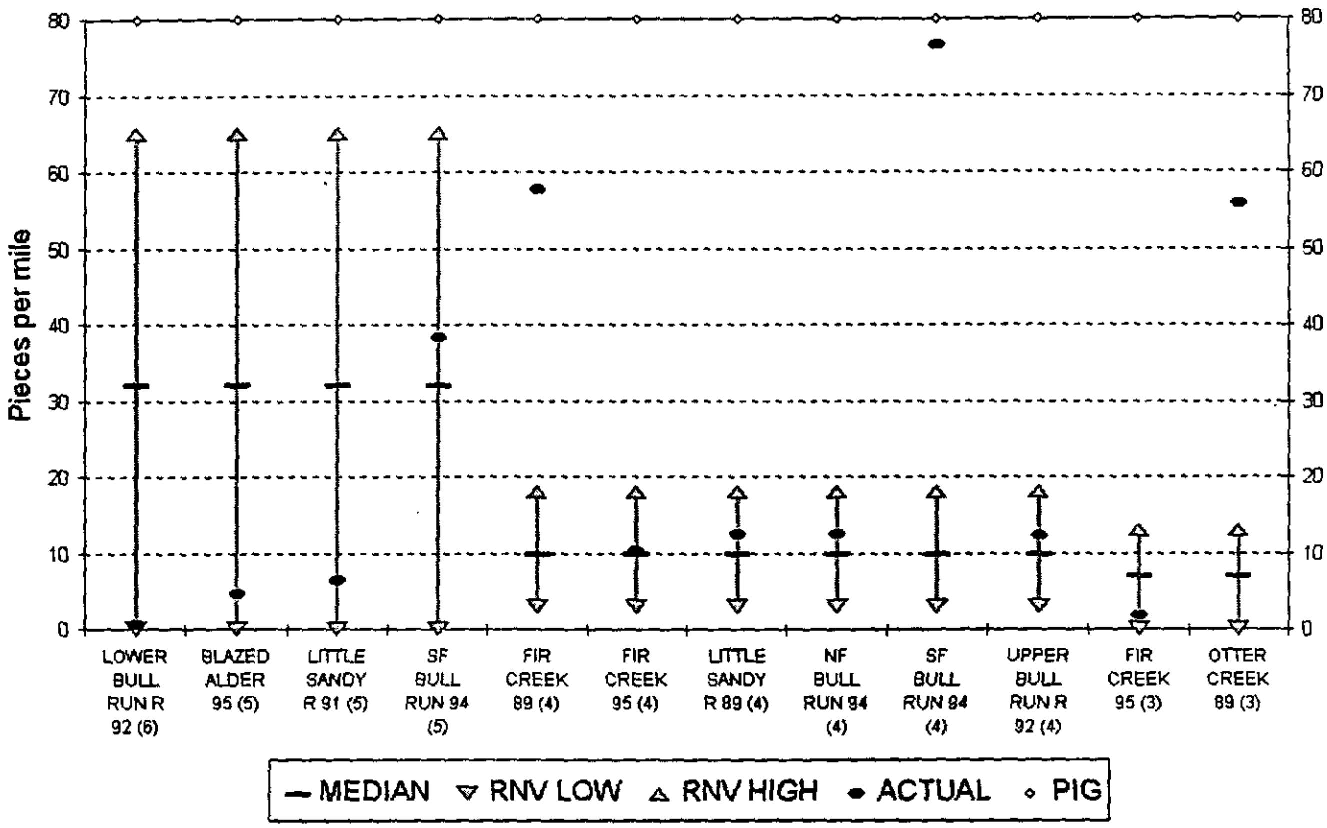
Large woody debris (LWD) provides: pool structure, sediment storage, substrate, partitioning of space, cover, nutrients, channel roughness, and velocity refuge for aquatic plants, fish, macroinvertebrates, and amphibians.

Debris jams are common in stream channels throughout the Bull Run Watershed. They are important transient features that can affect turbidity by controlling the mode and rate of channel erosion processes. Pools created downstream from debris jams provide sites where stream energy can dissipate in turbulent flow, rather than by eroding channel beds and banks (Keller and Swanson, 1979). Coarse bed materials that accumulate behind debris jams may armor channels and decrease erosion in weak parent materials such as unconsolidated tuffs and breccias. Fir Creek's channel exemplifies a stream that has naturally developed a stepped sequence of debris jams and accumulations of coarse bed material that has effectively armored the stream channel bottom through unconsolidated sections of the Rhododendron Formation (LaHusen, 1994).

Beneficial effects of debris jams are counteracted by their detrimental effects such as bank erosion caused by deflection of streamflow into unprotected banks. Another detrimental effect is catastrophic failure of debris jams with consequent release of sediment and channel scour. Failure of debris jams appears to occur episodically throughout the Bull Run Watershed (Nolan, 1984; Godbout, 1987). To quantify bedload transport in steep forested streams, Nolan (1984) surveyed several debris jams in intermediate-sized streams within the basin (LaHusen, 1994).

The current levels of large wood were queried from the SMART database. LWD has a diameter of 36 inches or greater, and length of 50 feet or greater. The RNV was established for the Sandy Basin by examining levels of LWD in unmanaged stream reaches stratified by stream order. In the same manner as pool counts and pool volume, to eliminate outliers and keep the RNV from being too wide, the RNV was established as the median plus and minus one standard deviation. Comparison to the PIG standards was completed because the PIG standards are an indication of the desired condition for streams in this area and are used as a "sideboard" for the current condition and the range of natural variation.

Chart 4-71 -- LWD Current Condition and RNV



As Chart 4-71 illustrates, levels of in-channel LWD are at the low end of the RNV and well below the median for similar stream orders within the Sandy Basin for: the Bull Run River, Blazed Alder, Little Sandy River, and the upper portion of Fir Creek.

It is notable that the RNV and current levels of LWD are well below the PIG standards. Fir Creek, an unlogged and unroaded basin -- therefore expected to be within the RNV and to meet PIG standards -- is well within the RNV in the lower portion (where it is a fourth order stream), but ranks at the low end of the RNV in its upper portion. Because both sections are well below the PIG standards, it may be appropriate to revise the PIG standards for this area based on site-specific information from the Bull Run Watershed and the Sandy Basin.

The contrast between LWD levels in an unmanaged area such as Fir Creek and an area heavily influenced by management such as Otter Creek illustrates problems when depending on the PIG standards. This dilemma is due in large part to the fact that PIG standards use a threshold for a standard rather than a range, which would more likely occur under natural conditions.

Fir Creek stream surveys taken from 1989 and 1995 yield very different levels of LWD. During this time period, no significant flow event occurred that would be expected with such a significant reduction in LWD (58 pieces of LWD per mile to 10 pieces per mile). (The maximum event was between 2 to 5 year recurrence interval.) Fir Creek has naturally developed a stepped sequence of debris jams and accumulations of coarse bed material that effectively armor the stream channel bottom through unconsolidated sections of the Rhododendron Formation (LaHusen, 1994). Thus, this unexplained reduction in LWD may have significant water quality effects.

Otter Creek also has levels of LWD outside and above the RNV. This area has been heavily disturbed, with timber harvest occuring in 73% of its Riparian Reserves. Otter Creek LWD levels are attributed to large amounts of recent LWD associated with the 1983 blowdown event.

Godbout (1986) concluded that within the Bull Run Watershed, primary factors influencing log jam movement include: size and relief of the upstream drainage area, valley bottom configuration, floodplain width, substrate composition, and channel sinuosity. Log jams most susceptible to movement are generally located in narrow valley bottoms on meander-free, bedrock-controlled streams that drain a large high-elevation area.

First 3.9 Miles of Bull Run Channel

The first 3.9 miles of the Bull Run channel from the confluence with the Sandy River, is classified as a box-like canyon with steep (>60%) side slopes. The next section of the river up to the lower reservoir has a U-shaped floor with moderate to steep sideslopes (>30%). The entire section of the lower Bull Run River contains a dominant substrate of small boulders with a bedrock control. Based on Godbout's conclusions this type of channel would not retain large amounts of LWD.

Blazed Alder Channel

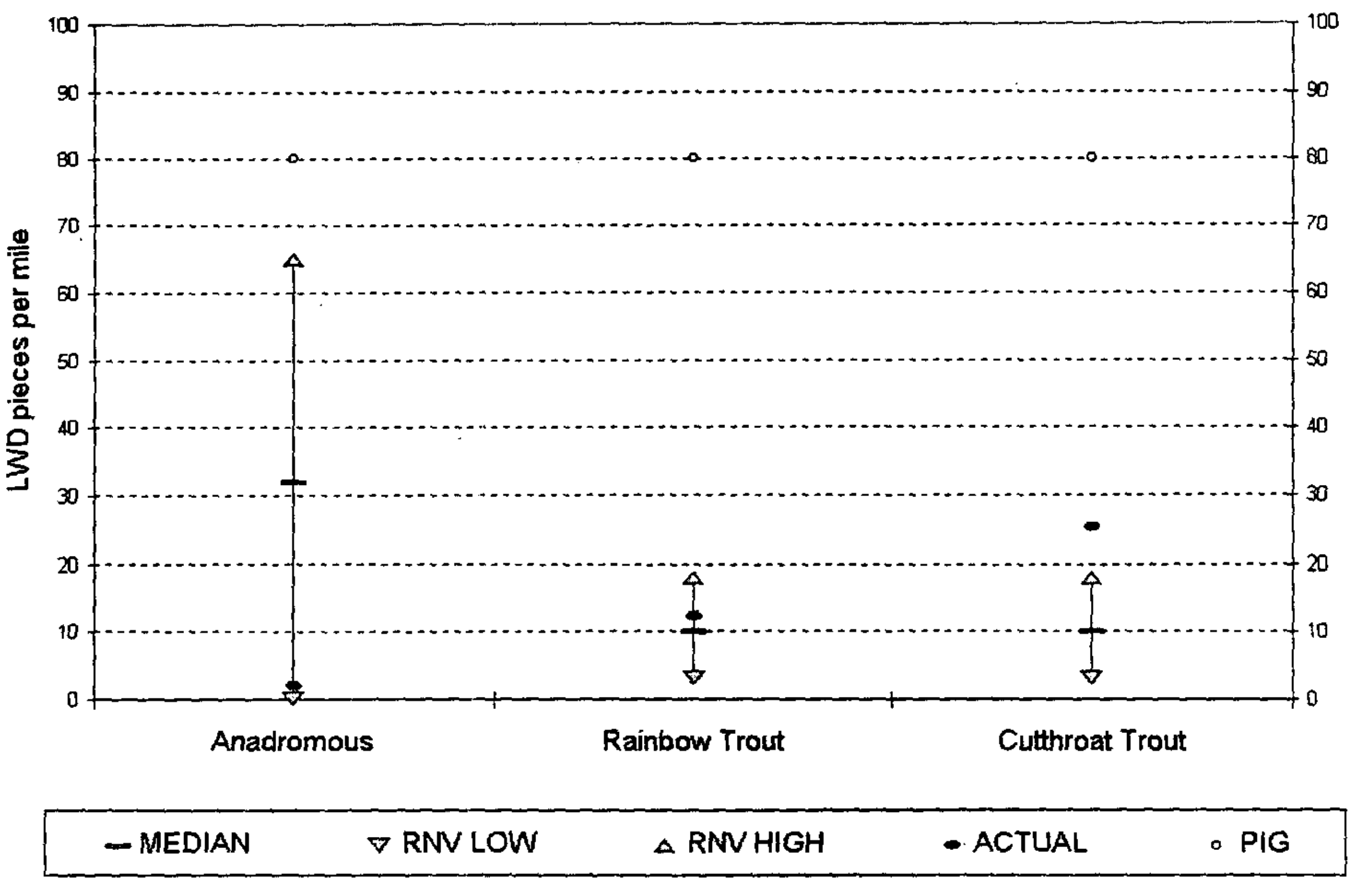
Current low levels of woody debris within the Blazed Alder channel are attributed to the channel's geometry. Blazed Alder has a high capacity to move log jams during peak flow events. This is due to a large, high-elevation drainage area, an incised flat bottom canyon with little floodplain development, low sinuosity, and bedrock substrate (Godbout, 1987).

Lower Little Sandy River

Levels of woody debris within the lower Little Sandy River are attributed to channel form, stand structure, timber harvest and associated management activities. The channel form is classified as narrow to moderate V-shaped, with moderate to steep side slopes. This type channel configuration is not optimal for retention of woody debris. Within the Bull Run Watershed, the Lower Little Sandy subwatershed maintains the highest percentage of Riparian Reserves within federal ownership that have been harvested. Within this subwatershed, 29% of the Riparian Reserves within federal ownership have been harvested -- 74% of which was harvested prior to 1980. In addition, harvest prior to 1980 would have most likely included stream cleanout as a standard practice.

Fish Stock Concerns

Chart 4-72 – LWD and Fish Stocks



All woody debris levels -- including LWD -- are at the low end of the RNV and well below PIG standards within the portion of the watershed utilized by anadromous fish (coho salmon, chinook salmon, sea-run cutthroat, and steelhead trout). This is attributed to a combination of natural factors, including channel type and configuration, as well as management factors -- such as removal of woody debris at the reservoirs and at the Little Sandy diversion.

The lack of LWD in this area also has the potential to affect spawning gravels in the watershed's anadromous section. Coarse bed materials that accumulate behind debris jams may have the potential to serve as spawning gravels.

Levels of LWD in the lower Bull Run River and lower Salmon River were compared. Within the Sandy Basin, the lower part of the Salmon River is the most similar stream reach to the lower Bull Run River. They are similar in stream types and basin area. Their major difference is that the Bull Run channel receives considerably more flow, 2.1 times as much for a 2-year recurrence interval event and 1.4 times as much for a 100-year event.

Even though portions of the lower Salmon River were cleaned of LWD after the 1964 flood, six pieces of LWD per mile currently occupy the lower Salmon River, compared to 1 piece per mile in the lower Bull Run River. While the lower Bull Run River channel is not optimal for retaining LWD, the levels of LWD appear to be below the RNV when compared with a stream of similar order in the Sandy Basin.

LWD levels in the portion of the upper Little Sandy River that is utilized by rainbow trout are below PIG standards but above the median and well within the RNV for the Sandy subbasin. Based on the RNV, LWD levels are not of concern in the upper Bull Run River.

In the upper section of the Bull Run River populated by a unique genetic stock of cutthroat trout, LWD levels are below PIG standards but outside and above the RNV. Based on the RNV, LWD levels are not of concern in the upper Bull Run River.

LWD Recruitment Potential

To assess the trend in in-channel LWD for this analysis, the LWD recruitment potential of Riparian Reserves was assessed using the methodology from the Washington Department of Natural Resources (DNR) Standard Methodology for Watershed Analysis. LWD recruitment potential was rated as high, moderate, or low based, as shown on the following matrix:

Dominant Tree Type	Young/ Sparse	Young/Dense	Mature/ Sparse	Mature/ Dense	Old/Sparse	Old/Dense
Conifer	Low	Moderate	Moderate	Moderate	Moderate	High
Deciduous	Low	Low	Low	Moderate	Low	Moderate

"Young" is defined as seedlings, saplings and poles; "Mature" is closed small conifer, closed variable structure, open small conifer, and open variable structure; and "Old" is open and closed large conifer. "Sparse" is less than 70% canopy closure.

Chart 4-73 – Distribution of LWD Recruitment Potential Classes

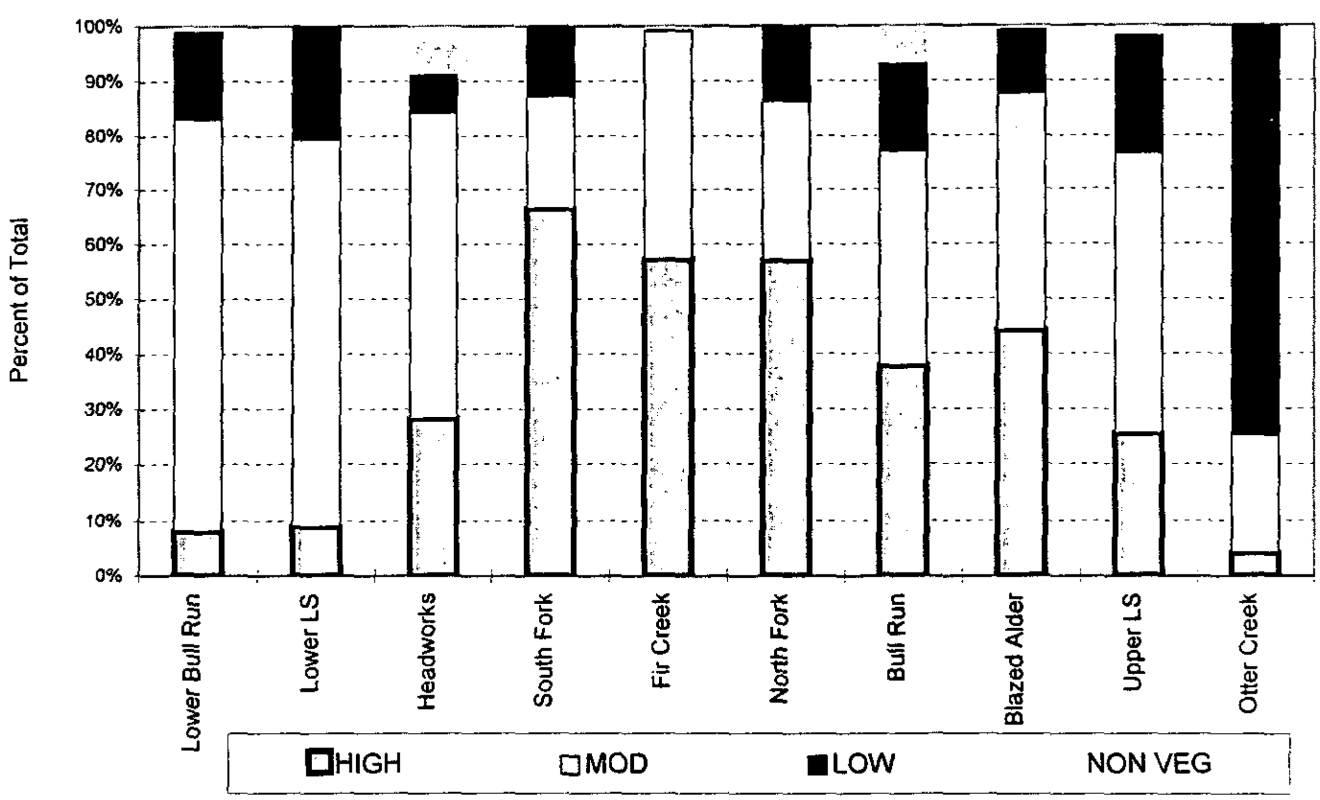


Figure 4-54 -- Large Woody Debris Recruitment Potential

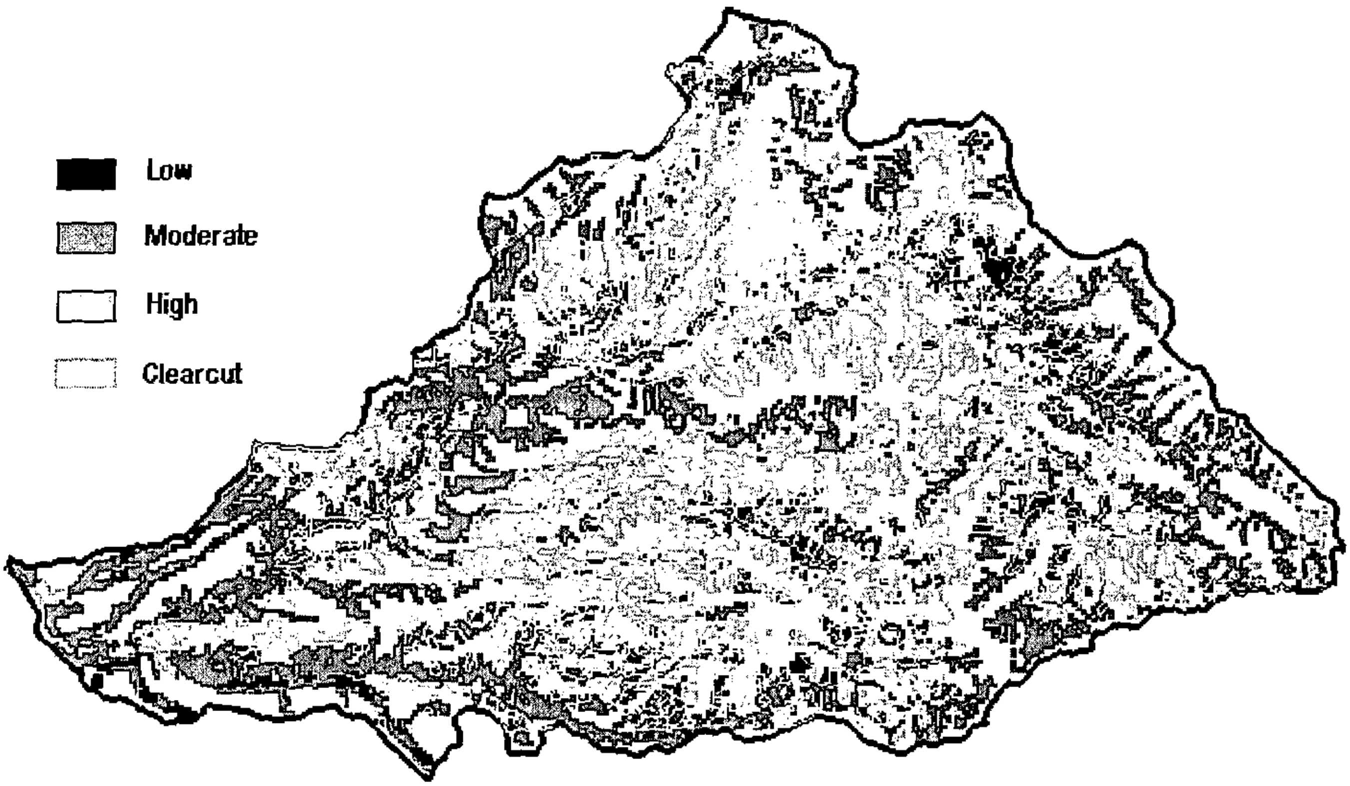


Table 4-49 -- LWD Recruitment Potential by Subwatershed

SUBWATERSHED	LOW	MOD	HIGH	NON VEG
Lower Bull Run	16	75	8	1
Lower LS	21	70	9	0
Headworks	7	56	28	9
South Fork	13	21	66	0
Fir Creek	0	42	57	1
North Fork	14	29	57	0
Bull Run	16	39	38	7
Blazed Alder	12	43	44	1
Upper LS	21	51	25	2
Otter Creek	74	21	4	0

Fifty-seven percent of the Riparian Reserves within the Fir Creek subwatershed (which is non-logged and unroaded) are in the high LWD recruitment class. This also reflects the condition in the South Fork, North Fork, and Blazed Alder subwatersheds, in which limited management activity has occurred inside the Riparian Reserves. Based on the values from Fir Creek, 50-60% of the area within the Riparian Reserves in the high LWD recruitment potential category appears to reflect the undisturbed LWD recruitment condition.

The Lower Bull Run and Lower Little Sandy subwatersheds have less than 10% of the area within Riparian Reserves in the high LWD recruitment potential category. Considerably lower than the undisturbed condition reflected by the Fir Creek subwatershed, this indicates impacts associated with land management activities or natural disturbances in this area.

Portions of the Lower Little Sandy and the Lower Bull Run subwatersheds burned in 1693 and in 1873. These events could account for some of this area's altered stand structure, which is reflected in the LWD recruitment potential. Within the Lower Little Sandy subwatershed, 29% of the area in Riparian Reserves has been clearcut. This is the highest level in the entire watershed.

A high percentage (75%) of the Lower Bull Run subwatershed's land-base within Riparian Reserves is in private ownership. Within these areas, records of timber harvest are not available. Within this subwatershed, 8% of the Riparian Reserves are in late-seral stand conditions, and 75% is in mid-seral stand conditions. Since the last fire in the Lower Bull Run subwatershed was in 1873 this would indicate altered stand structure associated with timber harvest or development in private land.

The Headworks, Bull Run, and Upper Little Sandy subwatersheds have from 28-38% of the Riparian Reserves in the high LWD recruitment potential class. This indicates a slightly altered condition from the undisturbed condition for this watershed. This is attributed to reservoirs, historical harvest, and the disturbance regime. The Headworks and Bull Run subwatersheds have 9% and 7%, respectively, of the Riparian Reserves classified as non-vegetation (water and rock). The amount of area within the low LWD recruitment potential class is well correlated with the amount of clearcut harvest within these watersheds.

The natural disturbance regimes of fire and windthrow also appear to have some effect on the LWD recruitment potential in these subwatersheds. Portions of the Headworks and Upper Little Sandy subwatersheds burned between 112 and 120 years ago. This could account for the stand structure that is classified as moderate LWD recruitment potential in these areas. A large portion (12%) of the Riparian Reserves within the Bull Run subwatershed blew down in the 1983 blowdown event, which may account for this subwatershed's altered stand structure.

Figure 4-54 identifies three continuous areas with low levels of LWD recruitment. The first area, Otter Creek, has been heavily impacted by windthrow and associated harvest activities (74% of its Riparian Reserves have been clearcut). During the mid-1970s, the other two areas, upper Cedar Creek and Blazed Alder, were both clearcut to the streams to provide for future reservoir construction. The reservoirs associated with these areas were never built and are not referenced in the Regional Water Supply Plan.

LWD Recruitment Potential and Fish Stocks

In the portion of the Bull Run Watershed utilized by anadromous fish (Lower Bull Run and Lower Little Sandy subwatersheds), the LWD recruitment potential is well below the undisturbed condition, as well as the LWD recruitment potential of the other subwatersheds. In addition, this same area currently has very low levels of in-channel LWD. The combination of these factors implies that in-channel LWD levels with not recover in the near term.

The Upper Little Sandy subwatershed that is utilized by rainbow trout is slightly altered from the natural condition for LWD recruitment. Currently, however, this area is above the median, and well within the RNV for in-channel LWD. Therefore, LWD recruitment potential is not of concern in the short term..

The upper Bull Run River which is utilized by cutthroat trout has slightly less LWD recruitment potential than the undisturbed conditions. Current levels of in-channel LWD, however, are well above the RNV for this area. Thus, future recruitment of LWD is not a concern in the short term.

Oregon Department of Fish and Wildlife Draft Sandy Basin Plan

The draft Sandy River Basin Fish Fish Management Plan is currently out for review. The habitat objectives from this plan are:

1. Maintain and improve upstream and downstream passage for fishin hte Sandy River basin at dams, water diversions, existing fishways, culverts, and where needed at in-channel debris jams.

2. Protect, enhance, and restore fish habitat in the Sandy River basin.

3. Inventory stream and watershed conditions using current methods to assess factors limiting fish production in the Sandy basin.

4. Reduce artificial introductions of sediment into the Sandy River and basin tributaries.

5. Restore natural streamflows where possible, and protect existing streamflows and water quality from degration associated with operation of dams, water diversions, effluents, mining, timber harvest, recreation, and other instream activities.

The Forest Service is coordinating closely with the Oregon Department of Fish and Wildlife regarding their plan.

Conclusions Fish Habitat

Anadromous Reaches (below dams)

- 19% of the historical habitat within the Bull Run Watershed is currently available due to dams on the Bull Run and Little Sandy rivers.

- Dams on the Bull Run and Little Sandy rivers have resulted in a severly altered low flow regime below these facilities. Both the Bull Run and Little Sandy rivers are essentially dewatered during the summer low flow period.

- Pool counts are at the low end of the range of natural variation, however, pool volumes are outside and above the range of natural variation indicating large mainstem pools.

- Large woody debris levels are very low (less than 1 peice per mile), but still within the range of natural variation..

- Large woody debris recruitment potential is well below the undisturbed condition.

Resident Reaches Above Dams

- Aquatic habitat types, pool volumes, large woody debris levels and large woody debris recruitment potential is in the mid to upper range of natural variation for these components and would appear to meet habitat requirements for resident fish.

Commodities

The section focuses on commodities available on National Forest lands within the Bull Run Watershed.

Timber

Logging in the watershed began in the 1800s with a minimal amount of harvest by the Bridal Veil Lumber Company inside the Bear Creek headwaters area. In 1925, harvest of nearly 500 acres cleared the site for Reservoir #1. Additional harvest in the Larch Mountain area occurred within the Little Sandy Watershed prior to 1950. During 1956-57, approximately 700 acres were cleared as construction started on Reservoir #2. Apart from this reservoir activity, specific harvest acreage and location within the watershed prior to 1958 is not well documented.

In 1958, a major harvest and road construction program began within the watershed on National Forest lands. This timber harvest continued into the 1960s to provide forest products under the policies of Multiple Use and Sustained Yield to furnish forest products and promote healthy and vigorous growing stands. This harvest and road building activity also provided better fire protection and, thereby, enhanced watershed protection.

As a result of a January 1973 windstorm, more than 1300 acres of forest blew down (Sinton 1996). Approximately 940 acres were salvaged. Since 1973, the majority of harvest in the physical drainage has been the salvage of blowdown. For instance, a December 1983 windstorm blew down an additional 3400 acres of forest (Sinton 1996). In the aftermath of this event, 1400 acres were salvage-logged in the late 1980s and early 1990s. Timber harvest activities in the Little Sandy Subwatershed have been ongoing since the 1960s.

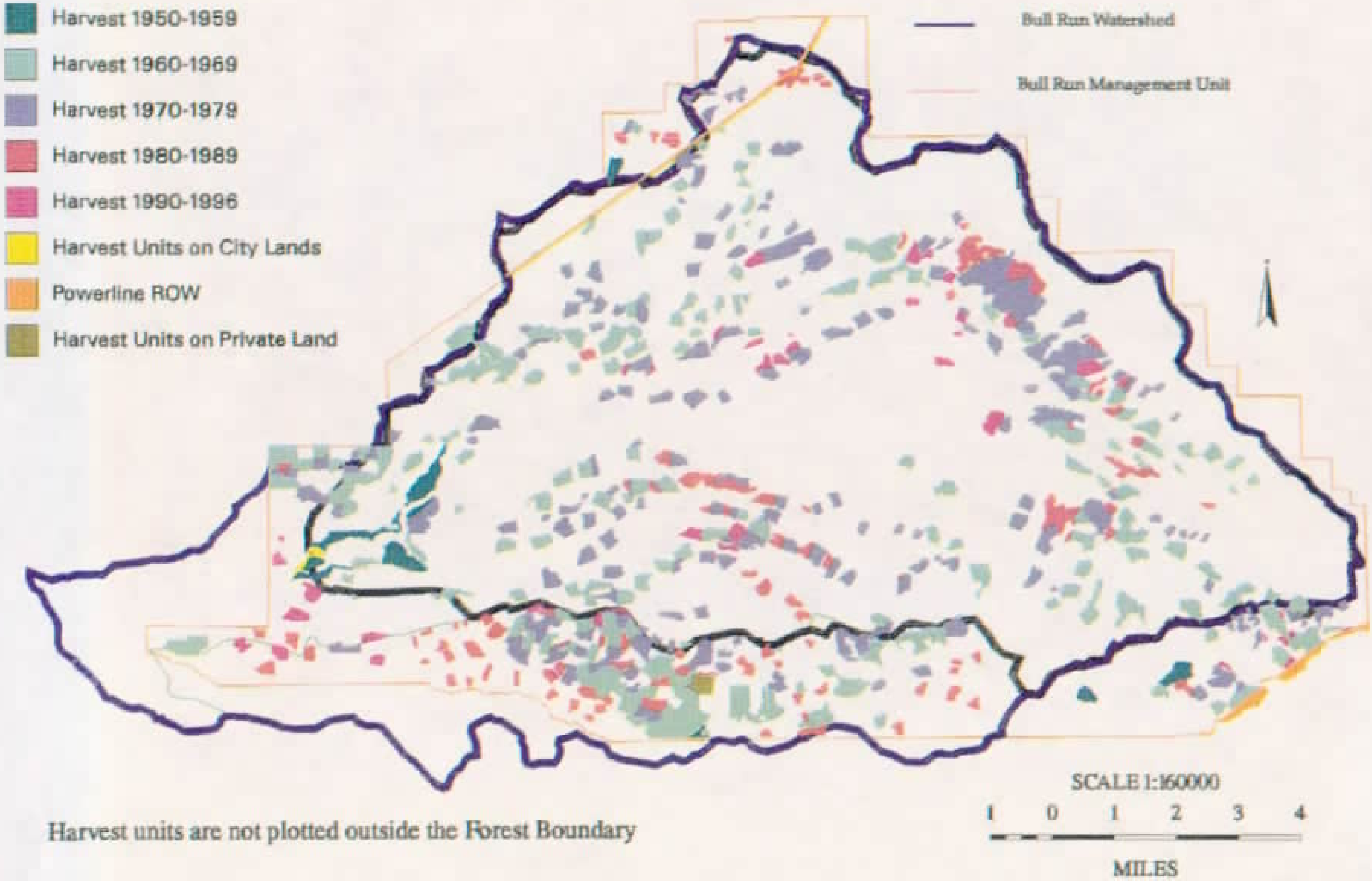
Timber harvest history and patterns on private lands within the Bull Run Watershed were not reviewed for this analysis.

Records for clearcut timber harvest data within the watershed come from two spatial databases. Sources used for the watershed analysis are from the ARCINFO managed stands coverage.

Table 4-50 -- Clearcut Timber Harvest (acres) on National Forest Lands within the Watershed

SUBWATERSHED	1950-1959	1960-1969	1970-1979	1980-1989	1990-1993	Total
Blazed Alder	0	986	445	279	128	1838
Bull Run	0	906	1719	556	289	3470
Fir Creek	0	22	62	7	0	91
Headworks	457	1591	1020	94	93	3255
Lower Bull Run	30	254	131	46	148	609
Lower Little Sandy	22	1240	748	576	198	2784
North Fork	0	388	363	86	0	837
South Fork	17	531	944	333	104	1929
Upper Little Sandy	0	650	245	274	0	1169
TOTAL	526	6568	5676	2251	960	15981

Bull Run Watershed Timber Harvest



Harvest units are not plotted outside the Forest Boundary

Special Forest Products

A variety of non-timber forest products are found on national forest lands within the watershed. These include: firewood, round wood posts and poles, mushrooms, huckleberries, floral greenery, and transplants. Due to access restrictions, however, none of these products are currently gathered on National Forest lands inside the Bull Run or Little Sandy watersheds. Firewood resulting from timber harvest activities has traditionally been transferred to sites outside the watershed for the general public's availability. Seasonal public use of Forest Service Road 2503 (in the Little Sandy Watershed) is allowed during deer and elk hunting seasons.

Minerals

There are three main categories of minerals: locatable, leaseable, and salable. Locatable minerals are generally hardrock minerals which are mined and processed for the recovery of metals such as gold, silver, copper, lead and zinc. Leaseable minerals include coal, oil, natural gas, and geothermal. Salable minerals include common mineral materials such as construction stone, sand, gravel, cinders, pumice and clay.

There are no existing locatable mining claims within the watershed. Furthermore, because the Bull Run Watershed Management Unit has been withdrawn from locatable mineral entry, no new mining claims can be established within its boundaries.

In the past, several mining claims were located north of Marmot in the Lower Little Sandy subwatershed. These claims have either been abandoned or closed. This is the sole location within the watershed in which locatable mineral development could occur. Based on geologic inventories, however, a low potential for economic deposits of locatable minerals exists within the Bull Run watershed.

There are no approved leases or pending leases for any leaseable minerals within the watershed. The US Bureau of Mines considers most of the watershed to be a "less favorable or unknown" area for leaseable minerals. Approximately 300 acres of the watershed near North Mountain are rated "moderately favorable" for geothermal. Additionally, the western half of the watershed (Range 5E and 6E), is rated "moderately favorable" for oil and gas. Considering the historical record and known geology in and around the watershed, the area must be considered to have low to moderate potential for oil, gas, and geothermal, and very low for coal and all other leaseable minerals.

There are six major developed rock quarries and numerous smaller quarries located within the watershed. For the most part, material from these quarries has been used by the Mt. Hood National Forest and City of Portland for watershed road construction projects. The majority of rock within the watershed is good quality material, suitable for construction rock. The watershed has a high potential for construction rock that could be processed to produce commercial quantities of riprap, pit run, or crushed aggregate. No other salable minerals occur in economically-feasible quantities within the watershed.

Road Construction History

Prior to 1950

Road construction began in the Bull Run Watershed in the 1890s when the City of Portland began using the Bull Run River for its municipal water supply. In the early 1900s, the Bridal Veil Lumber Company also built logging roads in the Larch Mountain area. Additional road construction in the 1920s enabled construction of the first Bull Run reservoir.

Through the 1930s, the Forest Service introduced roads as firebreaks and to access fire lookouts. By 1950, 70 miles of road had been built within the watershed, providing access to Reservoir #1 and the ridges along the north and south watershed boundaries. Pre-1950 road construction practices included: sidecast of fill material, burying of organic debris, and inadequate culvert sizing and spacing.

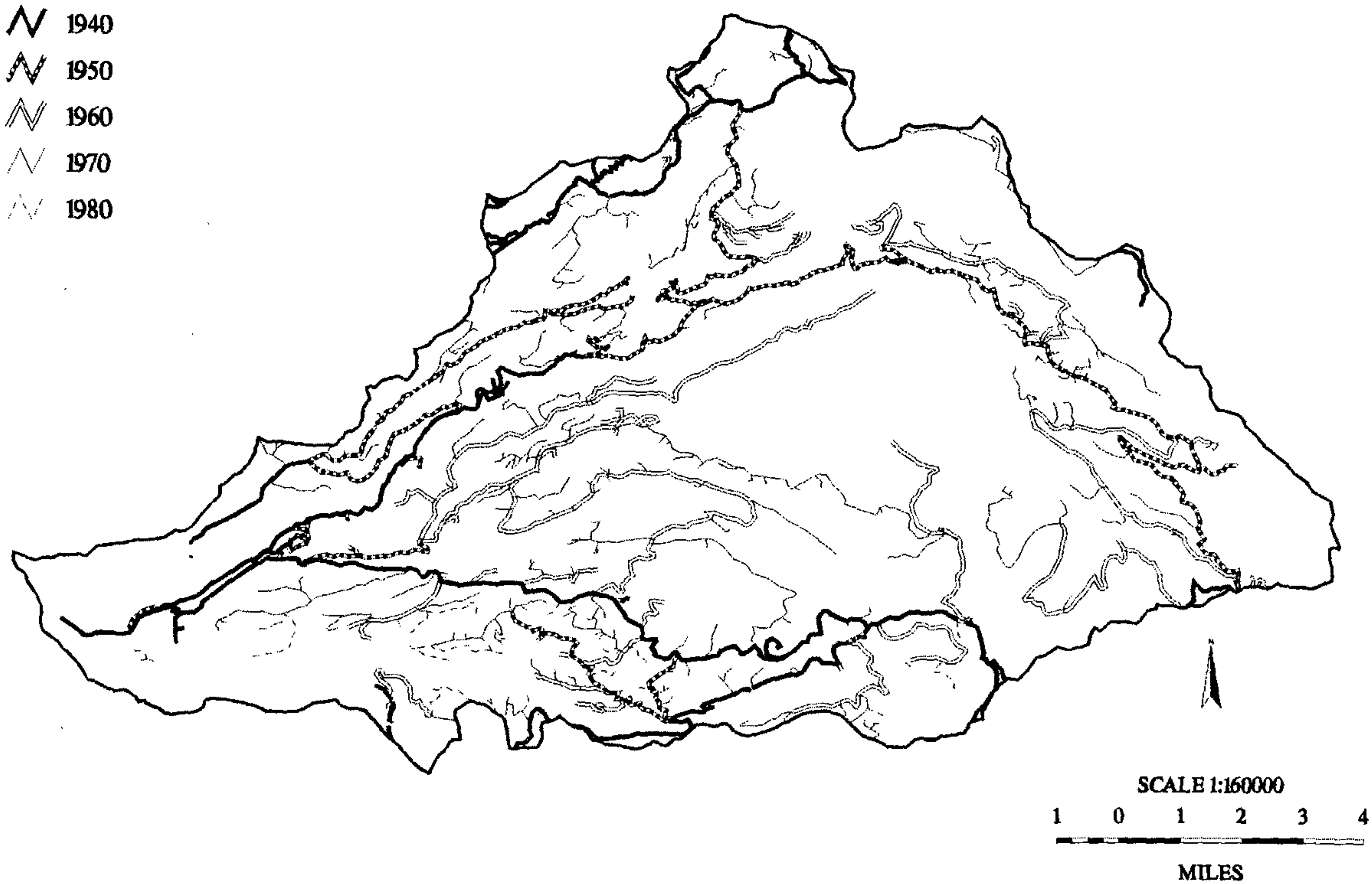
1950s

During the 1950s, Bull Run Watershed roads were constructed by timber purchasers for the Forest Service. By the end of the decade, roads accessed Bull Run Lake, the lower Little Sandy Watershed, and the North and South Forks of the Bull Run River. Under the era's timber sale contracts, these purchasers tended to construct low quality roads by sidecasting fill material, burying organic debris, and applying inadequate culvert sizing and spacing. Their roads also lacked rock surfacing.

1960s

By the end of the 1960s, the majority of the watershed's mainline roads had been constructed. Road 1211 was extended up the main Bull Run River valley, south of the reservoirs. Other roads were extended into the following drainages: North and South Fork Bull Run, Camp, Blazed Alder, and Hickman. In addition, by the late 1960s, road construction practices had substantially improved. Right-of-way debris was no longer buried, compaction of fill materials was commonplace, and asphalt surfacing was required on main log-haul routes. Culvert spacing was also being designed using improved knowledge of road drainage and local hydrologic factors.

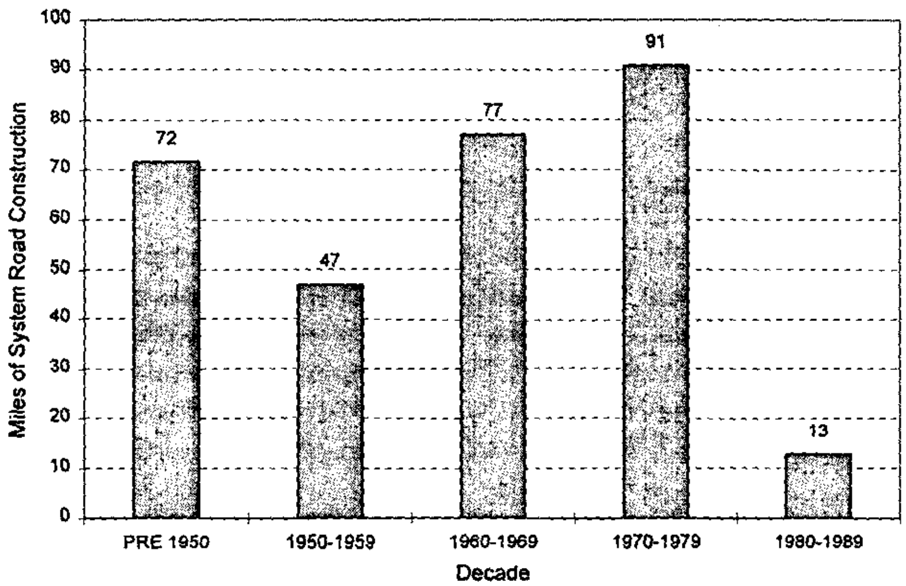
Bull Run Watershed
Road Construction History



1970s

Nearly two-thirds of the roading of the Bull Run -- more than 170 miles of Forest roads -- occurred in the 1960s and 1970s (Figure 4-57). By the end of the 1970s, with the majority of mainline roads completed, new construction turned to collectors and local roads. Road construction practices in the 1970s incorporated increased engineering and design standards. Since the late 1970s, no significant changes have been introduced in Forest road construction practices.

Figure 4-57 -- Road Construction History



Current Road Network

An additional 12 miles of system road was constructed within the watershed during the 1980s and 1990s. In more recent years, past construction practices -- such as burying organic debris, sidecast of fill materials, and uncompacted fills -- have contributed to current road maintenance problems. Sidecast and uncompacted fill materials may continue to destabilize over time, resulting in future failure of fill materials.

Additionally, decomposition of organic debris within roadbeds can result in road settling, slumping and sliding. Tension cracks in road beds have been identified in areas where these inferior construction practices were implemented (roads 1000 and 1200, north and south of Reservoir #2). Aside from a few locations in which steep slopes combine with weak bedrock geology, few areas exist within the watershed where road settling and slumping create slope stability hazards.

Figure 4-58 -- Current Road Distribution

SUBWATERSHED	TOTAL ROAD MILES	ROAD DENSITY
Blazed Alder	26.93	1.65
Bull Run	53.06	1.69
Fir Creek	2.85	.49
Headworks	80.28	3.25
Lower Bull Run	26.23	2.20
Lower Little Sandy	48.54	3.02
North Fork	22.67	2.72

Currently, 320 miles of road are located within the watershed. Overall objectives of the existing road system are based on management direction from Public Law 95-200 and the *Bull Run Planning Unit Final Environmental Impact Statement* (1979) (FEIS). Additional guidance is mandated from the *Bull Run Watershed Management Unit Administration and Operation Guidelines for Implementation of Sub-Basin Plans* (Mt. Hood National Forest, 1985).

These operation guidelines prescribe the following on an annual basis for all constant service roads within the physical drainage: brushing, culvert and trash rack clean out, and roadside revegetation and stabilization. (Constant service roads are defined as roads needed for yearly land management use; or those with maintenance levels 2 through 5).

Trends

Subsequent to the implementation of road maintenance guidelines in the FEIS and Administration and Operation plan, the National Forest road maintenance budget has declined considerably. Therefore, currently, (during the writing of this Watershed Analysis document) new road maintenance objectives are being considered for the Bull Run Watershed.

Over the last few years, approximately 20 miles of the watershed's roads have been closed by gate, berm, signing, or abandonment (operation maintenance level 1). To prevent damage to other resources, these roads receive basic upkeep. At this time, an additional 100 miles of the watershed's roads are also being considered for this level of maintenance.

(The discussion under Key Question #6 in Chapter Six contains additional information on the watershed's existing and proposed road network.)

Chapter 5

Landscape Analysis and Design

Chapter 5 Landscape Analysis and Design

Introduction

The Forest Landscape Analysis and Design (LAD) Process (Diaz and Apostol, 1992), joins forest planning with the principles of landscape ecology. This process displays the conditions that likely would result from implementing current plans, and assists forest managers in addressing landscapes as ecosystems. In doing so, the LAD process emphasizes the conscious design of patterns in the landscape.

LAD's objective in the watershed analysis process is to synthesize current management direction into a spatial depiction of vegetative patterns and forest structures; and to assist in synthesizing information about physical, biological, and social processes. Through the LAD process, future ecological patterns and potential landscape vegetation patterns are mapped, based on current land allocations and standards and guidelines.

This conceptual landscape design becomes an integral and essential step in answering the Watershed Analysis's Key Questions, especially regarding future trends.

LAD is an ongoing, iterative process. After completion of the Watershed Analysis, additional Landscape Analysis and Design steps should be conducted to:

- ***Develop an interim landscape design to manage for the desired future condition.***
- ***Graphically display where future management activities could occur to serve as a bridge between analysis and site-specific project development.***

Conceptual LAD Mapping Process

The Bull Run Watershed Analysis Team, together with an interdisciplinary group of resource specialists and representatives from the Portland Water Bureau and U.S. Fish and Wildlife Service, translated current management direction and landscape potential into a Conceptual Landscape Design Map. Through a spatial depiction of vegetative patterns and forest structures, this map projects and depicts how the watershed's landscape may appear 50-200 years into the future.

To do so, eight different "Design Cells" were created and mapped that illustrate these potential future vegetation patterns within the Bull Run Watershed. Design Cells are descriptions of future stand structure and vegetative patterns that will likely occur across the watershed as a result of current management direction.

In addition, information concerning physical and biotic characteristics of the landscape, social desires, and ecological processes and functions attained through the Watershed Analysis process also helped create the Design Cells.

Design Cells are descriptions of future stand structure and vegetative patterns that will likely occur across the watershed as a result of current management direction.

The following criteria were used to delineate individual Design Cells:

- Areas where structure and function of vegetation appear to be different at the landscape scale.
- Areas where structure or pattern of vegetation may differ -- now and in the future -- as a result of forest management.
- Areas with different landscape potential.
- Areas with recognizable natural landscape patterns.
- Areas that can be readily mapped at the landscape scale.

Design Cells

All eight individual Design Cells are described in terms of how these potential landscapes will likely appear in the future (Table 5-1) and inlcude:

- **Design Cell Name** -- *descriptive name that describes the Cell's future condition.*

- **Land Allocations** -- *list of Forest Plan allocations (which drive future landscape patterns) that occur in the Cell within the watershed.*

- **Ecological Unit** -- *predominant type of ecosystem.*

- **Landscape Pattern** -- *general arrangement of Cell type upon the landscape.*

- **Stand Structure** -- *general appearance of the Cell.*

- **Landscape Objective** -- *goals for land management within the Cell.*

Bull Run Watershed
Conceptual Landscape Design

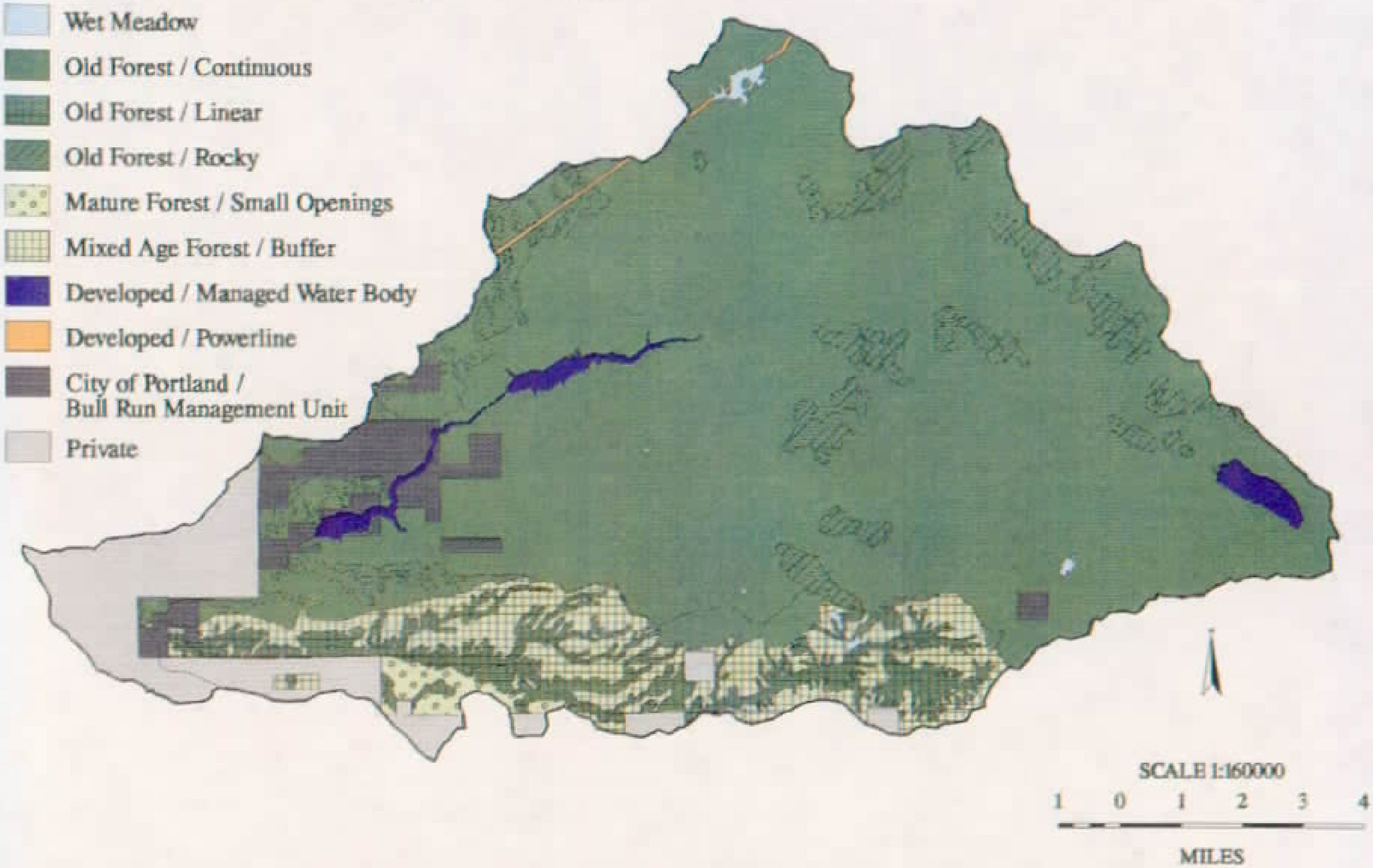


Table 5-1 -- Landscape Design Cells for Bull Run Watershed Analysis Area

DESIGN CELL NAME	ACRES	LAND ALLOCATIONS	ECOLOGICAL UNIT	LANDSCAPE PATTERN	STAND STRUCTURE	LANDSCAPE OBJECTIVE
Developed / Managed Water Bodies	1230	DA1/LSR	lakes / reservoirs	open water	non vegetated	• maintain and protect water quality and quantity • maintain and promote late successional forest habitat
Developed / BPA powerlines	150	DA1/LSR DA1	human infrastructure	linear openings	young trees, shrubs and grasses occasional taller trees in drainage areas	• powerline right-of-way
Wet Meadows	247	DA1 DA1/LSR DC1	wetlands	open water openings within forest	emergent forb and shrubs	• maintain and protect wetland diversity and function
Old Forest / Rocky	4438	DA1 LSR DA1/LSR	old forest with talus and rock outcrop	scattered rock patches	old trees; size may be limited by harsh site, standing dead and fallen trees, shrubs in openings and understory	• maintain and protect unique habitat and natural diversity
Old Forest / Continuous	60,748	DA1/LSR LSR BLM DB8 DC1	old forest	continuous forest cover with small natural openings	large, old trees; standing dead and fallen trees; shrubs and small trees in the understory	• maintain and protect water quality and quantity • maintain and promote late successional forest habitat

DESIGN CELL NAME	ACRES	LAND ALLOCATIONS	ECOLOGICAL UNIT	LANDSCAPE PATTERN	STAND STRUCTURE	LANDSCAPE OBJECTIVE
Old Forest / Linear	5,396	DA9 RR DA1	old forest along streams	linear arrangement of continuous forest along streams	large, old trees; standing dead and fallen trees; shrubs and small trees in the understory	• maintain and promote riparian resource values • maintain and promote connectivity between late successional forest patches • maintain and promote connectivity between stream and upland habitats
Mixed Age Forest / Buffer	6,259	BLM C1 DB8 DC1	managed forests	a mosaic of forest stands of varying ages openings <25 acres over less than 25% of the area	discontinuous forest canopy with multi-aged, multi-storied trees	• maintain and protect water quality and quantity • timber production • vegetation management recognizes windthrow and fire processes and aims to reduce effects of wind and fire on Bull Run Watershed Management Unit
Mature Forest Small Openings	795	B10 B2	managed forests	open patches within forest patch size <5 acres over 20% of area	grassy openings among even aged managed stands Varied. Naturally appearing stands from Hwy 26.	• provide high quality deer and elk winter habitat • provide visually appealing forest scenery • timber production

The following are examples of how some of the Design Cells could appear across the landscape.

Figure 5-2 Old Forest Continuous, Old Forest Rocky, Wet Meadow

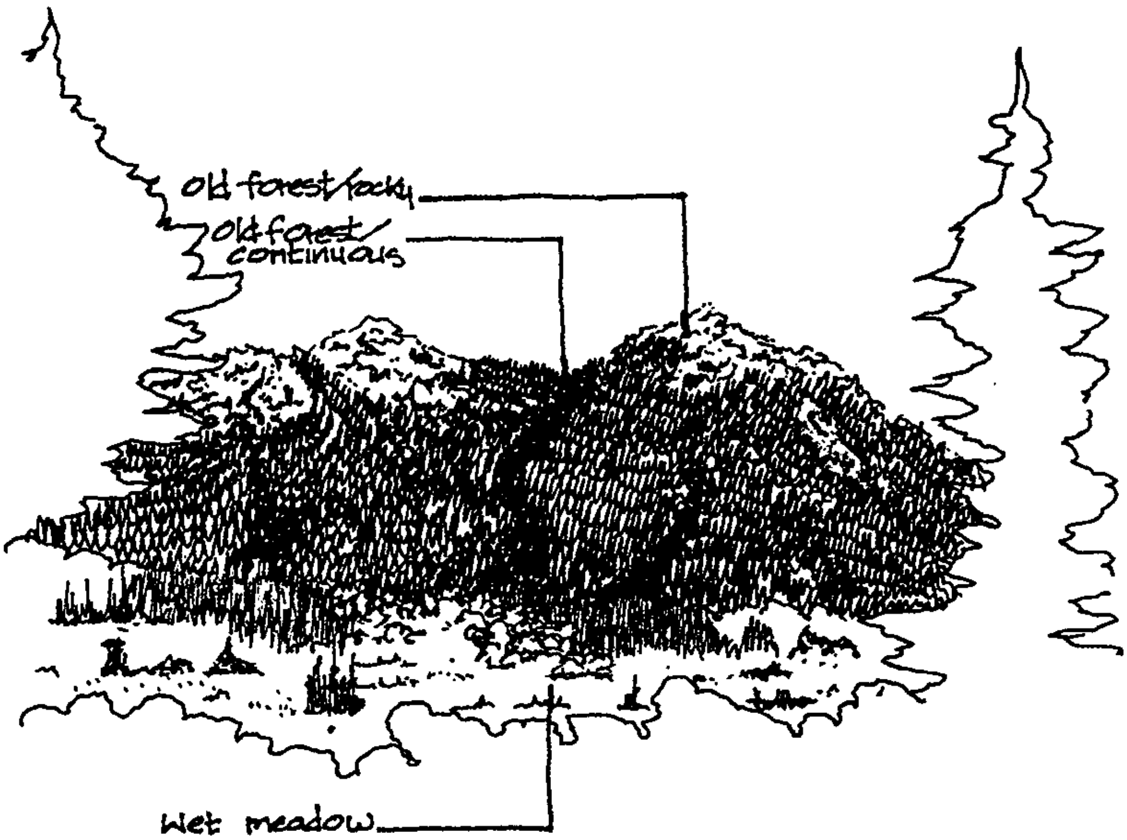


Figure 5-3 Developed/Powerlines

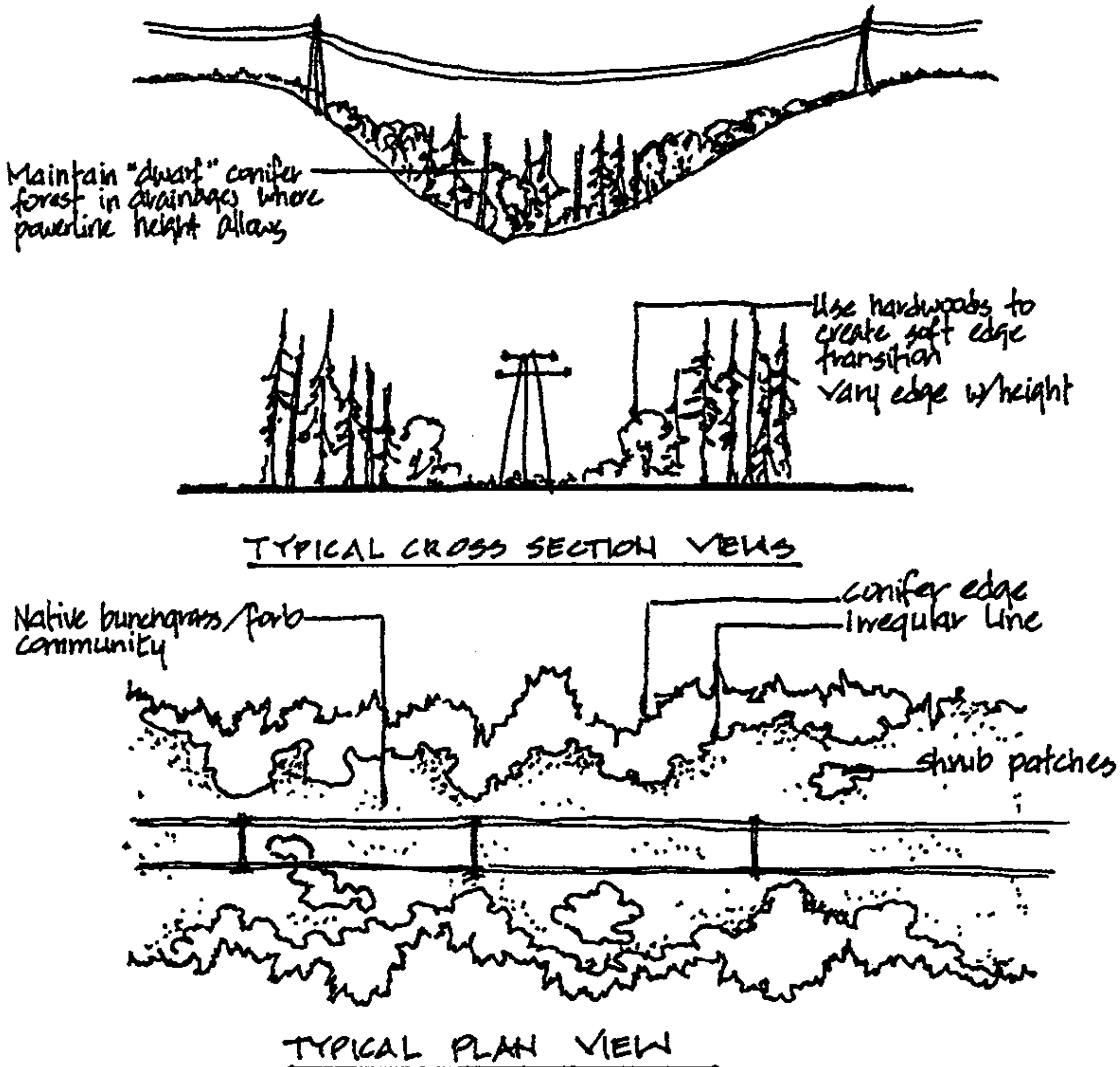
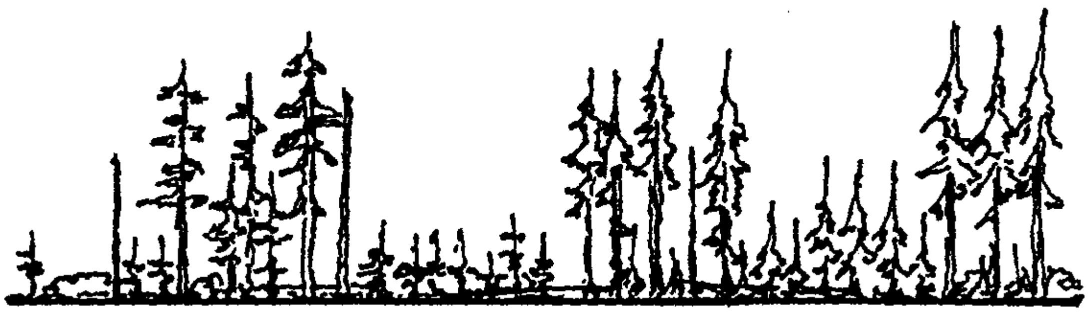


Figure 5-4 Mixed Aged Forest



TYPICAL CROSS SECTION VIEW

TYPICAL LANDSCAPE VIEW

Seral Stage: Future Trend

The Conceptual Landscape Design was used to calculate the future condition of the Bull Run Watershed in terms of seral stage and landscape pattern. Seral stage affects a variety of ecosystem functions, including: wildlife species use, hydrologic function, production of snags and coarse woody debris, nutrient cycling, and disturbance processes such as fire and windthrow. The conceptual future condition for seral stage is used in addressing many of the Key Questions in Chapter 6.

Conceptual Landscape Design Cells were projected into the following future seral stages:

Late-seral forest

- Old Forest/Continuous
- Old Forest/Linear
- Old Forest/Rocky
- Wet Meadows
- City of Portland Lands within the water supply drainage
- Some Private lands

Mid-seral forest

- Mixed-Age Forest/Buffer
- Mature Forest/Small Openings
- Some Private lands

Early-seral forest

- Developed/BPA Powerlines
- Some Private lands

Non-Vegetated

- Developed/Managed Water Bodies
- Areas currently classed as non-vegetated in vegetation layer

Assumptions include:

- The Mixed Age Forest and Mature Forest cells, although dominated by mid-seral forest, will -- at various points in time -- have small portions present in early seral forest, generally in small, open patches as well as include remnant patches of late-seral forest.

- The future trends of private lands are unknown, but may include a variety of seral stages. For this analysis, the current amount and location of existing seral stage on private lands were projected into the future. (Exception: City of Portland lands within the water supply drainage)

- Natural, unplanned disturbances are not accounted for and will, to some extent through time, alter the above projections.

- Wet meadows and Old Forest/Rocky Design Cells will be late-seral, but will generally include stable non-forest openings.

- Areas currently mapped as non-vegetated will remain as such in the future (no net increase or decrease).

The future trend for all three seral stages appears to be quite consistent with the range of natural variability.

Table 5-2 -- Seral Stage: Future Trends displays current (1996) and future amounts within the three seral stages compared to the range of natural variability (RNV). Watershed totals are presented as well as amounts by Forest zone.

Table 5-2 -- Seral Stage: Future Trends

(Entire Watershed)

Zone	Seral Stage	RNV* %	1996 %	Future** %
WH	Late	74-81	31	79
PSF	Late	72-98	66	90
Total	**Late**	**77-88**	**45**	**83**
WH	Mid	0-15	49	15
PSF	Mid	0-18	21	8
Total	**Mid**	**0-15**	**38**	**12**
WH	Early	0-25	18	4
PSF	Early	0-15	11	1
Total	**Early**	**0-21**	**15**	**3**

*RNV is derived from water supply drainage over a 350-year period, as presented in Chapter 4.

**Future, as used here, implies full implementation of the Northwest Forest Plan and sufficient time for successional processes to progress from early through late, approximately 120 years.

The future trend for all three seral stages appears to be quite consistent with the RNV. Early-seral forest is near the low end of RNV, but does not reflect the occassional harvest openings in the Mixed Age and Mature Forest cells *(see assumptions)*, or periodic, unplanned disturbance events.

Future Landscape Pattern

As forest succession progresses and edge effects diminish, the amount of interior habitat will greatly increase within the Bull Run Watershed.

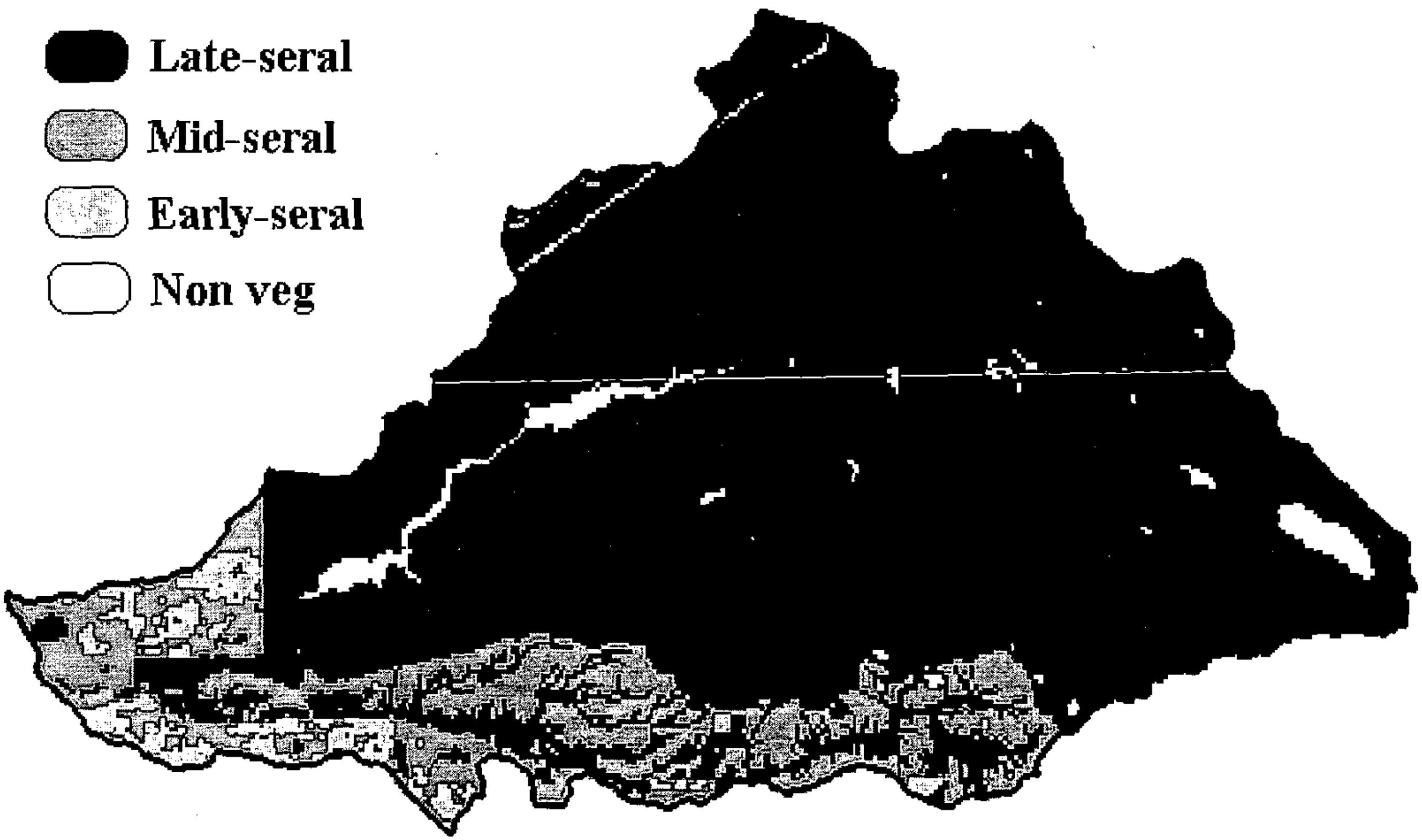
Landscape patterns across the watershed's Little Sandy portion will be dominated by various patches of mid-seral forests with connected linear corridors of late-seral forests within the Riparian Reserves -- as well as some scattered early and late-seral patches.

While the future pattern of private lands outside the water supply drainage is not known, it is suspected to be similar to current patterns with some arrangement of aggregated openings and fragmented forest lands.

The future landscape pattern within the water supply drainage will be dominated by unfragmented landscapes of late-seral forest with scattered natural openings (lakes, wetlands, talus/rocky areas). Growth of early and mid-seral stands to late (particularly within the LSR) combined with the subsequent loss of edge effect will substantially increase the amount of interior habitat.

Figure 5-1 -- Conceptual Landscape Design (shown earlier) and Figure 5-5 -- Future Seral Stage and Pattern, display future landscape patterns within the Bull Run Watershed.

Figure 5-5 -- Future Seral Stage and Pattern



Chapter 6

Key Questions/Synthesis

Chapter 6 -- Key Questions/Synthesis

Introduction

In this chapter, Key Questions are answered.

These answers provide synthesized, interpreted results based on the analyses described in previous chapters. Changes in ecological conditions and their probable causes are examined and explained, including implications for watershed management objectives.

The Key Questions were investigated in terms of past, present, and future. For example, *condition* in the statement "*conditions of the watershed*" – used with many Key Questions – refers to any of the following that exert influence:

- Historic events, both natural and human-caused.
- Current status or practices.
- Trends, or land allocations that may have future implications.

The results provide a basis for identifying and prioritizing management recommendations.

Key Question #1 -- How do conditions of the watershed contribute to habitat needs for species of concern associated with aquatic, riparian, terrestrial, and special habitats?

Aquatic/Riparian Habitats

Documented species of concern associated with aquatic-riparian habitats are listed in Table 6-1.

Table 6-1 – Documented Aquatic/Riparian Species of Concern

Species	Concern
Fir Clubmoss	Forest Service Sensitive Species
Coho salmon	Forest Service and State sensitive species; high risk of extinction; under review for Federal T & E listing.
Spring chinook salmon	High risk of extinction; status under review by State.
Winter steelhead	Moderate risk of extinction; proposed for Federal T & E listing.
Sea-run cutthroat trout	Forest Service and State sensitive species; moderate risk of extinction.
Pacific lamprey	State sensitive species
Resident cutthroat trout	Public interest; Mt. Hood National Forest management indicator species; unique genetic stock in upper Bull Run River and Bull Run Lake
Redband trout	Forest Service sensitive species
Cascades apatanian caddisfly	Forest Service sensitive species
Columbia dusky snail	ROD survey and manage species
Copes Giant Salamander	Forest Service sensitive species
Bald eagle	Federally listed as threatened
Common loon	Forest Service and USFWS sensitive species

Fir Clubmoss

Fir clubmoss, grows within the Bull Run Watershed's riparian areas usually on rotting logs and thick duff in shaded, damp cool riparian forest and wetland thickets. Seven fir clubmoss sites are dispersed across the watershed. In addition, abundant potential habitat also exists. Future surveys will most likely locate more sites.

The Late-Successional Reserve (LSR) portion of the watershed provides excellent habitat protection for this species. Riparian Reserves in theUpper and Lower Little Sandy subwatersheds should also offer sufficient habitat protection.

Any tree removal in Riparian Reserves near fir clubmoss sites should be far enough away to avoid impacting the shade, moisture, and temperature elements of this species' necessary microclimate.

Two other unlisted but uncommon endemic plant species live in the watershed's riparian areas: **Mt. Hood bugbane (*Cimicifuga lacinata*)** and **Hall's isopyrum (*Isopyrum hallii*)**. Both are associated with openings in riparian forest, often with hardwood-shrubby areas. If natural processes (such as windthrow and disease) that create these openings are allowed to occur within Riparian Reserves, habitat for these endemics should remain secure.

The watershed's aquatic-riparian areas also provide excellent potential habitat for many of the "Survey and Manage" fungi, lichen, and bryophyte species, a list of which is on file with the Zigzag Ranger District Botanist. Reserve designations should maintain and improve habitat for these "Survey and Manage" species habitats into the future.

Anadromous Fish

All anadromous fish within the watershed were grouped in this assessment due to similar habitat requirements and range of distribution within the watershed. Anadromous fish inhabit the portion of the watershed below the dams on the Bull Run and Little Sandy Rivers.

Coho salmon is listed by the State of Oregon and the Forest Service as a sensitive species. The National Marine Fisheries Service currently considers the Sandy Basin coho a candidate species for possible listing as a threatened and endangered species.

The spring chinook salmon run in the upper Sandy Basin is composed of two stocks, a native "early-run" and a later run derived from and supplemented with Willamette stock. The native run may now be extinct. Natural reproduction of the introduced run is increasing over time in the watershed.

The existing stock of native winter steelhead is composed primarily of late-run upper Sandy stocks. Prior to 1964, early-run stocks were released throughout the upper Sandy Basin. Hatchery release of early run stocks continue in the Sandy River below Marmot Dam. Adult returns to the upper Sandy Basin have been fairly stable averaging approximately 3,000 fish the past 30 years. Returning numbers, however, have declined during the last several years. It is currently proposed by the National Marine Fisheries Service (NMFS) for listing as a threatened and endangered species.

The sea-run cutthroat is a native stock and is listed as a sensitive species by the State of Oregon. The American Fisheries Society (AFS) report lists the stock in moderate danger of extinction. In recent years, few to none have been detected passing over Marmot Dam (ODFW, 1995).

Pacific lamprey are State Sensitive Species based on significantly depressed populations throughout their range (Weeks, ODFW 1993; Downey et al., 1993).

Individual Species Habitat Requirements

Coho salmon prefer areas with low water velocities such as low gradient small to medium sized streams, side channels, and the margins of mainstem rivers (Meehan and Born 1991; Groot and Margolis 1991). Large woody debris frequently acts as the roughness element creating the protected low velocity margins of the river that coho prefer to utilize.

Chinook salmon utilize larger streams and river systems. Chinook typically utilize large pools with large woody debris in low gradient areas along the mainstem and do not usually venture into tributaries or side channels.

Juvenile steelhead trout typically prefer faster water areas than coho or chinook salmon (Groot and Margolis 1991; Meehan 1991). Older steelhead juveniles prefer the heads of pools, and riffles with large boulder substrate and woody cover in the summer. During winter, older steelhead juveniles are found in pools, near streamside cover and under debris, logs or boulders.

The historic range of the Pacific lamprey (*Entosphenus tridentatus*) in the Columbia River Basin was coincident with anadromous salmonids. Pacific lamprey use the same spawning substrate as anadromous salmonids. Larval lamprey (ammocetes) spend 5-6 years in slow water, fine substrate, freshwater habitats before migrating to the ocean. Rapid or prolonged water withdrawals that dry out edgewater stream habitat is the greatest risk to larval lamprey (Dick Beemish pers. comm.). High water temperatures, water quality, and extremely high barriers are additional risk factors. The habitat requirements of Pacific lamprey are similar to those of coho and chinook salmon.

Based on the habitat requirements for individual species, key habitat components were identified for anadromous fisheries within the Bull Run Watershed.

- In-channel Large Woody Debris
- Pools
- Side channels
- Flow Regime within Range of Natural Variation
- Spawning Gravels (channel substrate within RNV)
- Habitat Access (availability to historical range of distribution)

Table 6-2 presents a summary of the status of critical habitat components for anadromous fish within the watershed. For more details on individual habitat components see the Fish Habitat section in Chapter 4.

Table 6-2 Assessment of Key Habitat Components for Anadromous Fish

Habitat Component	RNV- Range (mean)	Current Condition	Rating
Large Woody Debris (pieces per mile)	0-65 (32)	2	Outside RNV
Large Woody Debris Recruitment Potential (percent of Riparian Reserves in high category)	57%	9%	Outside undisturbed condition
Pool Count (pools per mile)	5-15 (10)	8	Within RNV
Pool volume (1000 cubic feet per mile)	0-273.3 (28.2)	768.9	Outside but above RNV
Side Channel Habitat (percent of total habitat)	not available	3% of total habitat length	Unknown
Flow Regime: instantaneous peak flows	See Chapter 4	See Chapter 4	Within RNV Bull Run River Outside RNV Little Sandy River
Flow regime: high flows	See Chapter 4	See Chapter 4	Outside RNV Little Sandy and Bull Run River above PGE power plant Within RNV Bull Run River below PGE power plant

Habitat Component	RNV- Range (mean)	Current Condition	Rating
Flow Regime: low flows	See Chapter 4	See Chapter 4	Outside RNV Little Sandy and Bull Run River above PGE power plant Severly altered below Bull Run power plant
Spawning Gravels	See Chapter 4	See Chapter 4	Uncertain, but appears to be outside RNV
Habitat Access (range of anadromy in miles)	40.9 miles	9.0 miles	Outside RNV

Anadromous fisheries habitat have been affected by management activities within the Bull Run Watershed and is outside the RNV.

- Reservoir and hydropower development have imposed barriers within the watershed that limit the range of anadromy to 22% of the historical levels.
- Dams on the Bull Run and Little Sandy Rivers are barriers to large woody debris, and sediment (suspended and bedload) routing from the upper portion of the watershed to the lower portion. This affects large woody debris and spawning gravels below the dams.
- Reservoir and hydropower operations have dewatered the Bull Run and Little Sandy Rivers upstream of the PGE power plant during low flow periods.
- Peaking operations associated with the operation of the Bull Run power plant have severly altered the low flow regime in the lower Bull Run River.
- Hydropower operations in the Little Sandy subwatershed alter the peak flow regime by diverting up to 800 cfs from the Little Sandy River which is roughly equivalent to the annual flood event.
- In-channel large woody debris being outside the RNV will limit the retention of spawning gravels.
- Development and timber harvest on private land within the lower Bull Run and Little Sandy subwatersheds has reduced the potential for future large woody debris recruitment in the Bull Run River.
- Pool habitat is within the RNV with large pools in the main channels

Conclusions

Habitat conditions have been altered from the RNV. Large woody debris densities are low, pool numbers are low, and side channel availability appears to be low.

Redband Trout

Redband trout are a Forest Service sensitive species. A stock of inland rainbow trout suspected to be redband trout have been identified in the upper Little Sandy River (Greg and Allendorf, 1995).

Redband trout habitat requirements are similar to those of steelhead trout. The redband prefer fast water areas (riffles) intermixed with pools and large woody debris. Critical habitat components for redband trout include:

- In-channel Large Woody Debris
- Pools
- Flow Regime within Range of Natural Variation
- Stream Temperature within RNV
- Habitat Access (current availability compared to historical range of distribution)

Table 6-3 Assessment of Key Habitat Components for Redband Trout

Habitat Component	RNV- Range (mean)	Current Condition	Rating
Large Woody Debris (pieces per mile)	3-18 (10)	12	Within RNV
Large Woody Debris Recruitment Potential (percent of Riparian Reserves in high category)	57	25	Outside undisturbed condition
Pool Count (pools per mile)	10-30 (20)	28	Within RNV
Pool volume (1000 cubic feet per mile)	0-32.2 (14.8)	154.8	Outside and above RNV
Flow Regime: instantaneous peak flows	See Chapter 4	See Chapter 4	Within RNV, yield not significantly different than Fir Creek

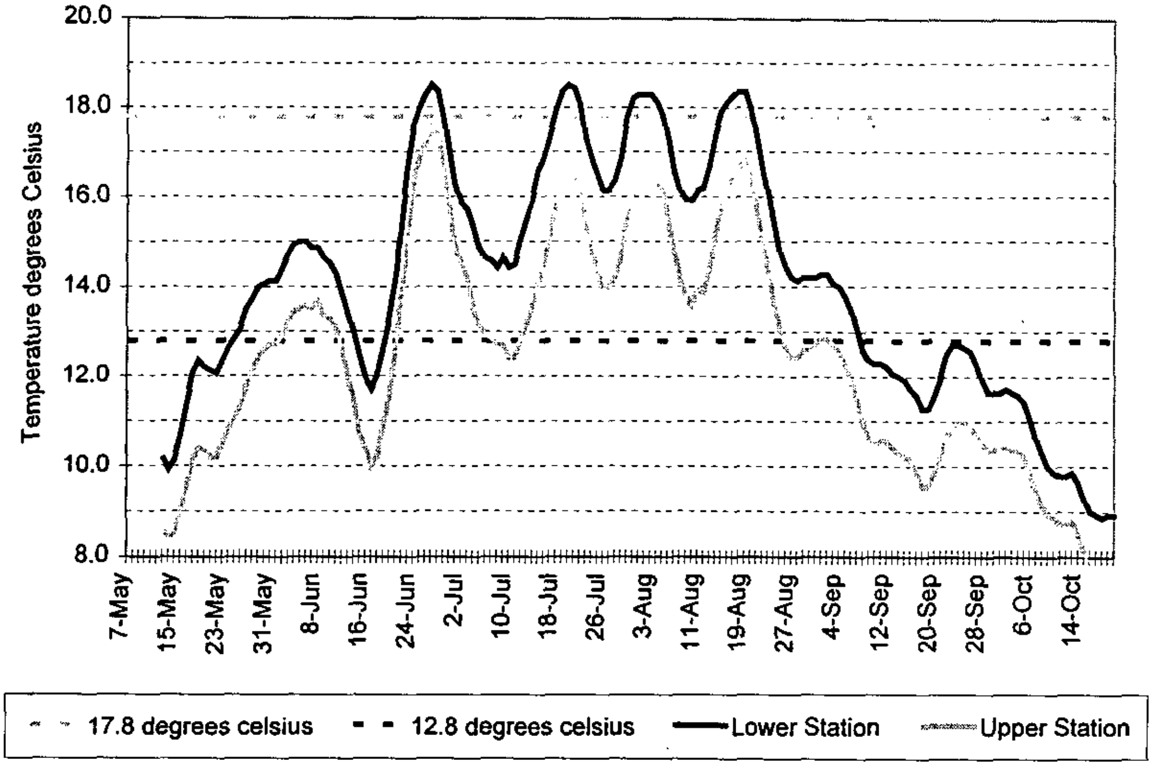
Habitat Component	RNV- Range (mean)	Current Condition	Rating
Flow Regime: low flows	See Chapter 4	See Chapter 4	Within RNV, no significant trend
Sediment Regime	0.0001 tons per acre per year delivery to streams	0.003 tons per acre per year delivery to streams	Altered, however magnitude of the difference is insignificant
Stream Temperature	unknown	7 day moving average exceeds 18^{0}C	Exceeds State Water Quality Standards for absolute stream temperature and salmonid spawning, egg incubation and fry emergence
Habitat Access	Not quantified	Not quantified	No artificial barriers to limit range

In most watersheds interbreeding of hatchery rainbow trout and native redband and/or competition of native redband and brook trout are concerns. Due to minimal stocking in this watershed the Bull Run is a refugia from genetic pollution and competition with exotic fish.

The critical habitat components of in-channel large woody debris and pools are within the range of natural variation. It appears that there any many large mainstem pools due to the high pool volumes within the upper Little Sandy River.

Seven day moving average stream temperatures within this watershed are well above State Water Quality Standards and the threshold of concern for salmonids.

Chart 6-1 Seven Day Moving Average Stream Temperatures Upper Little Sandy River 1992



The optimal temperature range for most salmonid species is 12-14^{0}C. Lethal levels for salmonids are generally in the range of 20-25^{0}C (MacDonald, 1991). State Water Quality Standards limit stream temperatures to 12.8^{0}C for spawning, egg incubation and fry emergence to protect salmonids during these life cycles. In 1992 seven day stream temperatures exceed 12.8^{0}C from the end of May to the beginning of September and stream temperatures exceeded 18^{0}C four times during the same period. Rainbow trout are spring spawners with the spawning, egg incubation, and fry emergence period lasting from April through mid September, so stream temperatures above 12.8^{0}C are a concern during this period. Redband trout have evolved higher temperature tolerances than coastal rainbow trout (Behnke 1992). However, stream temperatures exceeding 18^{0}C are a concern.

Conclusions

Even though many of the critical habitat components for redband trout are not of concern the habitat is in a degraded condition due to high stream temperatures from the end of May to the beginning of September.

Resident Cutthroat Trout

There is a genetically unique population of cutthroat trout located in Bull Run Lake and the Bull Run River above the barrier falls at river mile 21 (near the confluence of Bull Run and Cat Creek) (pers comm Katheryn Kostow, March 1996). Critical habitat components within Bull Run River include:

- In-channel Large Woody Debris
- Pools
- Flow Regime within Range of Natural Variation
- Stream Temperature within Range of Natural Variation
- Habitat Access (current availability compared to historical range of distribution)

Table 6-4 Assessment of Critical Habitat Components for Resident Cutthroat Trout

Habitat Component	RNV- Range (mean)	Current Condition	Rating
Large Woody Debris (pieces per mile)	3-18 (10)	25	Outside and above RNV
Large Woody Debris Recruitment Potential (percent of Riparian Reserves in high category)	57	38	Outside undisturbed condition
Pool Count (pools per mile)	10-30 (20)	9	Outside RNV
Pool volume (1000 cubic feet per mile)	0-32.2 (14.8)	49.1	Outside and above RNV
Flow Regime: instantaneous peak flows	see Chapter 4	see Chapter 4	Within RNV, no significant trend, yield not significantly different than Fir Creek
Flow Regime: low flows	12-16 cfs at lower spring below Bull Run Lake on Bull Run River	25-47 (1986-1989 releases) 57-61 (future releases)	Altered; due to flow augmentation from Bull Run Lake

Habitat Component	RNV- Range (mean)	Current Condition	Rating
Stream Temperature	5^0 C	9^0 C (1985-1989 releases) $5\text{-}6^0$ C	Altered, past releases from Bull Run Lake have increased stream temperatures in upper Bull Run River. Management Plan for future releases will not allow for temperature increases
Habitat Access	Not quantified	Not quantified	Within Bull Run River no effects. Within Bull Run Lake lake drawdown limits access to tributaries

***Habitat Conditions* Bull Run River**

Within the Bull Run River large woody debris and pool habitat is at or above the RNV (even though pool counts are not within the RNV, the pool volumes indicate large mainstem pools).

The flow regime is an altered condition due to Bull Run Lake releases. Releases for Bull Run Lake historically altered flows from 12-16 cfs at the lower spring below Bull Run Lake in the Bull Run River to 25-47 cfs and future releases will bring levels to 45-61 cfs. The highest natural flows measured in the upper Bull Run River in the period from September 1992 to March 1995 were 48 cfs (Bull Run Lake EA). In the upper Bull Run River releases from Bull Run Lake take the stream from base flow to high flow conditions in several days.

Historically releases from Bull Run Lake have increased stream temperatures approximately 7^0C at the lower spring. The management plan and lake release facilities are designed and improved to prevent temperature increases in the future.

Conclusions Bull Run River

The increase in flows from baseflow to bankfull , associated with past releases, prior to August 15 occurred during the egg incubation and fry emergence life cycles of the resident cutthroat trout. Increased stream velocities associated with releases have the potential for channel scour sweeping eggs and fry downstream.

The current management plan for Bull Run Lake does not allow releases prior to August 15. These releases are times so as not to affect newly emerged fry.

Stream temperatures associated with past releases increased stream temperatures 4^0 C but are still well below the State Water Quality Standard of 12.8^0 C for salmonid spawining, egg incubation and fry emergence.

Bull Run Lake

Sampling and inventory information indicate that there were approximately 2600 fish (excluding young of the year) in the lake on November 23, 1992 (Thorne, 1993). This relatively small population may be a result of the low productivity of the lake.

The hydroacoustic survey completed in November, 1992 indicated that densities of fish in the lake are quite low. Most fish appear to utilize the top five meters of the lake (5 fish/10,000 cubic meters), with very little use below that level (less than 1 fish/10,000 cubic meters.) The fish also showed a strong preferential use of shoreline habitat, with 40% located in the littoral zone (Thorne, 1993). The influence of water level management on the physical habitat conditions and the quantity and diversity of food items available in the shoreline areas is therefore of key concern for maintenance of the cutthroat stock.

Investigations of physical habitat conditions in the shoreline drawdown zone (Beak, 1993) show a striking change in quality and quantity as water level drops. Habitat in the top five feet of the lake (between elevation 3173-3178') contains the highest amounts of coarse substrate types (boulders and cobbles), which are very important as cover for juvenile fish as well as for production of many aquatic insect species important as food for fish. This narrow zone contains most of the large logs and root wads present (73%) and is very important for cover and production of insects.

Substrate material size class and large woody material both decrease with elevation. Below elevation 3148', the substrate is virtually all sand and silt with less than 4% of the woody material, providing almost no cover for fish or other aquatic life. The aquatic insect community favored at these water levels is less diverse, favoring just those species that utilize mud substrates.

There are other changes in habitat associated with lowering the lake level. The spring high water level is directly related to passage conditions for adult spawning cutthroat. As spring water level is lowered, upstream passage to the limited spawning habitat in the tributaries becomes increasingly difficult.

The largest and most productive shoal area in the lake is located at the southeast end, from elevation 3140-3178. Most of the shoal is located above 3148. It is associated with several of the tributaries important for spawning and appears to be important for rearing fish. The highest density of fish observed in hydroacoustic surveys was in this area. As water level drops, this highly productive habitat is removed.

There is evidence that lake level varies naturally on both a seasonal and yearly basis. Following the high water levels created by spring flows, the lake level drops an average of 12 feet by late summer. It also appears that relatively dry climatic conditions may prevent the lake from totally refilling to full pool in some years (1978-1981). This situation may lower the spring high water level by 4-5 feet. It is likely that the aquatic biological community of the lake historically was adapted to some natural variation of lake level.

However, water withdrawal in the period 1985-1992 has greatly increased the within-year and between-year variation in lake level from preceding periods. Water withdrawal (coupled with drought conditions) has created an unusually low lake level and amount of lake level variation. Nonetheless, in the past two years the lake had refilled. The increased fluctuation has likely affected the composition and quantity of the aquatic insect community and possibly other organisms such as amphibians, fish, etc. It is likely that this management regime has selected for insects that are more tolerant to these changes and of finer substrates.

It is believed that fish populations will increase from present levels if releases are not implemented. Future monitoring of these populations will be essential to determine trends under any selected alternative for lake level management.

Cascades Apatanian Caddisfly, and Columbia Dusky Snail

Due to their similar habitat requirements, these species were assessed together.

These species have been documented at cold water springs or require cold water stream or spring habitat. Cascades Apatanian Caddisfly, and Columbia dusky snail are documented in the Bull Run River in the springs below Bull Run Lake.

Habitat requirements for the Cascades Apatanian Caddisfly include: cold water spring areas, moderate to high gradient, cold, narrow (1-2 feet wide) perennial spring channels with dense shade by a coniferous and deciduous overstory, and elevation range from 4,000 to 5,000 feet.

Columbia dusky snail habitat requirements are springs and spring outflows, from low to high elevations in cold, pure, well oxygenated water. This species is often found in very small springs or channel margins of larger springs, and is most common on soft substrates, in shallow slow flows. It prefers oligotrophic pristine water sources with no macrophytes (Frest 1993).

Potential effects to these species come from altered baseflows, water quality degradation, and sediment inputs.

Habitat for *Apatania tavala*, a caddisfly listed as sensitive by the Forest Service (and Candidate, Category 2 by U.S. Fish and Wildlife Service), is present at both of the weir/springs in the Bull Run River below Bull Run Lake. A single specimen, suspected as this species, was collected at the springs in October, 1994. An aquatic snail (*Lyogyrus sp.*) was also collected at the same time. These species are adapted to cold water spring areas, with stable substrates and low amounts of sedimentation. There is a possibility that for species such as these, with very limited distribution, that historic or future releases of water from Bull Run lake might affect their habitat (Bull Run Lake PWA)

Sampling of the aquatic macroinvertebrate community in 1994 revealed that the springs and river contain low densities of comparatively few species of insects, although this is within normal limits for western Oregon (Wisseman, 1994.) The species found were indicative of cold temperature, high water quality environments. It is possible that some of the more sensitive of these species may have been affected by temporary temperature increases due to historic releases, possibly forcing them to migrate from this area or even increasing mortality rates. However, given that most of these species possess the ability to migrate and rapidly repopulate new areas, (and that there is good availability of nearby habitats in unaffected springs and tributaries), it is likely that any effects were temporary. (Changing the method of water withdrawal from the lake, guaranteeing cooler water temperatures with any releases in the future should mitigate for this possible impact.) It is even possible that relatively high warm flows in the past increased overall species diversity and or productivity (Wisseman, 1994).

With an improved intake to allow future water withdrawals from Bull Run Lake of water matching downstream temperatures at the springs, no significant impacts are expected. Without withdrawal, the downstream aquatic community would be expected to stabilize, likely in a condition of low species diversity and low productivity, similar to conditions prior to development and operation of water storage/release facilities at Bull Run Lake.

Cope's Giant Salamander

Surveys have documented the presence of Cope's larvae and neotenic adults in several localities within the watershed including Cougar Creek, Bear Creek, tributaries and downstream of the springs at Bull Run Lake.

The critical habitat components of streamside forest, stream temperature and stream substrate will be used in assessing habitat for Cope's giant salamander. Overall, the 1st and 3rd order streams, within mid to lower elevations of the watershed, should provide excellent habitat for Cope's giant salamander with a few exceptions where streamside forest, temperature, or silt have affected the habitat.

Overall, sediment yields, both natural and management influenced, are very low in this watershed. However, accumulations of silt in the depositional reaches may affect habitat substrate. This could potentially occur during short periods of time when storm flows and seasonal flushing deliver sediment to depositional reaches. These reaches are on the mainstem of the Bull Run River below Blazed Alder, Blazed Alder, and portions of Cedar Creek and Upper Little Sandy.

Streamside forest, based on subwatersheds, provides good habitat overall. However, there are areas of riparian reserves where early seral vegetation dominates and canopy closure is low. These areas include Otter Creek, Cedar Creek, lower Blazed Alder, and portions of the Little Sandy.

Since Cope's require cold water, any increases in stream temperature is a concern. Stream temperatures in the Upper Little Sandy have exceeded current state water quality standards. There is also a concern regarding temperatures in the lower Little Sandy due to low percentages of canopy closure resulting from harvest.

Implementation of Riparian Reserves may alleviate some of the concerns over riparian canopy closure and stream temperature.

Suitable habitat for Cope's also occurs at both springs to Bull Run Lake and a specimen was found downstream of the springs. The Bull Run Lake EA states the species "are not likely to have been affected by the temporary increase in flooded area" and that "in most cases, the temporary 'flood' had a positive effect on these species, increasing habitat availability and food". Cope's is mobile enough to use the "new" habitat and should be able to migrate back as flows dwindle.

Bald Eagle

Bald eagle nesting and foraging habitat in the watershed occurs mostly around Bull Run Lake and the reservoirs. Suitable nest trees occur within a ½ mile radius of these areas, as well as prominent trees and snags for perching.

Although there are many documented sightings of bald eagles in the watershed, nesting activity has not been documented. Good nesting habitat exists within the watershed, yet bald eagles are more abundant on the Columbia River and lower elevations in the winter, and move up into the Bull Run drainage to forage in the spring/summer breeding seasons.

In addition, there appears to be an adequate fish prey base at Bull Run Lake and the reservoirs throughout the breeding season. Osprey feed on fish of similar species and size as the bald eagle, and reproducing osprey in the watershed indicate a fish prey base that is adequate to support a bald eagle nest.

Two bald eagle management areas, of approximately 40 acres each, are located near Bull Run Lake and Reservoir 1. Proposed management direction is to "identify and protect nesting and feeding areas, and to manage potential nesting habitat for eagles".

Conditions in the watershed should continue to provide good foraging and nesting habitat for the bald eagle.

Common Loon

The critical habitat components for the common loon are breeding habitat and lack of human disturbance along with sufficient prey. Breeding habitat for the common loon is large, freshwater lakes within bare or forested habitats, from low to moderately high elevation (below timberline). Nests occur on or along the edge of water, often in dense aquatic vegetation or on a large, half submerged log. The diet of the common loon is primarily fish, although crayfish, leeches, and aquatic insect larvae are also eaten.

Although there are no known common loon nests on the forest, common loons have been noted in the lakes and reservoirs of the Bull Run Watershed since at least the late 1970's. The construction of the reservoirs created foraging habitat for loons, although it is likely that nesting or chick rearing habitat at Bull Run Lake was inundated by the dam.

The limited access to the Bull Run Watershed contributes to a higher potential for nesting loons, however, the reservoirs and Bull Run Lake support minimal emergent aquatic vegetation for nesting habitat.

From field surveys, it appears that most loons use the reservoirs for only a few days before continuing on to breeding grounds further north. However, common loons exhibiting pairing and territorial behavior have been consistently observed on the eastern one-third of the Upper Reservoir since at least 1980. The common loon is considered extirpated as a breeding species by the Oregon Department of Fish and Wildlife and nesting pairs are rare in the Pacific Northwest.

The Bull Run may provide a unique opportunity for nesting to occur. Because of territorial and pre-nesting behavior observed in past years only in this area, there is the strong possibility both that nesting attempts here in the past have failed, and that nesting may occur here in the future (Corkran, 1995).

Research conducted in other parts of the loon breeding range indicate that nests often fail when the adults are disturbed by human activity near the nest, therefore lack of human disturbance during breeding is a critical. Although the Bull Run has limited human disturbance, inadvertent harassment by logging and reservoir operations has been observed to alter the loon's use of the reservoir (Corkran, 1995). There is currently a use restriction on activities on the Upper Reservoir between April 1 and May 31. If nesting is suspected or confirmed, the restriction may be extended to July 15th. This use restriction has conflicted with reservoir operations, namely removal of woody debris which has been transported from upstream after storm events, and needs to occur when water levels are high enough to remove the large logs.

Terrestrial Habitat

Documented species of concern associated with terrestrial habitats are listed in Table 6-5.

Table 6-5 Documented Terrestrial Species of Concern

Species	Concern
Krushea	Forest Service sensitive species
Withered bluegrass	Mt. Hood NF inventory species
Stalked orange peel fungus	ROD survey and manage fungi species
Bondarzewia's polypore	ROD survey and manage fungi species
Cchanterelle	ROD survey and manage fungi species
Phaeocollybia kaufmanii, P. oregonensis	ROD survey and manage fungi species
Jelly-like black urn	ROD survey and manage fungi species
Ramaria araiospora, R. stuntzii	ROD survey and manage fungi species
Hypogymnia duplicata	ROD survey and manage lichen species
Bug on a stick	ROD survey and manage moss species
Ulota megalospora	ROD survey and manage moss species
Red-tree vole	ROD survey and manage species
Northern spotted owl	USFWS listed as threatened
Wolverine	Forest Service sensitive species

All of the above species, except for the wolverine, are associated with late-successional forests. The amount and distribution of late-successional forest, as well as conditions of the watershed influencing these forests are described in Key Question #3. In general, the Bull Run Watershed currently has a large percentage of late-successional forest, 45%. Under current management and in the absence of large scale disturbance, the amount of late-successional forest should increase in the future.

The late-successional forests of the Bull Run Watershed provide some of the most optimum habitat for old-growth dependent fungi, lichen, bryophyte, and vascular plant species within the Sandy Basin. Seventy-seven species, or 60%, of vascular plants listed in the Northwest Forest Plan as closely associated with old-growth forest are found inside the watershed. It also provides some of the best habitat for spotted owls and red tree voles on the Mt. Hood Forest.

Krushea

The small lily, krushea, can be found on the thick duff that encircles many of the watershed's old-growth Douglas-fir and western hemlock trees. These populations in the Bull Run Watershed are important because they represent the southern extent of this species' known range in North America and, thus, a unique portion of the species' gene pool.

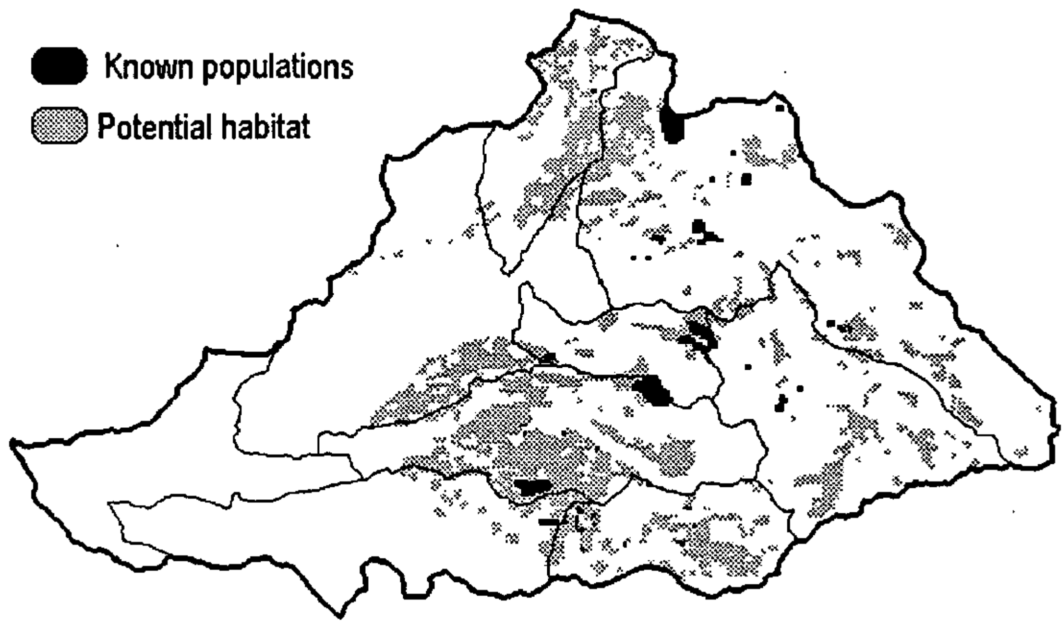
With almost one-half of the watershed in late-seral stands for the past 350 years, the Bull Run Watershed provides a significant area of habitat for Krushea in the southern portion of its known range.

At most krushea sites, either rotting wood or bark is evident, or a very old decomposing log or stump is located just below the site's surface. Areas with the most krushea have not burned for at least 200-300 years --allowing this abundance of rotting wood and duff to accumulate. Krushea may also posses a fungal associate that uses decomposing wood. The microclimate features (such as shade and humidity) of the watershed's old-growth forests provide for additional habitat requirements. More information on this species' biology is available in Chapter Four's Botany section, as well as in the draft *Species Management Guide for Streptopus streptopoides* (Kagan and Vrilakas, 1992).

For the most part, krushea's distribution in the watershed (Figure 6-1) correlates with old stands and the absence of fire.

Figure 6-1 shows the watershed's current potential habitat for krushea. It was created using the following habitat elements: elevation (1600-3900 feet); slope (<30%); stand types (open or closed large conifer stands, closed small conifer stands, or open small conifer stands with remnants); fire period (>300 years); and soil types (Zygore 5-30%, Sisi 5-30%, Last Chance 5-30%, Jackpot 5-30% and Damsite 5-30%).

Figure 6-1 -- Potential Krushea Habitat and Known Populations



Approximately 10,542 acres (12% of watershed) provides good krushea habitat. Historically, prior to timber harvest within the watershed, krushea may have been more abundant. In the future, the LSR designation should allow potential habitat to return to these historical amounts. While windthrow may temporarily eliminate some habitat, this process simultaneously provides a good source of future decaying wood. Fire suppression may also contribute to habitat development by allowing stands to age and duff to accumulate.

Four of the five major krushea sites noted in the draft *Species Management Guide for Streptopus streptopoides* as essential to the viability of the species in Oregon -- and perhaps the genetic viability of the species as a whole -- should be secure in the future. These are: Mt. Talapus; the proposed Big Bend Resource Natural Area (RNA); above Cedar Creek; and west of Township Meadows. However, the fifth site, the North Mountain site -- located outside the watershed -- is at risk from potential timber harvest. The Northwest Forest Plan suggests protecting these critical habitat areas as a mitigation measure, ROD, p. 33.

Fungi

The Bull Run Watershed currently provides habitat for eight documented "Survey and Manage" fungi: **stalked orange peel fungus, Bondarzew's polypore,**

chanterelles, jelly-like black urn, two Phaeocollybia types, and two coral fungi. Habitat features provided in the watershed include mature to old-growth forest with well-developed conifer litter and rotting wood. No known sites are currently threatened and all should be secure in the future. Surveys are expected to produce more locations for these fungi, as well as many other Northwest Forest Plan-listed fungi.

Lichens

The watershed's only documented Survey and Manage Strategy 1,2,3 lichen, ***Hypogymnia duplicata***, is truly rare (very few known sites). While its habitat -- foggy, wind-influenced forests -- is common within the watershed, because this species is naturally rare, few additional sites are expected to be found. The existing site should be well-protected by the LSR designation.

Excellent habitat exists for many more "Survey and Manage" lichen species and will be maintained or improved in the future within the LSR. If timber harvest occurs within the Little Sandy subwatersheds, lichen species habitat could be reduced to a lesser quality. In addition, any increase in air pollution in the future could threaten some pollution-sensitive species such as *Hypogymnia duplicata*.

Mosses and Liverworts

The Bull Run Watershed's road signs that warn drivers "Danger -- Moss" indicate how the watershed provides ideal conditions for many mosses and liverworts. Two "Survey and Manage" species are known from different forest habitats here. **Bug-on-a-stick** grows on the butt ends and sides of decaying logs. ***Ulota megalospora*** lives in the exterior canopy and on tree boles in late-successional forests. Conditions for both these mosses and 13 other bryophytes will be maintained or enhanced within the watershed's LSR. As with lichens, many bryophytes are also sensitive to air pollution and could be threatened by any future degraded air quality.

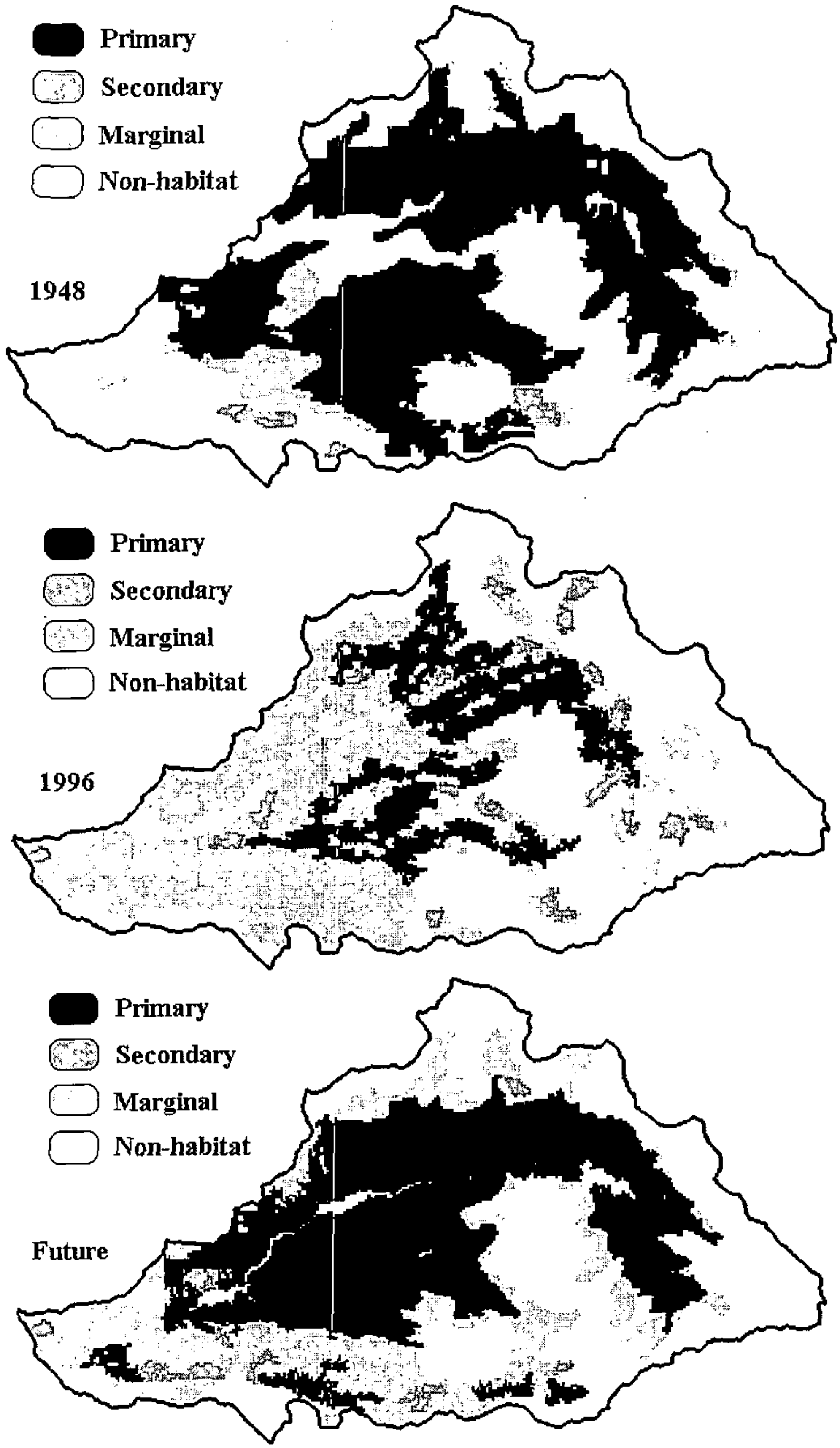
Red Tree Vole

The red tree vole is closely associated with old-growth Douglas-fir forests. The red tree vole spends most of its life in the canopy of coniferous trees and feeds on the needles. The voles main source of water is derived from fog drip and raindrops on Douglas-fir needles.

In 1995, a survey of red tree vole habitat was conducted on the Forest which included a portion of the Bull Run Watershed. Eight red tree vole nests were found in the watershed, with four exhibiting evidence of red tree vole occupation. All nests were found in large Douglas-fir trees, yet surrounding stands included both second-growth and old-growth stands.

The red tree vole habitat model was used to create a map of red tree vole habitat for the Bull Run Watershed for historic (pre-logging, 1948), current, and future time periods.

Figure 6-2 -- Historic, Current and Future Red Tree Vole Habitat



From this modeling, the following acres were determined.

Habitat	Historic Acres	Current Acres	Future Acres
Primary	36,536	13,093	34,432
Secondary	714	2,957	1,465
Marginal	3,858	20,837	14,867
Non-habitat	41,637	52,075	38,199

The modeling indicates that the Bull Run Watershed contains the largest and most continuous red tree vole habitat on the Mt. Hood Forest. 15% of the watershed is primary habitat, 3% is in secondary habitat, and 23% is considered marginal habitat. The high level of precipitation and occurrence of fog drip may also contribute to high quality habitat.

As the maps and table display, primary habitat for the red tree vole has decreased since 1948 with a large increase in marginal habitat. In the future, however, primary habitat should increase to historic levels although the pattern and arrangement varies somewhat.

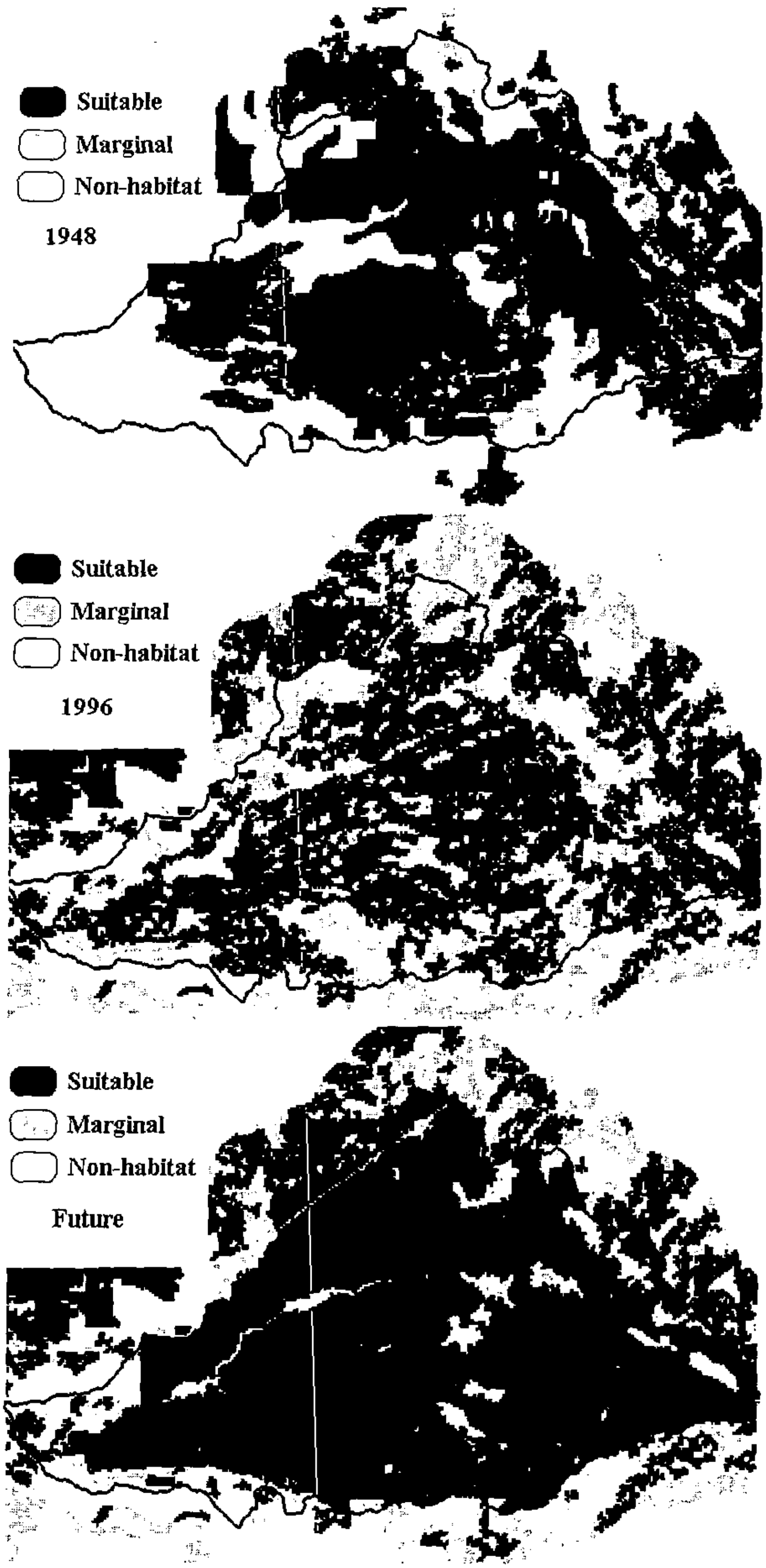
Current management direction will protect most of the red tree vole habitat in the watershed. Four confirmed red tree vole nests, however, occur in the Little Sandy Watershed in allocations subject to timber harvest. Recent interim guidance for red tree voles (USDA/BLM, Nov. 4, 1996) advises the use of ten acre buffers for protection of red tree voles and conducting additional surveys in project areas, yet protection of known populations is discretionary.

Northern Spotted Owl

The northern spotted owl is closely associated with old-growth stand conditions. Multi-layered old-growth forests are the preferred nesting habitat of spotted owls in Oregon, although suitable nesting sites are provided by both mature and second-growth stands with scattered old-growth and broken-topped trees.

The HABSCAPES program was run by Mt. Hood Wildlife Ecologist, Kim Mellen, to model spotted owl habitat for the Bull Run Watershed. The model was run for three points in time to reflect past, current and future conditions, and trends.

Figure 6-3 - *Historic, Current* and Future Spotted Owl Habitat



The three maps and accompanying table depict suitable, marginal, and non-habitat for the spotted owl. Suitable habitat includes large conifer and closed small conifer stands with remnants and a minimum patch size of forty acres. It also includes a percentage of home range in habitat. Marginal habitat often meets the stand structure requirements for owl habitat, yet the patch size is too small or isolated to be considered suitable habitat. Non-habitat would include areas that do not have suitable vegetative structure for spotted owls, such as reservoirs, lakes, and small size forested stands. (The categories suitable and marginal from this model both are considered nesting, roosting, and foraging habitat which is used for consultation).

Habitat	Historic Acres	Current Acres	Future Acres
Suitable	55,252	49,326	76,394
Marginal	850	2,846	511
Non-Habitat	26,644	36,791	12,056

As displayed in the maps and table, current acres of suitable owl habitat have decreased from historic levels, primarily due to timber harvest and windthrow which has fragmented the habitat. In the future, as stands mature, there will be a large increase in habitat available for spotted owls, above those of 1948. *Furthermore, the amount of interior habitat will increase.*

It is to be noted that the current acres figure, from the modeling, is somewhat different than the field verified figure presented in Chapter Four. From the field verification, 43,210 acres were determined to be suitable owl habitat. Private lands were not included in the field verification which may explain part of the difference.

In addition to suitable owl habitat, dispersal habitat is used for both foraging and as a crucial link for owls to travel between blocks of suitable habitat. Dispersal habitat within the Bull Run Watershed was calculated at approximately 56,000 acres, or 63% of the watershed. Therefore dispersal habitat is adequate for spotted owls.

The Bull Run Watershed contains a large amount of northern spotted owls. Twenty pairs reside within the watershed and an additional pair is located on the watershed's boundary. Seventeen of these pairs are located within the LSR. Of the three pairs outside the LSR, one is located on City of Portland lands and two inhabit Matrix lands within the Little Sandy Watershed. The two pairs in the Matrix receive 100 acre LSR designation (ROD C-10). Although one spotted owl pair is located on City of Portland lands, the City intends to manage these lands for late-successional habitat.

The Bull Run Watershed contains some of the best and most continuous owl habitat within the Mt. Hood National Forest. It also serves as an important connection between the Forest and lands in Washington state. Habitat should increase in the future and potentially provide for additional owl pairs.

Wolverine

The wolverine is a generalist species that can occupy a variety of habitats, however they are usually remote and devoid of humans and human developments. A wolverine was recently sighted at the Bear Creek House in 1996. A sighting was also reported in the Upper Sandy Watershed at the foot of Crutcher's Bench. Tracks have been confirmed southeast of the watershed in a fork of the Salmon River.

Because of its limited human harassment, the Bull Run Watershed provides high quality habitat. While the watershed most likely provides good foraging and transitional habitat, wolverines are more likely to be attracted to higher elevation habitats near timberline in adjacent wilderness areas. Potential denning habitat would most likely occur at higher elevations than in the Bull Run.

Special Habitats

Talus slopes, rock outcrops, and cliffs are expected to be stable habitats over time. The "Sensitive" plant **Howell's daisy** occurs in one identified site within the watershed on basalt rock in the Blazed Alder drainage. Potentially, additional basalt habitat for this rare endemic daisy could be threatened by a proposed third reservoir in this drainage. The inventory species **long-bearded hawkweed** also grows on rock outcrops. Talus and rock habitat is present in watershed for many potential rare, endemic species that originated in the nearby Columbia River Gorge.

Cliff sites within the Bull Run are also potential habitat for peregrine falcons. Although nesting peregrines have not been documented in the Bull Run, the Columbia River Gorge Scenic Area, located adjacent to the Bull Run Watershed, currently supports high quality habitat. Three wild pairs have been documented nesting in the cliffs on the Gorge's Oregon side. These peregrines are suspected to also utilize the Bull Run Watershed as a foraging site.

The Bull Run Watershed includes ecologically diverse wetlands in undisturbed, pristine condition. A Research Natural Area (RNA) has been proposed for Big Bend Mountain area due, in part, to the wetland habitats present (Hanken, 1995). Information on two other wetland areas, Latourelle Prairie and Goodfellow Lakes, and their associated species of concern, is available in Chapter Four's Botany section.

Six "Sensitive" plant species (also discussed in Chapter Four) live in the watershed's wetlands: **pale sedge, Indian rice, bog clubmoss, scheuchzeria, Strickland's taushia, and lesser bladderwort**. Wetlands are homes to four Mt. Hood NF inventory species: **cottongrass, stiff clubmoss, wild cranberry, and sweet gale**. In addition, three "Survey and Manage" vascular plants, **three-leaved goldthread, Mingan's moonwort and mountain moonwort** may potentially occur within the watershed.

The Bull Run Watershed's high-quality wetland habitat is predicted to remain stable in the future due to LSR and Riparian Reserve allocations, water supply protection, and low threat from fire.

Key Question #2 -- How do conditions of the watershed affect the ability to meet the Aquatic Conservation Strategy Objectives?

The Aquatic Conservation Strategy (ROD p. B-9) was developed to protect fish and other riparian dependent resources and species. Under the Northwest Forest Plan's Aquatic Conservation Strategy (ACS), a large portion of the Bull Run and Little Sandy Watersheds have been designated a *Tier 2 Key Watershed*, a source of high quality water. The Watershed Analysis process is required to provide the basis for determining Riparian Reserves and developing the baseline to assess maintaining or restoring the watershed's existing condition (ROD pp. B-10 & B-12).

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

Vegetative structure and composition served as the primary watershed and landscape-scale feature used to assess this objective. This feature best reflects watershed and landscape-scale conditions under which aquatic species, populations, and communities are uniquely adapted.

Based on a 350-year period for the Bull Run Watershed, the current amount of late-seral forest (45%) is below the natural range (77-88%). The current amount of mid-seral (38%) is above the natural range (0-15%). Early seral amounts (12%) are within the natural range (0-21). The largest deviations from these natural ranges are within the more productive Western Hemlock Zone.

For the most part, the watershed's landscape level effects are minimized as harvest units are dispersed among late-seral forests rich in structural diversity. Altered conditions and ecological processes, however, may exist in subwatersheds that are low in late-seral forests and dominated by aggregated harvest units. These subwatersheds include: Lower Little Sandy, Lower Bull Run, Headworks, and the Otter Creek area of Bull Run.

The current arrangement of seral stage amounts on the landscape is somewhat altered from that of a natural condition. In the past, large contiguous forest patches dominated the landscape. Currently, these large patches are often "perforated" or "fragmented" with scattered, small 20-60-acre open patches. (Refer to Chapter Four -- Vegetation/Landscape Pattern). This reduces the level of forest connectivity and the amount of interior habitat in late-seral forests. In addition, some portions of the landscape are dominated by aggregated openings of early-seral forest with low structural diversity.

Compared with natural conditions, vegetative composition and structure may be simplified in some areas of the watershed. Many of the watershed's existing early-seral stands and young mid-seral stands were initiated following timber harvest activities. Therefore, they lack the structural components left behind by natural fire such as snags, downed trees, large remnant trees and forest patches. Harvest activities since the late 1980's, however, tended to leave some structural components behind. Current Northwest Forest Plan standards and guidelines require even higher levels of these structural components to be retained after harvest, ROD p. C-39 to C-44.

Early-seral stand conditions outside or at the extreme ends of the Range of Natural Variation (RNV) have the potential to alter the flow regime through increased peak flows, and by decreasing base flows.

The Landscape Analysis and Design (LAD) process (Chapter Five) was used to depict what the watershed's stand structure would be like in the future based on current management direction. Thus, future landscape patterns for the watershed --as determined through this LAD process -- will be similar to patterns under natural conditions: large, dominating nonfragmented patches of late-seral forest. Furthermore, the distribution of seral stages will be consistent with natural ranges that existed during a 350-year period prior to increased timber harvest activities.

ACS Objective #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 the life history requirements of aquatic and riparian-dependent species.

(Because many of the factors that influence connectivity throughout the watershed also affect the watertable elevation in floodplains and wetlands, ACS Objectives #2 and #7 were assessed together.)

ACS Objective #7: Maintain and restore the timing, variability and duration of floodplain inundation and watertable elevation in meadows and wetlands.

Terrestrial Connectivity

Connectivity Between Watersheds

The Bull Run Watershed contains a large portion of Late Successional Reserve (LSR). The watershed is bordered to the northwest, north and east by the rest of this LSR, much of which is presently unfragmented late-seral forest. Existing conditions and future management direction will facilitate strong connectivity of late seral-forests between the Bull Run Watershed and adjacent lands to the northwest, north and east.

To the south, the watershed is bordered by an extensive area of aggregated openings dominated by early-seral, mid-seral, and developed lands within the U.S. Highway 26 Corridor. Connectivity between the Bull Run and Upper Sandy will be maintained through Riparian Reserves in the southeast portion of the watershed. Connectivity of late-seral-forests with other adjacent lands to the south may be minimal.

Connectivity Within the Watershed

At present, portions of Riparian Reserves in drainages that may provide important landscape connectivity may be compromised by extensive openings in the forest canopy. A north-south corridor formed by Falls Creek, Blazed Alder Creek and associated tributaries is "severed" by some rather extensive openings in the Otter Creek area (due to windthrow, salvage, timber harvest), and due to reservoir project work in the Blazed Alder/Nanny Creek area. An east-west riparian corridor comprised of Cedar Creek and South Fork may be compromised by extensive openings in upper Cedar Creek (reservoir project work, timber harvest). This may reduce riparian connectivity to wetland areas such as Goodfellow Lakes.

Hydrologic Connectivity

Lower Bull Run and Little Sandy Rivers

Dams on the Bull Run and Little Sandy rivers have resulted in a severely altered low flow regime below these facilities. Both the Bull Run and Little Sandy rivers are essentially dewatered during the summer low-flow period. Due to the diversion of the first 800 cfs in the Little Sandy River, it is not only dewatered for the summer low-flow period, but for the majority of the year.

Peaking operations associated with the operation of the Bull Run power plant have also resulted in a severely altered stream flow regime during the summer low-flow period below the power plant. Preliminary analysis indicates swings from 0-200 cfs in a one-hour period.

These factors have resulted in a lack of hydrologic connectivity in the lower 6.2 miles of the Bull Run River, and within the lower 1.7 miles of the Little Sandy River.

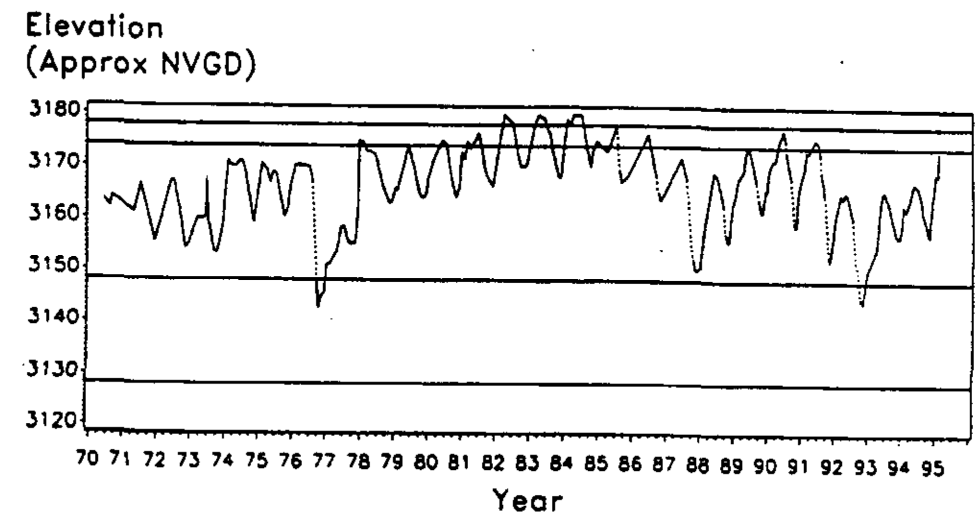
The lower sections of the Bull Run and Little Sandy rivers are characterized as U and V shaped channels with steep adjacent side slopes. There are no wetlands associated with these channels. Based on the channel morphology, a limited opportunity for floodplain development has been identified. Because of the lack of wetlands in this area, the altered low-flows do not have an impact on wetland inundation. The effect on floodplain inundation associated with reduced peakflows on the Little Sandy River would appear to be minimal due to the limited opportunity for floodplain development in this area.

Bull Run Lake

Bull Run Lake is in the headwaters of the watershed and has been used historically as a supplemental supply source during emergencies. Use was higher in the period 1985-1992 due to the unavailability of the east county wellfields at that time. Need for Bull Run lake in the near term future sould be much less.

Water withdrawals during 1985-92 have exacerbated natural lake level fluctuations and greatly increased the within-year and between-year variation in lake levels from preceding periods. Water withdrawals resulted in an unusually low lake level in 1992.

Chart 6-2 Bull Run Lake Water Levels



Dashed lines indicate releases by pumping or through valves; solid line indicates natural lake level changes.

Extent of management influence before 1976 is not well documented.

Water withdrawals from Bull Run Lake have affected connectivity with associated tributaries and with the shoal area on the southeast end of the lake.

The spring high water level is directly related to passage conditions for adult spawning cutthroat. As the spring water level is lowered, upstream passage to the limited spawning habitat in the tributaries becomes increasingly difficult.

The largest and most productive shoal area in the lake is located at the southeast end, from lake elevation 3140-3178. Most of the shoal is located above 3148. It is associated with several of the tributaries important for spawning and appears to be important for rearing fish. This area had the highest density of fish observed in hydroacoustic surveys. As water level drops, this highly productive habitat is removed.

Water withdrawals from Bull Run Lake from 1985-92 have resulted in disconnected tributary and shoal habitat. However, in 1996, Bull Run Lake was fully recovered and at bankfull during the spring high-water level period.

Wetland Modification

Latourelle Prairie, a 151-acre wetland located in the watershed's northern tip, was dammed in 1959 to become Boody Lake. In a 1967 photo, approximately one-third of the wetland appears flooded. Approximately 55 acres of wetland habitat were eliminated. The dam is now essentially breached by a large unregulated culvert spillway. A 1977 photo taken after a series of spillway failures and impoundment fluctuations shows water levels back to pre-dam levels.

In addition to approximately 18 years of unnatural water levels, additional disturbances have included a powerline corridor intruding through the wetland's northwest corner, and clearcut harvest units partially bordering its northwest and eastern edges. Despite these disturbances, Latourelle Prairie appears to be in good health. When pre-dam 1958 and 1995 photos are compared, its physical shape and distribution of water appear similar. In addition, elk herds still forage here and Indian rice has been located in the previously flooded area.

Goodfellow Lakes (three individual lakes) are located north of the watershed's southern boundary near North Mountain and the headwaters of the Little Sandy River. A large wetland is located at the western-most lake's north end. In 1970 the Forest Service analyzed a City of Portland proposal to modify the west and middle Goodfellow lakes for water storage. By 1972, all three lakes and the wetland were surrounded by clearcuts and the western-most lake was drained to facilitate dam construction. Aerial photos from 1972 and 1974 show the west lake totally dry in summer.

The program was halted after it became apparent that the water storage project's benefits would be far less than the project's costs. Sometime after 1974 the elevation at the west lake's outflow was restored. Lake levels in a 1977 photo approximate pre-disturbance conditions. Similar to Latourelle Prairie, the physical integrity of Goodfellow Lakes appears similar today (1996) to a 1948 photo -- the trees are simply smaller.

It appears that historical modifications of Latourelle Prairie and Goodfellow Lakes has not resulted in an altered pattern of wetland inundation in these areas.

Roads

Current research indicates roads function hydrologically to modify streamflow generation in forested watersheds by altering the spatial distribution of surface and subsurface flowpaths. Observations suggest that roadside ditches and gullies function as effective surface flowpaths, which substantially increase drainage density during storm events (B. Wemple, 1994). This function has the potential to quickly route stormflows offsite, preventing the storage and slow release that maintains hydrologic connectivity and watertable elevation in wetlands. Areas where this process is of concern are located in the Headworks and Otter Creek subwatersheds.

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

Field reconnaissance in the Bull Run Watershed by LaHusen (1994) revealed that stream channel processes were the dominant sources of sediment in the watershed. (See also Chapter 4, Stream Geomorphology, Stream Stability).

Channel Stability

In the Bull Run Watershed the erodiblility of the geologic unit serves as the primary factor that controls stream stability. Stream channels with the Troutdale and Rhododendron Formations are subject to mass failures, are easily eroded, and are considered unstable. Once these unstable channels are disturbed, accelerated erosion of unconsolidated and unprotected streambanks can persist for prolonged periods (LaHusen, 1994).

Much of the total length of Bull Run Watershed stream channels are incised into massive and competent flows of andesite and basalt. Accordingly, episodes of streamside mass wasting will most likely be limited to sections of stream channel within the Rhododendron Formation (LaHusen, 1994).

The majority of the unstable stream channels within the watershed are located in the Lower Bull Run and Lower Little Sandy subwatersheds, with inclusions into the lower portions of the South Fork of the Bull Run River, Cedar Creek, Fir Creek, and Hickman Creek.

Areas of unstable stream channels with the potential to generate sediment through streambank and streambed erosion have been identified. Any sediment generated in these areas has the potential to be routed downstream to depositional stream reaches, and, thereby, to affect water quality and aquatic habitat. A study of turbidity sources in the watershed has identified these sources as the primary source of sediment and turbidity in the watershed (LaHusen, 1994).

Although stored fine-grained sediment is uncommon in the watershed's channels, some streamside deposits do exist. Alluvial flood plains and terraces exist in the wide, relatively low-gradient valley bottoms that have formed in the Bull Run Watershed by lateral erosion of relatively weak geologic formations.

For example, erodible alluvial deposits are present adjacent to small stream channels that empty into the northern portion of the upper reservoir from: Five-mile Creek, Bear Creek, Deer Creek, and Cougar Creek. In addition, Cedar Creek, the lower South Fork Bull Run River, and the lower segment of Fir Creek also have relatively wide valley bottoms with erodible deposits. Sediment that has been deposited during high velocity streamflows into the Bull Run Watershed lacks fine particles that may linger in suspension in reservoirs. (This sediment typically consists of sand, gravel, cobbles, and boulders.) Weathering and soil genesis on old deposits gradually leads to accumulation of finer particles. As these deposits erode during exceptional storms, the potential severity of downstream water-quality problems increases (LaHusen, 94).

Major depositional areas below unstable stream reaches are identified in the Bull Run River from the reservoirs downstream to the confluence with the Sandy River (See stream geomorpology section in Chapter 4.)

November 1995 and February 1996 Storm Events

An intense precipitation event in November 1995 resulted in two landslides with direct delivery to the stream system. Both of these landslides were in areas mapped as "high" hazard. The West Branch of Falls Creek and the Bull Run River -- just below the Headworks -- experienced landslides during this storm. Neither of these landslides are believed to be related to human activities (Piehl, Anderson, pers comm. 1995).

During the February 1996 storm event, three road-related failures associated with unstable geology occurred along the 10 Road and below the Headworks along the lower Bull Run River.

ACS Objective #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.

By any objective standard, the water quality of the Bull Run Watershed's streams can only be described as extraordinary. From the earliest days of using the basin as Portland's water supply, its purity has been lauded. At present, chemical measurement of dissolved species in the water require the utmost in analytical skill because of the minimal amounts of their concentrations -- generally at or near the limits of detection for accepted analytical methodologies (Aumen, Hawkins and Grizzard, 1989).

The waters of the Bull Run are of excellent quality . . . The quality of the streamflow is only slightly changed from the rainfall and snowmelt (Aumen, Hawkins and Grizzard, 1989).

Outside the water supply drainage, water quality is a concern with respect to:

- Stream temperatures appear to be higher than the current state water quality standards in the Upper Little Sandy River. This is attributed to Goodfellow Lakes, nonvegetated talus, a large streambed relative to the streamflow in the lowflow period, and harvest activities along streams.
- Water quality concerns associated with dewatering of the Bull Run and Little Sandy below dams and diversions (temperature, DO, conductivity, etc.).

- Water quality changes from diversion of Sandy River mainstem water into the Bull Run (turbidity and false attraction).

ACS Objective #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.

Unmanaged Condition

Aquatic ecosystems within the Bull Run Watershed evolved in a sediment regime derived from geologic rates of mass wasting and surface and channel erosion processes. Schulz (1980) found less than 2% of the watershed rated as high mass wasting potential. This would indicate an infrequent and localized contribution to the sediment regime from hillslope failures.

Forested watersheds have been found to have a very low surface erosion potential when fully vegetated (Swanson and Grant, 1982). Thus, under a forested condition, the watershed would also have very low sediment supply from surface erosion. Channel erosion in an undisturbed watershed would occur during infrequent flood events.

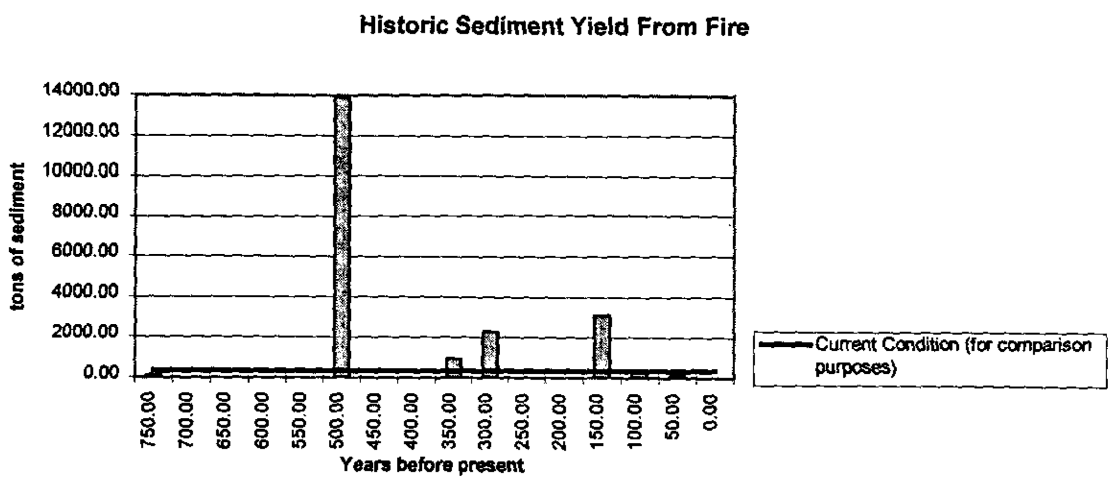
Prior to human use of the watershed, sediment production would have resulted from natural disturbances such as fires, floods and possibly windthrow. Forest cover loss following wildfire would result in episodic and brief increases in surface erosion and mass wasting rates. Sediment supply would spike for the first few years following fire, and would recover to near zero as ground cover became reestablished and hillslopes stabilized.

Krusemark et al. (1996) documented the historic pattern and intensity of fires in the Bull Run Watershed (not including the Little Sandy subwatersheds). The authors characterized the fire regime as infrequent, high severity events. Over the 750-year period they examined, several wildfires burned extensive areas within the watershed. The current estimated surface erosion rates were substantially exceeded by historic fires 500, 330, 300, and 120 years ago (Chart 6-3). As shown in Chart 6-3, erosion rates from fires in the watershed would have returned to zero in a short period in the aftermath of these fires.

Timing, Volume and Rate

The episodic nature of the sediment regime in an unmanaged condition contrasts with the watershed's current condition. In the current managed condition, the sediment yield from disturbed surfaces such as roads and harvest (Chapter Four -- Sediment Production) remains at a continuos, low level. In an unmanaged condition, large spikes are generated in the sediment yield when wildfires consume more than 2000 acres within the watershed (depending on soil types affected). The recovery to near zero is rapid following fire. In a managed condition, recovery would not occur while road surfaces and other cleared areas remain on the landscape.

Chart 6-3 -- Historic Sediment Yield from Fire



Storage and Transport

Prior to construction of the Bull Run reservoirs, some of the sediment generated within the watershed would have been retained within the watershed's depositional reaches while the remainder would have been routed through. Currently, more fine sediment deposition is likely in the reservoirs. Less fine sediment is routed below to the mainstem Bull Run River and beyond. Study of sediment storage in Reservoir #1 since completion in 1929 indicates less than 1% storage capacity reduction during that period despite sediment transport in the

1964 flood event and the 1972 dam failure on the North Fork Bull Run River (Person, 1995).

In-Channel Processes

LaHusen (1994) evaluated the sediment regime through field observations and the examination of historic turbidity data. On the basis of observations of erosion scars, LaHusen found streamside sites to be the most evident sources of turbidity within the watershed. Through the examination of the turbidity data, LaHusen found that the dominant erosion and sediment processes were active solely during storms. Watershed processes that increase the magnitude of stormflows could increase channel erosion and sediment transport. (For more information, see Chapter Four -- Flow Regime.) LaHusen identified the Log Creek channel in particular, which suffered severe scour following failure of the dam at Blue Lake.

To reduce the sediment increases in the watershed, restoration activities should focus on reducing the effects to the peak flow and sediment regime related to roads. While sediment from management activities in the watershed is relatively low (when compared to other watersheds), steep, nonvegetated road cuts and roads with native surfaces should be prioritized for restoration. Additionally, road densities should be reduced through decommissioning unneeded roads in all subwatersheds experiencing effects from stream drainage network expansion and increases to peak flows.

ACS Objective #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.

Peak and High Flows

- The only statistically significant Seasonal Kendall trend for peakflow magnitude in the watershed is identified in the Little Sandy River. This trend is of very low magnitude (annual change is 0.6% of the 1 year recurrence interval flood event).

- Higher peakflows per square mile are evident between the unmanaged "control" watershed (Fir Creek) compared to North Fork and Blazed Alder[1]. Differences in peakflows per square mile in North Fork and Blazed Alder are attributed to the watershed's precipitation patterns.

- Based on current stand conditions, all the major subwatersheds are below levels associated with the potential for adverse impacts from increased peak flows associated with rain-on-snow events. Although Otter Creek's area is too small to analyze with this methodology, based on canopy closure levels within this area, the potential for increased peak flows from rain-on-snow events raise concerns.

- Stream channel network expansion by roads is a concern in all the subwatersheds (except Fir Creek). The effect of this process on the timing, magnitude, and duration of peakflows is dependent on many variables unique to each basin and are not known at this time.

- An altered peak streamflow regime in the Lower Little Sandy is associated with the diversion of 800 cfs to the Bull Run power plant. (Roughly equivalent to the one-year recurrence interval flood event.)

Baseflows

- There are no statistically significant trends for 30-day duration low flows for: any of the key stations, Cedar Creek, Blazed Alder, or the Little Sandy River.

- All the stream gages, except Blazed Alder, have greater low-flow yields per square mile than Fir Creek. This is attributed to natural variation between runoff-producing properties in these areas (see Chapter 4 for discussion).

- The lower Bull Run and Little Sandy rivers are dewatered between the dams and the Bull Run power plant during the summer low flow period.

- Peaking operations associated with the operation of the Bull Run powerplant result in a severely altered flow regime during the summer low flow period.

[1] Based on Seasonal Wilcoxen-Mann-Test of annual peaks

ACS Objective #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.

(ACS Objectives #8 and #9 were assessed together by evaluating stand structure and seral stage within Riparian Areas.)

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

Riparian areas are particularly dynamic portions of the landscape. They are shaped by disturbances that are characteristic of upland ecosystems (such as fire and windthrow), as well as disturbance processes unique to stream systems (such as lateral channel erosion, peakflow, deposition by floods and debris flows). Maintaining the integrity of the vegetation is particularly important for riparian-dependent organisms, including amphibians, arthropods, mammals, birds and bats.

Forty-one percent of the Bull Run Watershed is comprised of riparian areas. Eighty-eight percent will be managed as Riparian Reserves as outlined under the Northwest Forest Plan Aquatic Conservation Strategy (ROD, pp. B-12 to B-17). The remaining 12 percent of the watershed is comprised of private lands located, for the most part, within three of the western subwatersheds (Lower Bull Run, west half of Headworks, and the southern edge and western portion of Lower Little Sandy).

At present, riparian areas of the Bull Run Watershed, are comprised of :

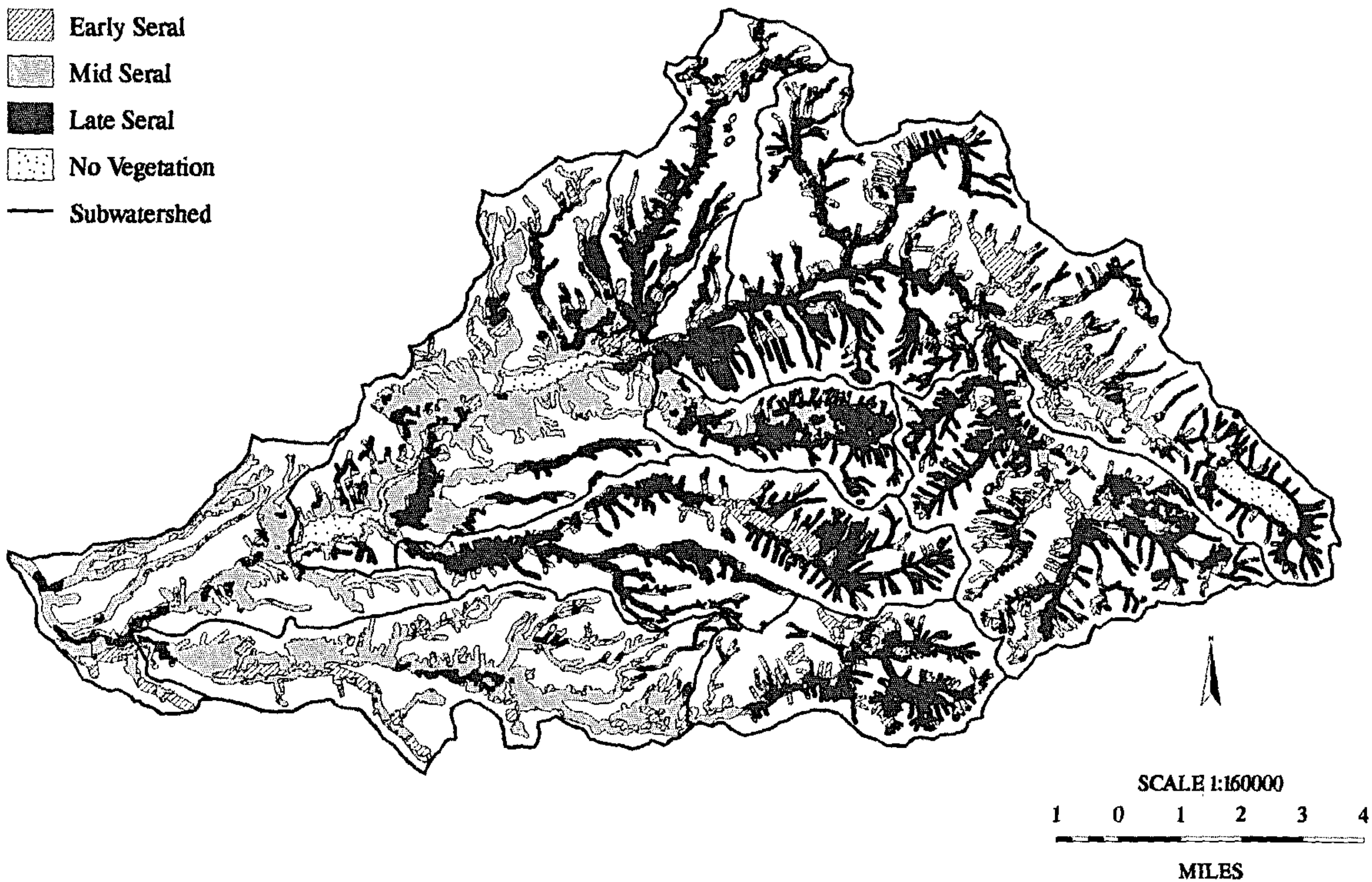
- 46% late-seral
- 38% mid-seral
- 13% early-seral
- 4% non-veg (rock/water)

These proportions are quite consistent to current conditions for the entire watershed. The Range of Natural Variability (RNV) concept and methods (as outlined in Chapter Four -- Vegetation) was also used to develop a range for seral stage amounts within riparian areas. Current conditions within riparian areas for late-seral are outside (below) that of the established range and, in turn, are outside (above) for mid-seral. Current amounts of early-seral at the landscape scale within riparian areas are within the established RNV.

Table 6-6 -- Seral Stage Within Riparian Areas (% of total riparian)

Seral Stage	RNV	1996	Future (30-50yrs)	Future (120+yrs)
Early	0-22	13	2	2
Mid	0-16	38	28	5
Late	72-84	46	66	88
Non-Veg	1	4	4	4

Bull Run Watershed
Seral Status Riparian Reserves



The forest Landscape Analysis and Design process (Chapter Five) was used to depict how the watershed's landscape should appear approximately 120 years in the future. A substantial amount of riparian recovery may occur much sooner as forest succession is allowed to progress. Future seral stage trends within the next 30-50 years are also displayed in Table 6-6.

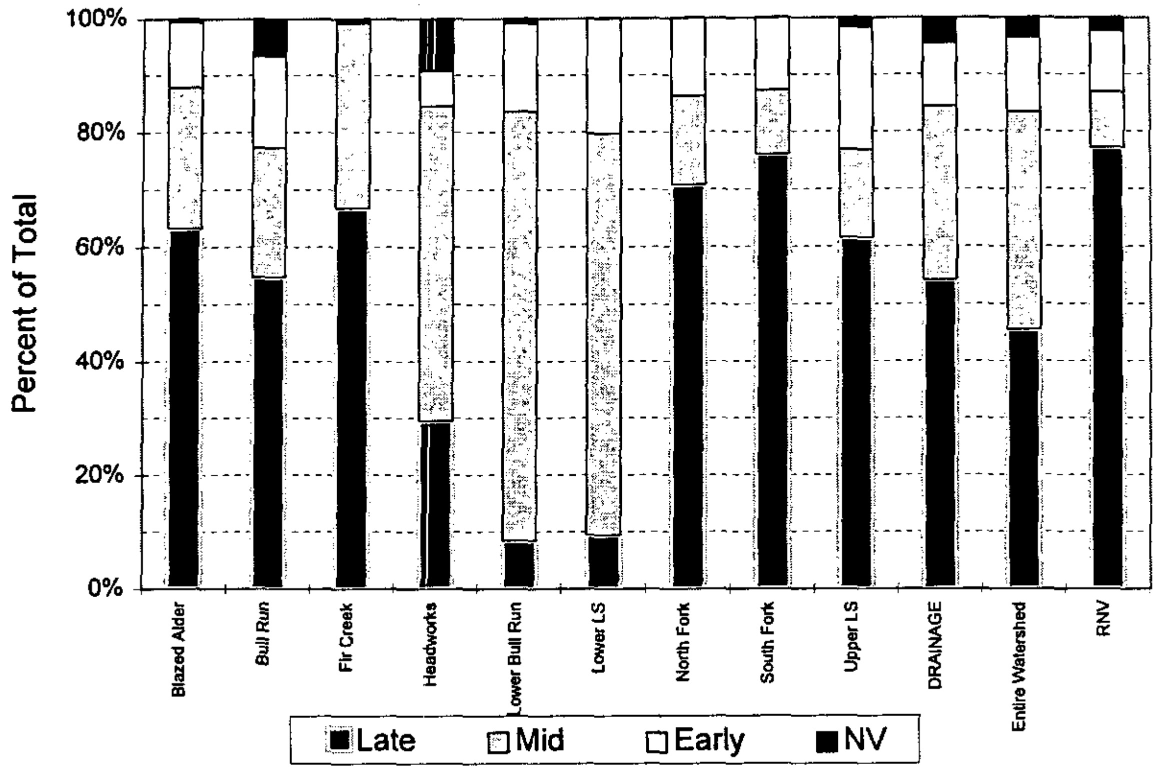
In addition, within the next 30-50 years, the majority of existing early-seral stage stands will have moved into mid-seral stands. And, existing mid-seral stands that currently have a component of large trees will have progressed to the late-seral stage. Long-term future amounts of the three seral stages appears to be within the RNV

At the landscape level, three subwatersheds (Lower Bull Run, Lower Little Sandy, and Headworks -- as well as the Otter Creek portion of the Bull Run River) account for most of the deviations in the amount of late-seral. Windthrow, salvage, reservoir clearing, and timber harvest account for most of the reduction in late-seral below that of the RNV.

The mid-seral forests in Lower Little Sandy and Headworks subwatersheds include a large amount of natural stands that are transitional between mid to late-seral. These originated after fires in 1873.

Chart 6-4 displays riparian seral stage amounts by subwatershed.

Chart 6-4 -- Riparian Area Seral Stage



Summer and Winter Thermal Regulation

Riparian buffers can have an effect on solar radiation, air temperature, wind speed, and relative humidity -- all of which have some influence on thermal regulation within the Riparian Reserves. Stand structure within the Riparian Reserves addresses many of these processes. Direct solar radiation intercepting the stream surface, however, is the principal factor in raising stream temperature in forested watersheds. Thus, canopy closure will be addressed in this section.

Chart 6-5 -- Riparian Buffer Effects on Microclimate (FEMAT Figure V-13)

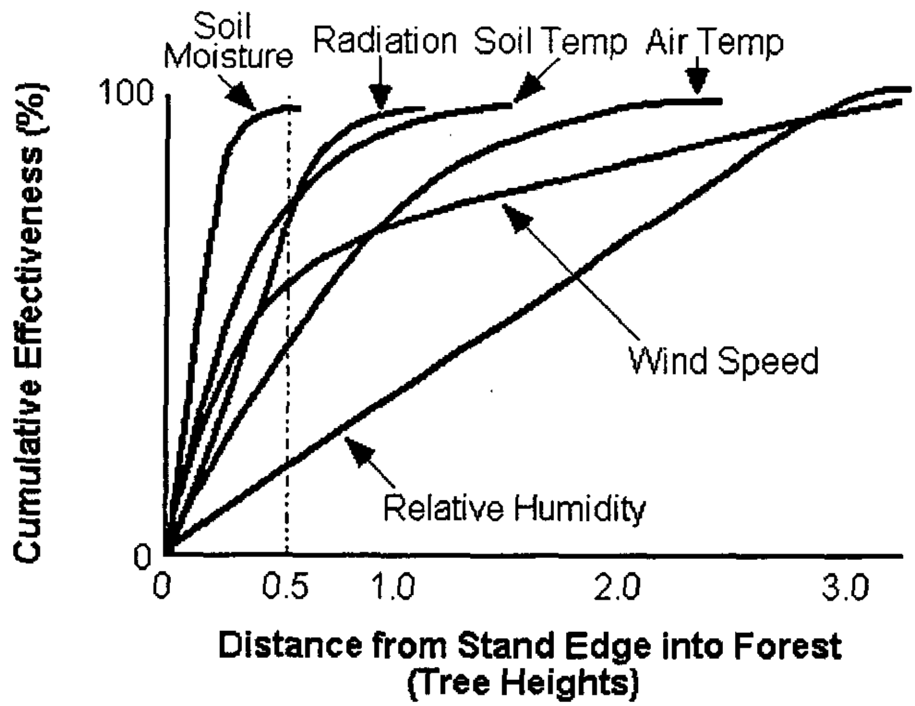


Chart 6-6 Riparian Reserve Canopy Closure

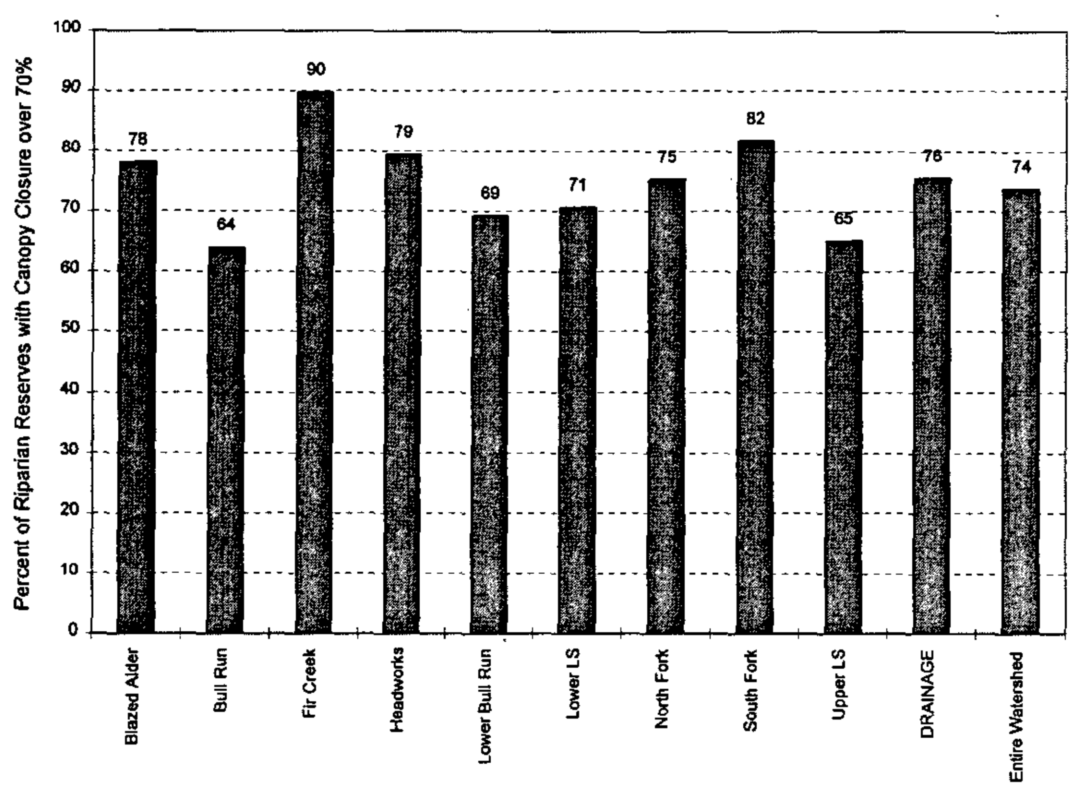


Chart 6-6 details shade levels across the watershed. Fir Creek represents the undisturbed condition with 90% of the area within the Riparian Reserves having more than 70% canopy closure. As Chart 6-6 illustrates, the percentage of the riparian area with over 70% canopy closure is below 70% in the following subwatersheds: Bull Run, Lower Bull Run, and Upper Little Sandy.

Within the Little Sandy River, stream temperatures appear to be higher than current state water quality standards. Stream temperatures are slightly higher (1.2^0 C) in the Bull Run River than in Fir Creek. The higher temperatures in these streams may be influenced by lower levels of stream shade or may be the natural condition for these streams. It would be useful to quantify the influence of created openings on stream temperatures with a tool such as SHADOW (Park, 1993).

Nutrient Filtering

Riparian vegetation regulates the exchange of nutrients and material from upland forests to streams (Swanson et al. 1982; Gregory et al. 1991). This is an important function of the Riparian Reserves.

Most of the nitrogen lost from forests to streams is relatively small for most undisturbed forest ecosystems (Cole 1979, Triska et al. 1984). Nitrogen inputs from forest management activities are usually associated with: logging, fire, and forest fertilization. Recent research indicates that riparian zones are important sites for denitrification (Green and Kauffman 1989). In the Bull Run nitrate levels are quite low due to active conversion in hte aquatic ecosystem.

Within the aquatic system, organisms involved in nutrient cycling in streams (particularly bacteria, fungi, and algae) reside on surfaces such as wood and rock. These organisms are capable of transforming nitrogen, phosphorus, and other nutrients between inorganic and organic forms.

Levels of woody debris within the watershed indicate adequate sites for organisms involved in nutrient cycling. Evidence indicates that levels of in-channel large woody debris have some influence on nitrate nitrogen levels of streams within the Bull Run Watershed. Higher levels of in-channel large woody debris were associated with lower levels of nitrate nitrogen. Areas within the watershed with low levels of in-channel large woody debris (Lower Bull Run River and Lower Little Sandy River) may have higher levels of nitrate-nitrogen.

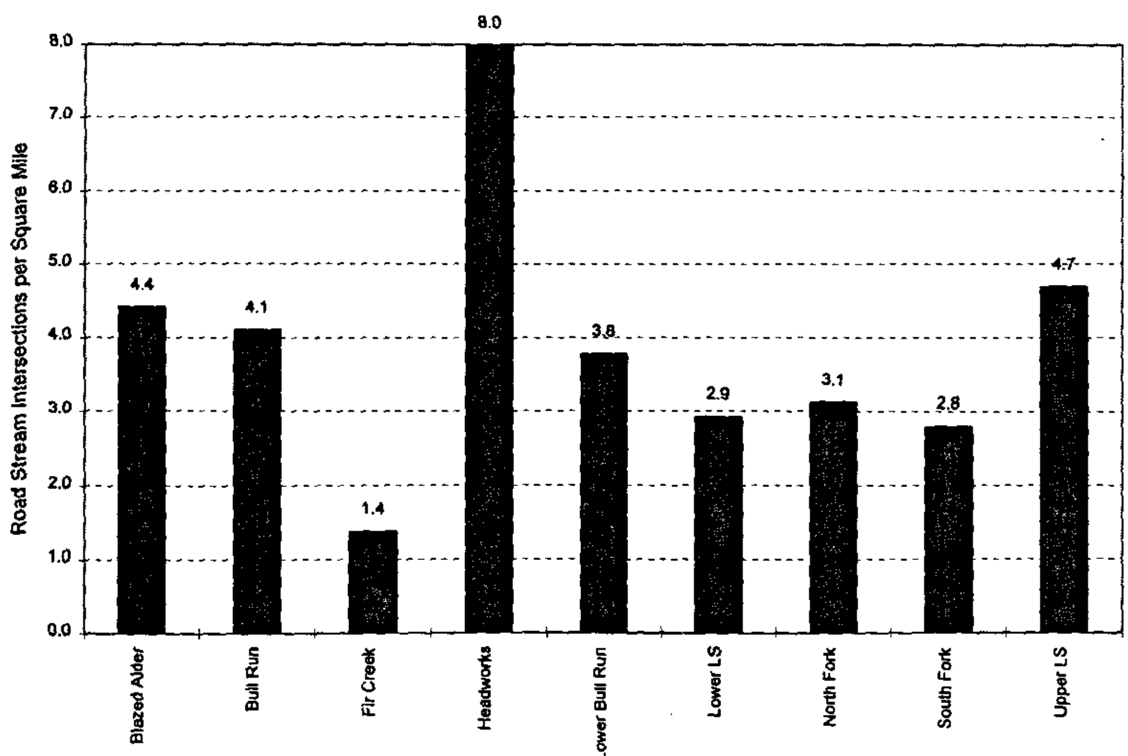
Surface Erosion

Species composition and structural diversity required to maintain appropriate rates of surface erosion is a function of effective ground cover within the delivery zone to streams. At the watershed scale, roads are the largest single impact to effective ground cover within this zone.

Field reconnaissance in the Bull Run Watershed by LaHusen (1994) found that stream channel processes were the dominant sources of sediment in the watershed. (See also Chapter 4, Stream Geomorphology, Stream Stability). In contrast, roads and harvest units were not found to be large contributors to the watershed's sediment budget. One exception noted by LaHusen, however, were steep, nonvegetated road cuts adjacent to stream crossings.

Chart 6-7 illustrates the density of road and stream intersections by subwatershed.

Chart 6-7 -- Road and Stream Intersections per Square Mile



As detailed in Chart 6-7, the Headworks subwatershed has considerably more stream crossing per square mile with the potential for nonvegetated road cuts and associated erosion.

Bank Erosion and Channel Migration

Effects of watershed conditions on stream channel stability were discussed earlier in this key question. Lack of riparian vegetation next to unstable channels with respect to streambank erosion and inner gorge failure will intensify any problems. Root systems in streambanks of the active channel stabilize banks, allow development and maintenance of undercut banks, and protect streambanks during large storm flows (FEMAT V-25).

Late and mid-seral stands should have the root strength required to prevent excessive bank erosion and channel migration. Those subwatersheds with a high (greater than 20%) percent of the riparian area with early seral stands would be of concern with respect to bank erosion and channel migration. Upper and Lower Little Sandy subwatersheds are in this category and may have levels of bank erosion and channel migration outside acceptable limits.

Large Woody Debris Inputs

Table 6-7 -- LWD Recruitment Potential by Subwatershed

SUBWATERSHED	LOW	MOD	HIGH	NON VEG
Lower Bull Run	16	75	8	1
Lower LS	21	70	9	0
Headworks	7	56	28	9
South Fork	13	21	66	0
Fir Creek	0	42	57	1
North Fork	14	29	57	0
Bull Run	16	39	38	7
Blazed Alder	12	43	44	1
Upper LS	21	51	25	2

Fifty-seven percent of the Riparian Reserves within the Fir Creek subwatershed (which is non-logged and unroaded) are in the high LWD recruitment class.

This also reflects the condition in the South Fork, North Fork, and Blazed Alder subwatersheds, in which limited management activity has occurred inside the Riparian Reserves. Based on the values from Fir Creek, 50-60% of the area within the Riparian Reserves in the high LWD recruitment potential category appears to reflect the undisturbed LWD recruitment condition.

The Lower Bull Run and Lower Little Sandy subwatersheds have less than 10% of the area within Riparian Reserves in the high LWD recruitment potential category.

Compared to Fir Creek subwatershed, this indicates impacts associated with land management activities or natural disturbances in this area.

Key Question #3 -- How do conditions of the watershed influence late-successional habitat?

Impetus to evaluate this Key Question comes from both the large proportion of late-seral habitat (45%) and extent of Late-Successional Reserve (LSR) (69%) within the watershed. Late-successional (or late-seral) forests include both mature and old-growth age classes.

Conditions that Influence Late-Successional Forests in the Bull Run Watershed

Conditions influencing late-successional forests in the watershed include site productivity, disturbance regimes, and management direction.

Site Productivity

The Bull Run Watershed's warm, moist climate, heavy rainfall and generally productive soils make this area conducive to rapid and large tree growth. Roughly 70% of the watershed is comprised of highly productive moist to wet plant associations.

Disturbance Regimes

The Bull Run Watershed's fire regime is similar to fire regimes in very wet areas. In fact, the watershed is less likely to burn than areas directly adjacent to its north and south flanks. The watershed's high moisture presence can affect the moisture content of dead fuels and live foliage throughout the dry season. This moderates the potential fire intensity and severity (Krusemark et al. 1996). These warm, wet conditions found across most of the watershed also facilitate rapid decomposition of fine fuels.

The watershed's long fire return interval allows sufficient time for late-successional forests to develop. Until active timber management began in the 1950's, approximately 3/4 of the watershed had been covered by late-successional forests for 350 years. A large proportion of late-successional forest remains and is dominated by very old stands, most over 500 years, with the majority of the remaining stands over 300-years-old. (See the Composite Fire History Figure in Chapter Four, Fire section.)

With current fire suppression techniques and a 10-acre fire control policy, most future fires in the Bull Run will remain small. Risk of fires in the Bull Run is low, yet a fire or multiple fires under the right weather conditions and an east wind event could result in a large, stand replacement fire which would affect the amount of late-successional forest.

Throughout time, windthrow events have reduced the amount of late-successional forest within the watershed, yet extensive windthrow in the Bull Run is relatively uncommon. Since 1948 only two events have generated windthrow covering more than 2% of the forest.

Easterly winds channeled down the Columbia River Gorge funnel directly into the watershed exposing trees both on the windward and lee slopes and windthrow will continue in the future. The risk of windthrow near clearcut edges is decreasing as these edges increase windfirmness in sometimes as little as a decade. As current younger forests age, windthrow risk will increase over the next several decades as more forest becomes older and taller and therefore more vulnerable to windthrow. Therefore late-successional forest may be reduced in portions of the watershed.

Insects and pathogens within the Bull Run are also important agents of change. Laminated root disease is scattered throughout the Bull Run and will cause small scale disturbance. Although only small Douglas-fir beetle outbreaks have occurred within the Bull Run Watershed in the past, large outbreaks could still occur in the future, especially with successive windthrow events. Low level populations of other insects and pathogens will continue to cause small scale disturbance that may affect late-successional forest.

In addition, with the passage of the Oregon Resource Conservation Act, the cutting of trees is generally prohibited across most of the LSR. The LSR contains approximately 10,428 acres of plantations. Dense plantations originally planted for timber management and left unthinned may lead to altered stand dynamics. This could result in stand stagnation and a delay or compromise in achieving late seral forest conditions, and potentially increasing susceptibility to other disturbances such as windthrow, insects and disease, and fire.

Management Direction

For more than 100 years, extensive areas of the Bull Run Watershed have been managed for municipal water supplies. In turn, this primary management focus has resulted in various policies and laws that have greatly reduced human entry and limited non-water resource extraction. These restrictions have helped perpetuate the current levels and quality of late-successional forests within the watershed.

Timber harvest and reservoir construction projects have lessened the amount and altered the pattern of late-successional habitat within the watershed, particularly in stands classed as Large Conifer (dominated by trees >21"dbh). Currently, 36% percent of the watershed's federal lands contain stands of Large Conifer, compared to 61% in 1948. (Refer to Chapter Four, Vegetation/Structure.)

The predominant management direction for most of the watershed includes not only protection of water supplies, but also protection for late-successional forests (ROD, 1994). Management direction from the Northwest Forest Plan combined with water protection legislation will maintain or enhance late-successional forests on 83% of the watershed. The Northwest Forest Plan's strategy to meet the needs of late-successional forest species includes:

- **Late Successional Reserves** (LSR) intended to maintain a functional, *interacting, late-successional and old-growth forest ecosystem* (ROD p. C-11).
- **Riparian Reserves** to provide for greater connectivity of late-successional forests within watersheds and among LSR's for dispersal of mobile species such as the northern spotted owl, and serve as refugia for species that disperse only short distances (ROD pp. 7 & 29).
- **Isolated patches** of late-successional habitat in matrix lands for species to move between LSR's and for refugia for sessile species (ROD p. B-1).

In addition, standards and guidelines from the Northwest Forest Plan state that watersheds with less than 15% late-successional forest on federal lands should be protected (ROD p. C-44). The Bull Run Watershed as defined in this analysis is currently well above this criteria at 49%.

Amount and Distribution of Late-Successional Forests in the Bull Run Watershed

The total amount of late-successional forest is currently outside (below) the natural range of variability (RNV) established for the area. (refer to Table 6-8 below, and Chapter Four/Vegetation/Seral Stage.) This deviation is strongly influenced by timber harvest, windthrow salvage, and reservoir construction projects. Had these activities not occurred, assuming the same fire history, the current amount of late-seral forest would be nearly within the RNV -- based on a period of 350 years.

Under current management direction and in the absence of large-scale fire or windthrow events, the amount and pattern of late-successional forest will move closer to the RNV in the short term, 30-50 years. It will move within the RNV in the long term, 120+ years. Additionally, within the LSR, the amount could conceivably move above the RNV. However, small areas of low site productivity and small-scale disturbances through time would most likely limit increases above the RNV.

Amounts of late-successional forest for the entire watershed and for the area managed as Late Successional Reserve (LSR) are displayed in Table 6-8. Present conditions and future conditions in two time periods are outlined. Future conditions assume current management direction (see Chapter Two), projected forward in time (see Chapter Five). In addition, a pre-harvest era (1948) "snapshot" is also presented for the LSR.

Table 6-8 -- Percent of Watershed Areas in Late-Successional Forest

Area	1948	1996	Future (30-50 yrs.)	Future (120+ yrs.)
Entire Watershed (88,962 ac)	--	45	62	83
LSR **(RNV=77-88%)** (61,133 ac)	77	57	68	97
All other lands (27,829 ac)	--	17	49	52

Note: Future, short-term = 30-50 years from 1996; Future, long-term = full implementation/realization of conceptual landscape design (120+ years) in absence of disturbance.

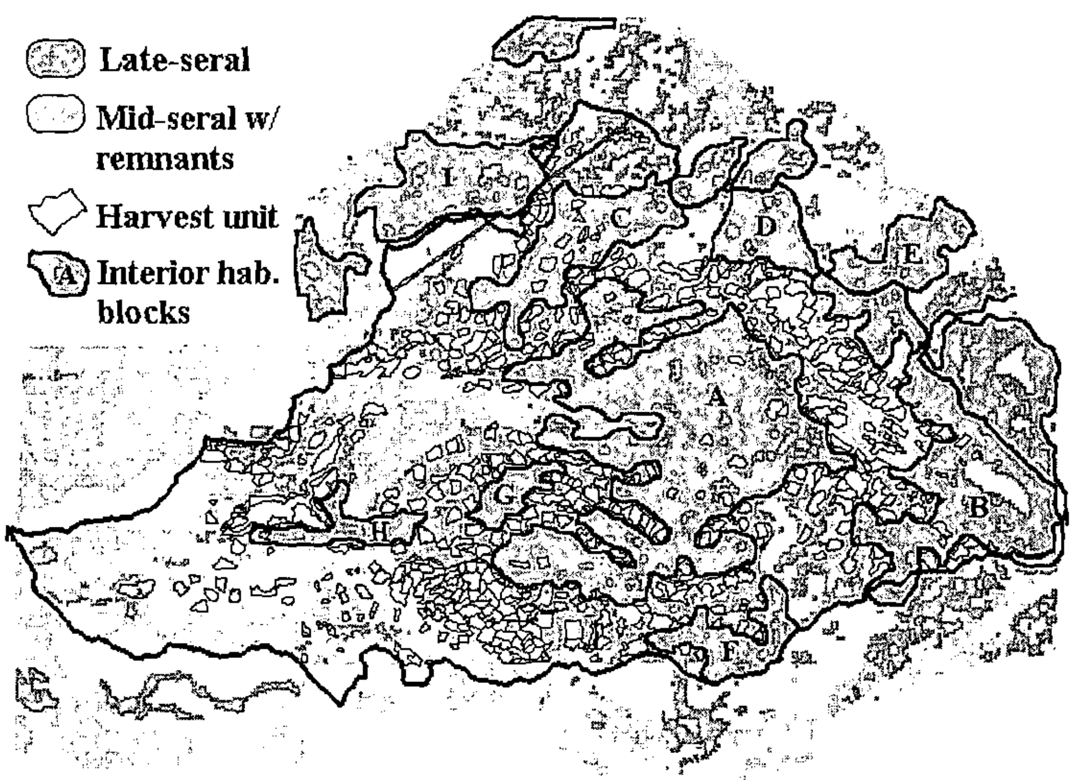
The distribution or arrangement of late-seral stands throughout the landscape is an important component of ecosystem diversity. This distribution serves a significant role in providing for biological and structural diversity across the landscape.

Interior habitat is defined as late-seral stands that are at least 500 feet from openings (openings, for this purpose, are early-seral forest patches and exclude stable natural openings such as wetlands or rock patches). Current landscape patterns in the watershed include dispersed openings (refer to Chapter Four/ Vegetation/ Landscape Pattern) which limit the amount of interior habitat. Young plantations have high contrast edges that may create edge effects as far as 500 feet into adjacent late-successional forest. This reduces the effective amount of interior habitat for late-successional species such as the northern spotted owl.

Figure 6-5 displays the largest, most connected blocks of interior habitat that are currently present in the watershed. Large blocks of interior habitat within or partially within the Bull Run Watershed are common and include two over 5000 acres; three between 2500-5000 acres; one between 1000-2500 acres; and three between 600-1000 acres. Connectivity across the LSR that includes much of the Bull Run Watershed may currently be hindered by a lack of suitable connective habitat between some large areas of interior habitat. For less mobile species, this may reduce the overall effectiveness of the LSR at present.

Figure 6-5 also displays the arrangement of late-seral (or late-successional) forests in the Bull Run Watershed. Stands immediately outside the watershed are also displayed to give a sense of connectivity to adjacent watersheds. Mid-seral stands with remnants that could transition to late-seral forest in the near future (less than 50 years in most cases) are also shown.

Figure 6-5 -- Large Blocks of Interior Late-Seral Habitat

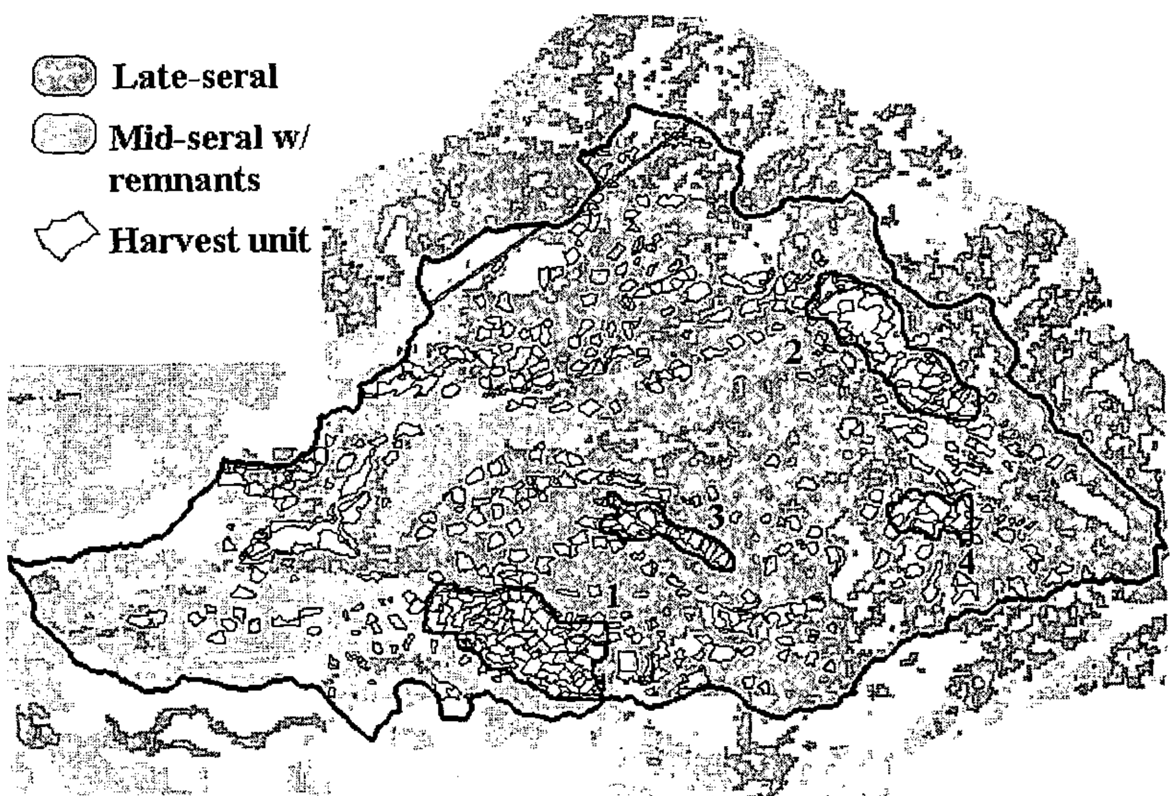


Landscape patterns where openings become aggregated have very little if any interior late-successional habitat, and may have very poor connectivity. The connectivity role of Riparian Reserves (as outlined in Aquatic Conservation Objectives #1,2 and 9, ROD, p. B-11) becomes critical in such areas, especially outside the LSR. Specific areas identified with landscape scale implications are displayed in Figure 6-6 and include:

1. East end of the Lower Little Sandy subwatershed (*This area is mostly outside of the LSR*)
2. Otter Creek area
3. Upper end of Cedar Creek
4. Upper Blazed Alder Creek (historic reservoir site)

Maintenance of upslope late-successional components until riparian recovery, and riparian silviculture to encourage this recovery should be considered where allowed (Lower Little Sandy area).

Figure 6-6 -- Areas of Concern to Riparian Habitat Recovery



Isolated patches of remnant old-growth forest are ecologically significant in functioning as refugia for a host of old-growth associated species, particularly those with limited dispersal capabilities, not able to migrate across large landscapes of younger stands. It is prudent to retain what little remains of this age class within landscape areas where it is currently very limited. (ROD, p. C-44).

Within the Bull Run Watershed, three subwatersheds (Lower Little Sandy, Lower Bull Run, and Headworks) are very low in late-successional forest habitat and in old-growth (see Seral Stage Amounts by Subwatershed Figure in Chapter Four,Vegetation). Where possible, management approaches that maintain portions or components of these isolated old-growth patches should be considered.

Future Landscape Pattern and Connectivity

In Chapter Five, the Conceptual Landscape Design and the Future Seral Stage and Pattern Figures, provide a visual display of future Bull Run Watershed landscape patterns. As outlined in Chapter Five, future landscape patterns across the Little Sandy portion of the watershed will be dominated by various-aged patches of mid-successional forests and connected linear corridors of late-successional forests within the Riparian Reserves, as well as periodic small patches of early-successional forest. While future pattern of private lands outside the water supply drainage is not known, it is estimated to be some arrangement of aggregated openings and fragmented forest lands -- similar to current patterns.

Future landscape pattern in the LSR and City of Portland lands within the water supply drainage will be dominated by unfragmented landscapes of late-successional forest with scattered natural openings (lakes, wetlands, talus-rocky areas). As forest succession progresses and edge effects diminish, the amount of interior habitat and connectivity will greatly increase even in the short term.

Key Question #4:-- How do conditions of the watershed affect the capabilities of the Bull Run Watershed Management Unit to meet the principal management objective of Public Law 95-200, as set forth in the *Mt. Hood National Forest Land and Resource Management Plan* (Mt. Hood Forest Plan)?

Rationale: Public Law (PL) 95-200 required and established the Bull Run Watershed Management Unit and The Bull Run Planning Unit Land Management Plan. The plan was completed in 1979 and incorporated into the 1991 Mt. Hood Forest Plan. PL 95-200 designates the principal management objective of the Bull Run Watershed Management Unit as the continued production of "pure, clear, raw, potable" water for municipal use. Management direction for this objective comes from the 1979 Plan.

This question will be answered by examining watershed conditions, streamflow regime, water quality, and future trends.

Watershed Conditions that promote the continued production of pure, clear, raw, potable water for municipal use.

The Bull Run water supply drainage is characterized with a stable geology, highly productive soils, and a climate that promotes rapid revegetation.

Much of the lack of response to logging (by present methods) results from the geologic stability of the watershed and because of the favorable site conditions which encourage revegetation. There is a shortage of fine particles (clay) usually associated with turbidity in surface waters with unstable slopes. In this context, it is a forgiving and robust system. (Aumen, Hawkins, and Grizzard, 1989).

Hillslope Geomorphology

- The proportion of unstable lands within the subwatersheds are low (2-17%).
- Surface erosion from undisturbed forest lands is low.
- Modeled (DNR) and observed rates (LaHusen) of surface erosion from disturbed forest lands within the watershed are low.

- In the Bull Run Watershed, high natural vegetative recovery, road surfacing and intensive erosion control practices on road cuts within the watershed have been effective at limiting erosion from roads.

Soils

- The Aschoff-Bull Run and Damsite-Sisi soils are deep, medium textured, and contribute to high site productivity within the watershed. The Aschoff-Bull Run and Damsite-Sisi soil groups comprise approximately 43% of the total watershed area.

- Soil properties of the Aschoff-Bull Run and Damsite-Sisi soil groups contribute to rapid infiltration of precipitation and snowmelt, as well as to high soil moisture storage. As a result, soils in the watershed have low surface erosion hazards when undisturbed.

Continued Production

Streamflow within the water supply drainage can easily meet demand during the wet months. Supply, however, must be satisfied from storage during the months of July, August and September. The median reservoir drawdown window length is 90 days. The assessment for continued production will focus on processes that influence water yield during the low-flow period.

Management activities within the water supply drainage appear to have increased flows during the critical low-flow period when demand exceeds supply.

Based on annual water yields, the gage on the lower Bull Run River reveals a 7.38% increase between the pre (1920-1959) and post (1960-1992) management treatment periods. Treatment effects (roads and silviculture) on water yield were positive for all months -- with increases ranging from 2.07 cfs to 3.31 cfs (Hawkins, 1995).

All the stream gages, except Blazed Alder, have greater low-flow yields per square mile than Fir Creek. This is attributed to natural variation between runoff-producing properties in these areas.

Clean, Clear, Raw Potable Water

This analysis indicates that based on the limited differences between the control watershed and managed watersheds and lack of trends with a measurable magnitude of change on an annual basis management activities have not limited the production of clean, clear, raw potable water in the water supply drainage. This finding is consistent with recent studies of water quality in the Bull Run water supply drainage.

Aumen, Hawkins and Grizzard, 1989:

By any objective standard, the water quality of the Bull Run Watershed's streams can only be described as extraordinary. From the earliest days of using the basin as Portland's water supply, its purity has been lauded. At present, chemical measurement of dissolved species in the water require the utmost in analytical skill because of the minimal amounts of their concentrations – generally at or near the limits of detection for accepted analytical methodologies.

Eilers, 1994:

In summary, if logging and associated activities had an effect on water quality during the 1970's and 1980's in the Bull Run watershed it was not observed in this review of historical data from the key stations and reservoirs. Although logging activities are often associated with the increased transport of suspended solids and NO_3, the magnitude of any increases that may have occurred were less than that which could be observed given the limitations in analytical methods and sampling design.

LaHusen, 1994:

Field reconnaissance in the Bull Run Watershed found that stream channel processes were the dominant sources of sediment in the watershed. (See also Chapter 4, Stream Geomorphology, Stream Stability.) In contrast, roads and harvest units were not found to be large contributors to the watershed's sediment budget. One exception noted by LaHusen were steep, unvegetated road cuts adjacent to stream crossings..

Future Trends

Based on disturbance regimes discussed in Chapter 4, the effects of fire and windthrow on water quality and quantity were examined.

Effects of Fire on Water Quality

Excerpted from the 1988 Blowdown FEIS:

The potential exists for a fire of large magnitude within the next several hundred years that could affect water quality. Even though the impact might be relatively short lived in terms of ecosystem time scales, the effects could be undesirable in terms of the City of Portland water supply.

The fire regime for the Bull Run Watershed's water supply's physical drainage is dominated by a "high" severity fire regime, characterized by infrequent fires of generally high intensity stand replacement events (Krusemark, et al, 1996).

These "high" severity fire regimes are characterized by infrequent severe crown or surface fires that cause high tree mortality, or stand replacement fires that typically result in total stand mortality and moderate to high loss of the duff-litter layer. Unlike "moderate" fire severity regimes, the landscape following "high" severity fire regimes are usually dominated by a lack of residual (remnant) trees that will ultimately regenerate into an even-aged stand. These fires are generally associated with: drought years, east wind weather events which lower humidity, and an ignition source such as lightning. Fires are often of short duration, but of high intensity and severity (Krusemark, et al, 1996).

Excerpted from the 1988 Blowdown FEIS:

Few field studies have addressed the effects of fire in a systematic way, although some information is available in the Bull Run Watershed itself. The Fox Creek study examined the effects of logging and slash burning on several streams (Fredriksen and Harr, 1988). The study demonstrated that nitrate increased slightly in streams following burning of a clearcut watershed. But the greatest increase was seen in a stream running through a clearcut in which the slash was not burned and was left to decompose naturally. Phosphate concentrations did not change appreciably during the study period.

Several other studies have documented nitrate increases following clearcutting and burning, although the increases do not persist for more than a few years (Likens et al 1970, Brown et al. 1973, Stuart and Dunshie 1976, Tiedemann et al. 1978).

Phosphate concentrations do not seem to be affected as much as nitrate concentrations (Brown et al. 1973, Stuart and Dunshie 1976, Fredriksen and Harr, 1988). The most significant impact on streams noted in all these studies seems to be increases in suspended sediment concentrations from logging practices (Beschta 1978).

Most field studies have concentrated on the effects of slash burning following clearcutting. Very few investigators have had the opportunity to follow the effects of catastrophic fire on a watershed. Even if samples are *collected from the watershed following a large fire, it is very rare to have sufficient pre-fire data with which to compare post-fire data. One study in the Southeast examined the effects of prescribed burning over a five-year period on stream nutrient concentrations (Richter et al. 1982). Although no effects on water quality were noted, the magnitude of the burning was low enough that it in no way duplicated the effects of a catastrophic fire over a large portion of a watershed.*

Most investigators note that the effects of fire will vary depending on the type of soils, the prevailing slopes around the stream channel, and the intensity, and duration of the fire itself. A fire that takes place in a watershed with high fuel levels, steep slopes, and unstable soil will undoubtedly have more impact on nutrient concentrations in streams than will a fire of lesser intensity in a watershed with gentle topography and stable soils.

When studies have demonstrated that fire results in increased nutrient concentrations in streams, the increased concentrations disappear within a period of a few years (Brown et al. 1973, Fredriksen and Harr, 1988). While this may be acceptable under most circumstances, significant deviations from base concentrations in the Bull Run watershed for as little as several months could have major impacts on the City of Portland's water supply. Short term deviations from normal water quality standards in the past have forced the City to revert to well water supplies, a practice which causes considerable increases in operating costs. An additional consideration is that even though slight increases in nutrient concentrations might not violate water quality standards, they could potentially affect algal and other microbial populations in downstream reaches and in the reservoirs.

Effects of Windthrow on Water Quality

The reconstruction of windthrow patterns over the last 100 years in the Bull Run Watershed has shown that the windthrow disturbance regime is characterized by a range of event frequencies, sizes, and magnitudes. The patterns have been related to both landscape features, such as landforms, and canopy openings. However, the windthrow patterns as well as the disturbance regime itself will vary over time as many of the contributing factors are dynamic in nature.

Increased Concentrations of Large Woody Debris in the Stream Channel

Excerpted from the 1988 Blowdown FEIS:

Increased concentrations of woody debris could have an indirect effect on nutrient cycling through its control on channel geomorphology. It is well documented that large woody debris can totally dominate channel morphology in streams of the Pacific Northwest (Swanson et al. 1976, Swanson and Lienkaemper 1978, Kellor and Swanson 1979). Formation of debris dams can change a high gradient channel with high velocity into a series of pools and riffles. The pools tend to form below debris dams, and areas of slower water occur above the dams (Beschta and Platts 1986). These channel features result in greater retention of organic matter which allows more microbial processing to occur in place. Without retentive structures, organic matter would be carried out of the stream system without being processed by microbial activity (Bilby and Likens 1980). This would lead to lower levels of nutrient cycling in the stream and would impact the biological community.

Increased channel complexity would also result in a loss of stream power, which is a measure of the total energy of the flowing water. This could affect concentrations of fine particulate organic matter (FPOM) as it has been shown that physical abrasion by stream flow is a major pathway of FPOM formation from woody debris (Ward and Aumen 1986). Even though more wood surface area would be available for FPOM production, the decrease in stream velocity could offset the potential increase.

Another effect of increased concentrations of woody debris would be the increase in surface area available for colonization by microorganisms. This would impact nutrient cycling in the channel and would probably enable the system to more efficiently cycle nutrients and retain them in place. Decreases in downstream transport of nutrients might result, although the net result depends on the resolution of the role of debris as a nutrient source versus a nutrient sink.

Increases in debris concentrations would also result in an increase in nutrient capital to the stream ecosystem, which could potentially affect the biological community. Woody debris is a contributor of nutrients to the ecosystem, although the process of wood decomposition is a relatively slow one. The effect of this nutrient input would only be seen on long-term time scales. Wood contains substantial amounts of carbon, nitrogen, and other nutrients essential to living organisms.

Decreased spiraling lengths for nutrients could also result from increased debris concentrations, with the average distance traveled downstrearn by a nutrient molecule being decreased. The longer term impacts are less clear, particularly with regard to the ultimate fate of more tightly conserved nutrients. Little information is available about the *transformations that take place when a nutrient molecule is sequestered in place.*

It is possible that increased concentrations of woody debris could lead to higher nutrient concentrations in the channel because of nutrient release through decomposition processes. Research has demonstrated the potential for nutrient release through the actions of microorganisms on woody debris, although field work is warranted to confirm this pattern (Aumen et al. 1983, 1985a, 1985b). The study conducted in the Log Creek drainage demonstrated nutrient release, although the study was of short enough duration that decomposition could have no effect. Decomposition results in mineralization of nutrients as the substrate is decomposed, although these nutrients may be recycled in place instead of being released downstream. Even if nutrients are released in greater amounts through decomposition, the increased surface area of wood and higher microbial activity may offset this increase by incorporating the nutrients into microbial biomass.

Higher concentrations of woody debris increases the potential of FPOM input to the stream sediments. the impact of this increase is not known, although higher organic matter concentrations in the sediment could lead to development of more extensive zones of anaerobic processing. These types of conditions result in the formation of microbial by-products that are different from those formed by aerobic processing. Some of these products include low molecular weight organic acids that could affect the metabolism of other microorganisms in the system. Surface area for microbial attachment would also increase, although the contribution of this to increased microbial activity is not certain. More information is needed on the relative activity of attached versus free-living microorganisms.

Effects of Blowdown Slash on Water Quality

In the Fox Creek drainage located in the South Fork Subwatershed, partial clearcutting caused a fourfold increase in nitrate-nitrogen when slash was broadcast burned. A six-fold increase occurred when the slash was allowed to decompose naturally.

Maximum values followed the same pattern, with a high of 0.08 mg/L when the slash was broadcast burned and 0.27 mg/L when the slash was left to decompose (Harr and Fredrickson, 1988).

This study has implications on increased nitrate-nitrogen levels associated with blowdown slash. Results from the Big Bend Creek study on effects of untreated blowdown on water quality in the Bull Run subwatershed, determined similar nitrogen levels above and below the blowdown area (1991 Annual Activity Schedule).

Effects of Fire and Blowdown on the Flow Regime

Created openings from wildfires and blowdown have the potential to effect the flow regime though a number of processes including:

- Increased peak streamflows from rain-on-snow events.
- Decreased baseflows associated with reduced levels of fog drip.
- Increased baseflows associated with decreased levels of transpiration.

The primary mechanism by which forest practices affect peak streamflows is alteration of snow accumulation and snowmelt in response to forest canopy density. The greatest likelihood for significant, long-term cumulative effects on forest hydrologic processes is caused by the influence of created openings from timber harvest and roads on snow accumulation and snowmelt (DNR, 1993).

Research in the watershed's Fox Creek drainage revealed that harvesting 25% of a watershed resulted in a decrease in low flow amounts. This was attributed to a reduction in canopy interception of fog associated with precipitation (Harr, 1982).

Analysis of streamflow data from the "Fox Creek experimental watersheds" through 1983 indicate a significant recovery from the impacts on summer water yield due to a loss of fog drip on timber harvesting.

Recovery begins about five or six years following harvest, possibly due to renewed fog drip from prolific revegetation. Apparently, once the temporary reduction in summer yield is offset by renewed fog drip, the expected increase in yield due to decreased evapotranspiration can be observed. Redistribution of fog drip may be a major factor in the measurements of local interception and water yield (Ingwersen, 1985).

Without knowing the exact extent of the impacted areas it is not possible to predict the effects of these processes on the flow regime.

Key Question #5 -- What is the relationship between land allocations, watershed conditions and availability of commodities such as timber and other wood products, plant materials and minerals?

The majority of the Bull Run Watershed is covered by Public Law 95-200, which was recently amended with the passage of the Oregon Resource Conservation Act of 1996 (ORCA).

The Act *"prohibits the cutting of trees in that part of the unit consisting of the hydrographic boundary of the Bull Run River Drainage, including certain lands within the unit and located below the headworks of the city of Portland."* The Act also prohibits salvage sales in this area. Exceptions in the Act permit cutting of trees for the protection, enhancement, or maintenance of water quality and quantity; or for the construction, expansion, protection or maintenance of municipal water supply facilities. It also includes some exceptions for transmission of energy and hydroelectric facilities.

The Oregon Resource Conservation Act of 1996 also requires a study of the Little Sandy Watershed that is within the Bull Run Watershed Management Unit. The study shall determine the impact of management activities on the quality of drinking water provided to the Portland metro area, and identify ecological and cultural features and other significant values within the Little Sandy Watershed. Timber sales are prohibited for two years from the date of the Act while the report to Congress is prepared and reviewed.

In addition, the majority of the watershed is closed to public access and travel. As a result, the availability of wood products and plant materials are very limited within the watershed.

Timber

Table 6-9 combines land management direction from the Oregon Resource Conservation Act, the Northwest Forest Plan, and the Mt. Hood Forest Plan. (Refer to Chapter 2.) Table 6-9 also indicates on which lands timber harvest is scheduled as an output under the combined management direction. Timber harvest is not scheduled on any lands within the hydrographic boundary described in Section 604 of the ORCA.

Table 6-9 -- General Management Direction

GENERAL MANAGEMENT DIRECTION FOR BULL RUN AND LITTLE SANDY WATERSHEDS	ACRES IN WATER-SHEDS	PERCENT OF WATER-SHEDS	TIMBER HARVEST SCHEDULED?
(DA1/ LSR) Bull Run Watershed - Physical Drainage/Late Successional Reserve/ORCA	60,068	68	NO
(DA1) Bull Run Physical Drainage/ORCA	2,999	3	NO
(DC1) Bull Run Watershed Mgt. Unit / Timber Emphasis (portion inside ORCA hydrographic boundary)	1,509	2	NO
Late-Successional Reserve (portion outside ORCA hydrographic boundary)	1,064	2	NO
(DB8) Bull Run Watershed Mgt. Unit Earthflow/ORCA	116	<1	NO
(DC1) Bull Run Watershed Mgt. Unit / Timber Emphasis (portion outside ORCA hydrographic boundary)	5,780	5	YES
Riparian Reserve	4,836	5	NO
(DA9) Bull Run Watershed Mgt. Unit Key Site Riparian	395	<1	NO
(B2) Scenic Viewshed	420	<1	YES
(B10) Deer and Elk Winter Range	375	<1	YES
(C1) Timber Emphasis	301	<1	YES
100-Acre LSRs	250	<1	NO
BLM District Designated Reserve	67	<1	NO
BLM General Forest Management Area	205	<1	YES

Each allocation in Table 6-9 has accompanying standards and guidelines for timber harvest. Timber harvest is not scheduled on any lands within the Bull Run hydrographic boundary described in Section 604 of ORCA. Scheduled timber harvest may occur on 7,148 acres within the Little Sandy Watershed. This equates to 8 percent of federal lands within the combined Bull Run and Little Sandy watersheds.

Timber harvest is a principal management objective and a scheduled output within the C-1 Timber Emphasis land allocation. Land allocations where timber harvest is a secondary management objective and a scheduled output include: Bull Run Watershed Management Unit/Timber Emphasis, Deer and Elk Winter Range, and Scenic Viewshed.

The following summarizes the guidance for timber harvest on lands with scheduled timber outputs. The potential for future harvest on these lands (short term)-- based on current vegetation conditions -- is also addressed.

The Conceptual Landscape Design identifies long-term vegetation objectives for the land allocations in the watershed (See Chapter 5). The landscape pattern represented by the design cells is also presented.

Scheduled Timber Harvest (Little Sandy Watershed)

<u>Timber Emphasis</u>

There are 301 acres of this land allocation in the watershed. Currently, more than one-half of this land allocation is in a precommercial size class. There are 146 acres in the commercial size class, dominated by small conifers (9.0"-20.9" dbh).

Timber Emphasis lands are represented within the Mixed Aged Forest, Scheduled design cell. The future landscape pattern represented by this design cell would be a mosaic of forest stands of varying age classes. Harvest planning would minimize potential effects of windthrow and fire processes on the Bull Run Watershed Management Unit.

Bull Run Watershed Management Unit/Timber Emphasis

There are 5,780 acres of this management area in the watershed. Nearly half of these acres (2,801) contain trees of commercial size class (greater than 9 inches dbh).

Bull Run Watershed Management Unit/Timber Emphasis lands are also represented by the Mixed-Aged Forest, Scheduled design cell. The future landscape pattern for these lands is a mosaic of forest stands of varying ages. Harvest designs would prioritize the protection of water quality. Secondarily, harvest designs would address windthrow risk and fuel reduction. There is a small component of the Wet Meadows design cell in this allocation. These areas would be characterized by small wetland openings within the broader landscape.

Deer and Elk Winter Range

There are 375 acres of this land allocation in the watershed. Scheduled timber harvest may occur on these lands as long as winter habitat for deer and elk is provided.

Approximately 38 percent (143 acres) of these lands are presently in a precommercial size class. Sixty-two percent (242 acres) are in a commercial size class (greater than 9 inches dbh).

Deer and elk winter range is represented by the Mature Forest, Small Openings design cell. The future landscape pattern represented by this design cell would be open patches within the forest.

Scenic Viewshed

There are 410 acres of this land allocation in the watershed. Timber harvest and salvage may occur where the actions maintain the "desired landscape character."

Most of the area in this land allocation (348 acres) is in a commercial size class, (greater than 9 inches dbh).

Scenic Viewshed lands are represented by the Mature Forest, Small Openings design cell. The future landscape pattern represented by this design cell is small patches within the forest that provide visually appealing forest scenery.

Bureau of Land Management Lands

The Bureau of Land Management owns 390 acres within the watershed and includes Riparian Reserve acres. The majority of these lands (205 acres) in the Upper and Lower Little Sandy subwatersheds is to be managed for timber production. The future landscape pattern representing these lands is the Mixed Aged Forest, Scheduled design cell. The remaining 67 acres are located in the Headworks subwatershed and are represented by the Old Forest, Continuous design cell. The BLM lands in the Headworks subwatershed will be managed as District Designated Reserve which is similar Late Successional Reserve.

Current Stand Conditions

For the land allocations where timber harvest is a scheduled output, Table 6-10 illustrates the approximate acreage of commercially sized stands. This table is presented only as an estimate of the current condition for watershed-scale planning efforts.

Table 6-10 -- Current Size Class (Acres)

GENERAL MGMT. DIRECTION	Closed Small Conifer 9-12"dbh and >40% canopy cover	Open Small Conifer 9-12"dbh and >40% canopy cover	Large Conifer >21"dbh and >40% canopy cover
Deer and Elk Winter Range	200	10	32
Scenic Viewshed	301	32	15
Timber Emphasis	109	10	27
Bull Run Watershed Mgmt. Unit Timber Emphasis	1991	279	531
Total Acres	2601	331	605

Non-Federal Lands

The role of non-federal lands in the watershed was not reviewed for this section.

Probable Sale Quantity Assumption Validation

ORCA generally prohibits the cutting of trees in the area consisting of the hydrographic boundary of the Bull Run River Drainage, including certain lands within the unit and located below the headworks of the city of Portland. This includes all Forest Service lands in the watershed analysis area outside the Little Sandy subwatersheds. For this reason probable sale quantity assumption validation was completed only for the Little Sandy subwatersheds.

Following the adoption of the Northwest Forest Plan, the Mt. Hood National Forest used the Forplan model to estimate the probable timber yield under the amended land management direction. Probable sale quantity estimates included some assumptions that were based on either incomplete or missing data. Assumptions were made for percent of lands in riparian reserves, unstable lands and owl activity centers. For modeling purposes, the following estimates were used:

Table 6-11 -- Little Sandy Watershed - Estimated "Other Withdrawals and Adjustments" used in PSQ Modeling

	Land Allocations (acres)				
	DA	B and DB	C and DC	LSR	All Lands
Riparian Buffers	183	842	5,657	458	7,140
Unstable Lands	11	54	415	44	525
Owl Activity Centers	0	0	111	82	193

A lands - Administratively withdrawn
B lands - Primary resource emphasis other than timber
C lands - Timber emphasis
LSR - Late successional reserve
D lands - Areas within the Bull Run Management Unit

The watershed analysis updated the vegetation database and incorporated site specific analysis to re-calculate the acreage in the above categories. Improved information on geology, the stream network, location of spotted owls, etc. contributed to a new tally of lands in the "other withdrawals and adjustments" category. Site potential tree heights were established for riparian reserves and these were mapped for the watershed. Unstable lands were estimated from Schulz (1980) and still require field validation. Known spotted owl activity centers, (ROD C-10) were delineated for the watershed. The updated information for "other withdrawals and adjustments is provided below in Table 6-12.

Table 6-12 -- Little Sandy Watershed -- "Other Withdrawals and Adjustments" from the Watershed Analysis

	Land Allocations (acres)				
	DA	B and DB	C and DC	LSR	All Lands
Riparian Buffers	5	632	4049	151	4,836
Unstable Lands[2]	0	0	0	0	0
Owl Activity Centers	15	0	79	99	193

The watershed analysis estimates revealed significant shifts from the PSQ "other withdrawals and adjustments". The PSQ analysis appears to have overestimated reserve lands in the watershed. The numbers in Table 6-12 more accurately reflect the conditions of the Little Sandy watershed and could be used to recalculate the PSQ.

Wood Products

Availability of wood products is indirectly related to the watershed's timber harvest levels. Plantations in the watershed are capable of supplying significant amounts of post and pole firewood. Due to access restrictions and cessation of logging activities, no secondary wood products are currently available from within the Bull Run Watershed. Some products, however, may be available within the Little Sandy Watershed, but public access is restricted.

Plant Materials

Mushrooms, huckleberries, floral greenery, and plants suitable for transplanting all grow within the watershed. Restrictions on public access to the majority of the watershed restricts the commercial availability of these products.

[2] There are no lands classified as "Schulz High Hazard" in the Little Sandy Watershed

Minerals

There are currently no leaseable or locatable mineral claims within the watershed. The watershed is closed to locatable minerals. There are five developed rock quarries identified for long-term use in the Conceptual Landscape Design. These quarries are: Porter Point, Southside, Windy, Chitwood and Talapus.

Key Question #6: -- What is the road network that supports the existing infrastructure and long-term management needs within the watershed? How do conditions of the watershed affect the road network?

Introduction

Key Watersheds are a priority for restoration in the Northwest Forest Plan. A Key Watershed primary objective is the reduction of road mileage (ROD B-19). This direction, coupled with the Forest Service's declining road maintenance budget, prompts the need to review the Bull Run Watershed's current open road network.

Thus, this Key Question provides an overview of the methods used to:

- Design the watershed's future road network
- Identify the watershed's proposed long-term open road network
- Describe the conditions of the watershed's roads
- Propose recommendations for the maintenance or restoration of the watershed's road network.

The data and information used by the Watershed Analysis Team in this process was derived from an analysis of the watershed's current conditions (described in Chapter Four), and the Conceptual Landscape and Design (LAD) process (described in Chapter Five).

A Tier 2 Key Watershed, the Bull Run Watershed is noted for its high quality habitat and as a source for high quality water. To minimize the effects of the road network on water quality, the watershed's roads have been maintained to high standards according to the Best Management Practices for the Maintenance of Water Quality (USFS, 1988). Continued use of Best Management Practices for road restoration and maintenance should enable the continued achievement of high water quality standards.

Conceptual Road Design

Steps to developing the future road network included the identification of:

- The existing road and trail network, (Road Map).
- The location of all structures and installations requiring road access for regular maintenance and service, (Figure 6-7 -- Bull Run Watershed Infrastructure).
- The long-term management goals and objectives for the watershed's lands, (Conceptual Landscape and Design).
- The biological and physical processes and functions active in the watershed, (Current Conditions and Trends).

The resulting Conceptual Road Design identified roads key to maintaining the infrastructure and management objectives that were identified during the Watershed Analysis process.

Bull Run Watershed Infrastructure

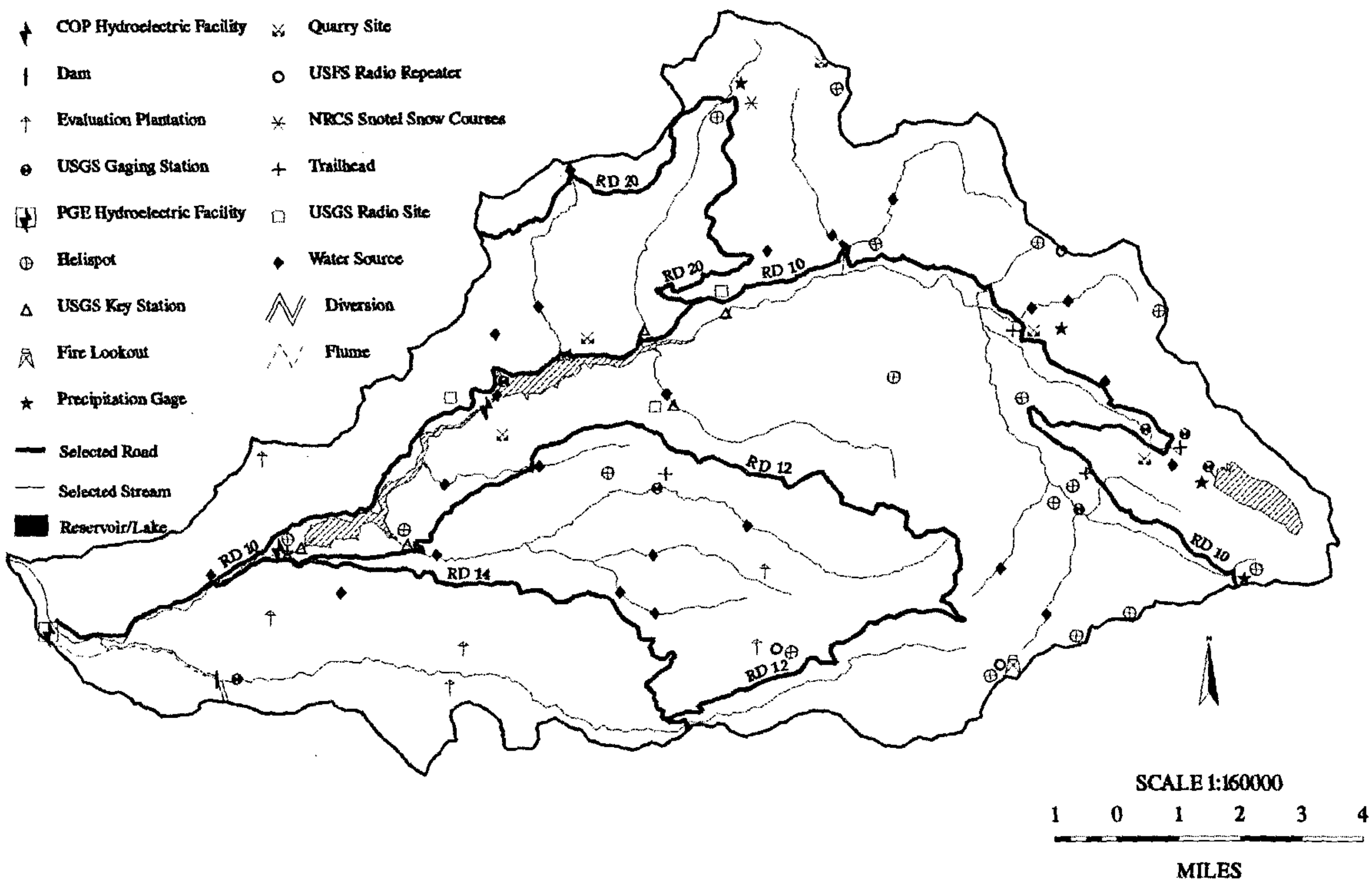


Figure 6-8 displays the proposed long-term open road network and access needs for the Bull Run Watershed. This Conceptual Road Design proposes to reduce the watershed's current 320 road miles to approximately 246 miles. (Roads on private lands were not included in the design). Roads and road segments absent from Figure 6-8 were determined to be non-essential for the maintenance of facilities, or conflicted with land management objectives. Consequently, they will be prioritized for proposed restoration and closure.

Table 6-13 Conceptual Road Design - Miles of Road by User Group

Road User Group	Long Term (miles of road)	Short Term (miles of road)
4 or More Users	49.9	
3 Users	19.4	
COP, Fire	16.8	
COP, Silviculture	2.1	
COP, Utility	1.2	
COP, Wildlife	4.9	
Fire (short term), Silviculture	1.5	
Silviculture (short term), Tours	3.0	
BLM	2.0	
COP	19.3	
Fire	13.0	11.8
Silviculture	20.7	2.4
Tours	1.0	
Utility	3.4	
Wildlife	6.5	
Total	164.7	14.2

The Conceptual Road Design maintains connections from the Bull Run Watershed to neighboring lands. Routes through the watershed to be maintained in the long- term for all users: the 10 Road through to the Clear Fork drainage; the 1010 Road to Walker Prairie; the 2000 Road to Latourell Prairie and Gordon Creek; and the 1400 Road to the Sandy drainage.

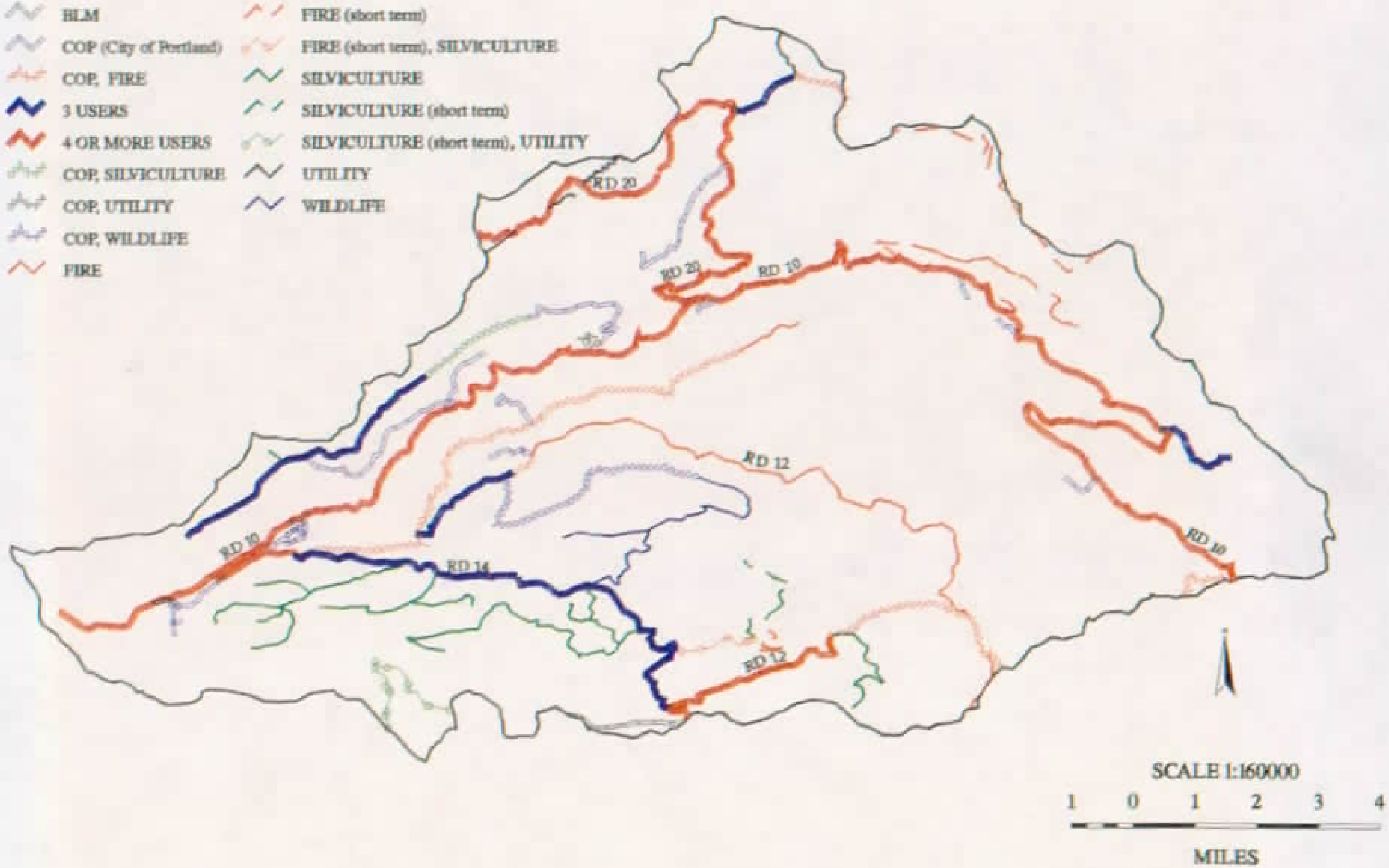
Figure 6-8 describes the principal road users identified during the conceptual design process. Assumptions used in coding the map legend:

- "Short-term roads" were needed by users for less than five years. Therefore, they could be closed after this time period.
- All infrastructure, regardless of maintenance responsibility, supporting municipal water supply is coded "City of Portland."

- Silvicultural access is focused on lands designated Bull Run Watershed Management Unit/Timber Emphasis in the Little Sandy watershed. Additional short-term silvicultural access is also necessary to maintain evaluation plantations throughout the Bull Run Watershed. (Final review of silvicultural needs will follow the Late-Successional Reserve Plan).

- Short-term access is necessary to the Table Mountain radio repeater, located on the watershed's northeast boundary. This road (2030), passable only by high clearance four-wheel drive vehicle, is difficult to maintain. In the advent of wildfire, Road 2030 -- in its current state -- could serve as a control line to potentially slow the spread of ground fire. This road's restoration could include alder revegetation to provide nitrogen fixation and a short-term vegetative fire break.

Bull Run Watershed
Conceptual Road Design



Road conditions

To prioritize roads for maintenance or restoration, many conditions were mapped and tabulated for each of the watershed's roads. These conditions were recognized during the Watershed Analysis process as detracting from watershed function or process. Roads with one or more of these conditions were prioritized for maintenance if they remain open, and restoration if they are closed.

Identified Road Conditions:

- High slope hazard (Schulz, 1980).
- Subwatersheds with greater than 10% drainage network expansion (see Chapter Four).
- Subsurface intercepts-roadcuts where interception of ground water occurs
- Special habitat and wetland disturbance (the watershed contains approximately 100 acres of roads in special habitats, and 60 acres of roads in wetland habitats).
- Recurring road maintenance (cutslope erosion [CS], slumps [SLP], slides [SLD], bare soil [BS], inadequate bridges [BRG].
- Deer and elk winter range (B10) land allocation.
- Barriers to fish passage.
- Road segments calculated to have high (H) or moderate (M) rates of surface erosion.

Table 6-14 provides a sample of the tabulated information for open roads in the Conceptual Road Design. Road User Groups, identified for each of the open road segments, are coded in as:

Road User Groups

CP City of Portland and all other support to municipal water production

FI Fire detection, suppression and initial attack

WI Wildlife and biological monitoring

PU Public tour routes

SI Silvicultural access for timber and vegetation management, and evaluation plantation maintenance

UT Utilities

BP BLM and Private lands within the watershed

Table 6-15 lists roads not identified by any user group for travel within the watershed. A closure plan will be developed be developed for these roads.

Table 6-14 -- Conceptual Landscape: Roads to Keep Open/Maintain

Road Number	User Groups	Miles	Slope Hazard	Drainage Network Expansion	Subsurface interception	Wetland Connectivity	Special Habitats	Fish Passage	Recurring Road Maintenance	Surface Erosion	Notes
1000000	CP FI WI PU	17.42	Y	Y			Y	?	CS SLP SLD		talus, loons, bald eagle
1010000	CP FI SI	5.15	Y	Y							To 510 jct.
1010000	CP SI	2.06	Y								from 510 jct to 10 rd
1027000	CP FI	1.26	Y								Lolo pass
1200000	CP FI	5.19	Y								microwave
1200000	CP FI WI	2.14		Y		Y					
1210000	CP WI	4.79				Y	Y		CS		
1211000	CP FI	7.17	Y	Y					BRG CS SLP		
1211411	CP	0.88	Y								access to dam #1
1400000	CP FI SI WI	1.96	Y near jct 12	Y near jct 1401							
1400410	SI	3.61		Y							DC1
1401000	SI	1.25		Y							DC1
1401201	SI	4.53		Y						M	DC1
2000000	CP FI WI PU	6.30		Y		Y					Latourelle prairie
2000120	CP	2.76	Y						CS		North Fork Slide
2030000	CP FI UT	1.25				Y			CS	M	Table Mtn Radio Repeater
1000000	CP FI WI PU UT	13.14							CS SLP SLD		
1000016	CP	0.49									
1000018	CP	0.43									Dam #1, powerhouse
1000026	CP	0.25								H	
1000052	CP	0.19									Larson's ranch, conduit access
1000117	QU	0.21									Windy pit

Road Number	User Groups	Miles	Slope Hazard	Drainage Network Expansion	Subsurface interception	Wetland Connectivity	Special Habitats	Fish Passage	Recurring Road Maintenance	Surface Erosion	Notes
1000132	FI ST	0.57									RAWS station
1000151	CP	0.59									Geotech
1000183	CP	1.68								M	Larsons ranch, conduit access
1000184	CP	0.47									
1000300	CP	0.43									
1000524	CP	0.76									
1008000	CP	3.42									Alternate access to Headworks
1008158	CP	1.14								M	
1010000	CP	2.82									
1010000	CP UT	0.47									
1010125	CP UT	0.73							BS		Porter's Pit
1010233	SI	0.29									
1015000	FIST	4.89							BRG		
1020000	CP WI PU	1.64								M	
1200000	CP FI SI WI	3.37									
1200000	FI	10.01									
1200000	SI	0.18									
1200018	CP FI	0.23									
1200033	CP	0.15									
1200044	FIST	0.90									
1200055	FI	0.06									
1200056	FI	0.09									
1200126	CP	0.76									
1200166	FIST	0.60							??		
1200166	CP FI	0.21							??		Aschoff Butte
1200400	CP FI	0.96							CS		Hickman Butte
1200400	FI	0.43									
1200411	CP FI	0.52									Hickman Butte
1200478	FI	0.60									

Road Number	User Groups	Miles	Slope Hazard	Drainage Network Expansion	Subsurface interception	Wetland Connectivity	Special Habitats	Fish Passage	Recurring Road Maintenance	Surface Erosion	Notes
1210000	WIST	5.11									
1210202	WIST	1.43									
1211000	FI	1.11							BRG SLP CS		
1228000	SIST	2.45									Knifeblade EP
1400000	FI SI WI	8.98									
1400038	SI	0.35									
1400056	SI	0.28									
1400077	SI	0.28									Crab EP
1400110	SI	1.21									DC1
1400201	SI	1.96									DC1
1400415	SI	0.98									DC1
1400420	SI	1.33									DC1
1400421	SI	0.54									
1401061	SI	0.25									
1401386	SI	1.28									
1414000	FIST SI	1.47							SLP		
1414000	SIST	2.39									Turtle EP
1509044	UT	0.64								M	
1509510	FI SI	1.41									
1820000	FI ST										To Clear creek
2000000	CP FI SI WI PU UT	2.46									Deer Creek access
2000000	CP FI WI PU UT	3.67									
2000013	UT	0.56								M	
2000016	UT	1.24									BPA ROW?
2030000	CP FI	6.86							CS		Blue Lake Road. Currently undriveable. Table mtn radio repeater
2030104	UT	0.94							CS		BPA ROW?

Road Number	User Groups	Miles	Slope Hazard	Drainage Network Expansion	Subsurface interception	Wetland Connectivity	Special Habitats	Fish Passage	Recurring Road Maintenance	Surface Erosion	Notes
2030223	CP	1.19									
2503000	BP	2.02								M	B10 allo?
2503000	SIST PU	3.05									B10 allo? Pica EP
2503000	FI SI	1.78									B10 allo?

Table 6-15 - Conceptual Landscape: Roads to Close[3]

Road	Miles	Subsurface Intercepts	Drainage Network Enhancement	Slope Hazard	Wetland Connectivity	Recurring Road Maintencance	Surface Erosion	B10 Allocation	Notes
1000037	0.26						M		
1000039	0.10						M		
1000084	0.22						M		
1000522	0.55						M		
1000527	0.62						M		
1010025	0.56						M		
1010030	0.30						M		
1010123	1.49						M		
1010265	0.50			Y			M		
1015105	1.95	Y	Y			CS			
1015144	0.95	Y							
1020016	0.19						H		
1020022	0.15						H		
1020028	0.49						H		
1025000	5.25					CS	M		
1027000	9.10	Y	Y	Y		??	M		
1027444	0.01					CS			
1200166	1.77						M		
1200202	0.35						M		
1200222	3.05					??			
1200224	0.82					CS			
1200400	0.00					SLP			

[3] Blanks in this table to not neccesarily represent lack of data. The watershed analysis team in coordination with district personnel filled out the table to the best of their ability based on data available at the time.

Road	Miles	Subsurface Intercepts	Drainage Network Enhancement	Slope Hazard	Wetland Connectivity	Recurring Road Maintencance	Surface Erosion	B10 Allocation	Notes
1210000	0.14					CS SLP			
1210428	1.70	Y	Y						
1211000	1.45					BRG SLP CS			
1211072	0.14						M		
1217000	2.24	Y		Y					
1228000	0.14					SLP			
1400000	0.33					SLP			
1400150	0.24						M		
1401000	2.26					CUL			
1401077	0.24						M		
1414000	1.79					SLP			
1509048	0.32						M		
2000000	0.06				Y, Talapus area	BS			
2000025	0.38						M		
2000120	0.02						M		
2030000	0.02			Y			M		
2030034	0.46						M		
2503014	0.05						M		
2503044	0.04							Y	
2503100	0.40						M		
2503110	0.22							Y	
2503115	0.03							Y	
2503120	0.21							Y	
2503130	1.30							Y	
2503140	0.14							Y	
2503150	0.60						M		
2503160	0.18						M		
2503180	0.62						M		
1015106		Y							
1015126		Y							Owl timber sale
1210301		Y							

Road	Miles	Subsurface Intercepts	Drainage Network Enhancement	Slope Hazard	Wetland Connectivity	Recurring Road Maintencance	Surface Erosion	B10 Allocation	Notes
1228012		Y							
1000011	0.11								
1000021	0.11								
1000023	0.53								
1000024	0.11								
1000025	0.07								
1000028	0.16								
1000030	0.73								
1000031	0.18								
1000032	0.36								
1000033	0.18								
1000034	0.06								
1000035	0.08								
1000038	0.10								
1000042	0.16								
1000043	0.06								
1000044	0.00								
1000052	0.05								
1000081	0.23								
1000099	0.33								
1000101	1.37								
1000115	0.16								
1000241	0.39								
1000300	0.07								
1000401	0.48								
1000404	1.58								
1000519	0.48								
1000530	0.96								
1010000	0.10								
1010020	0.18								
1010022	0.66								

Road	Miles	Subsurface Intercepts	Drainage Network Enhancement	Slope Hazard	Wetland Connectivity	Recurring Road Maintencance	Surface Erosion	B10 Allocation	Notes
1010024	0.11								
1010110	0.26								
1010220	0.21								
1010230	0.12								
1010233	0.33								
1010236	0.42								
1010250	0.31								
1010255	0.20								
1010400	1.07								
1015000	1.71								
1015020	0.09								
1015021	0.19								
1015024	0.33								
1015050	0.17								
1015108	0.14								
1015121	0.56								
1015125	0.41								
1015129	0.34								
1025110	0.72								
1025115	1.28								
1027022	0.50								
1027030	0.18								
1027031	0.28								
1027043	0.08								
1200000	0.37								
1200011	0.43								
1200013	0.43								
1200014	0.16								
1200015	0.25								
1200017	0.14								
1200034	0.13								

Road	Miles	Subsurface Intercepts	Drainage Network Enhancement	Slope Hazard	Wetland Connectivity	Recurring Road Maintencance	Surface Erosion	B10 Allocation	Notes
1200040	0.16								
1200055	0.06								
1200101	0.23								
1200111	0.39								
1200120	0.53								
1200131	0.30								
1200138	0.32								
1200204	0.44								
1200206	0.37								
1200208	0.26								
1200212	0.40								
1200225	0.25								
1200310	0.73								
1200330	0.32								
1200345	1.32								
1200370	0.15								
1200478	0.27								
1210051	0.28								
1210054	0.14								
1210056	0.16								
1210057	0.12								
1210058	0.13								
1210059	0.15								
1210060	0.12								
1210061	0.15								
1210062	0.50								
1210063	0.15								
1210110	0.61								
1210143	1.10								
1210202	0.04								
1210381	0.42								

Road	Miles	Subsurface Intercepts	Drainage Network Enhancement	Slope Hazard	Wetland Connectivity	Recurring Road Maintencance	Surface Erosion	B10 Allocation	Notes
1211065	0.14								
1211118	0.91								
1211121	1.41								
1211411	0.17								
1211415	1.17								
1228023	0.19								
1228030	0.27								
1228050	0.40								
1228100	0.30								
1228121	0.58								
1228128	2.36								
1400056	0.09								
1400076	0.13								
1400111	0.52								
1400140	0.88								
1400148	0.15								
1400200	0.31								
1400201	0.57								
1400202	1.10								
1400204	0.47								
1400205	0.37								
1400240	0.48								
1400320	0.89								
1400416	0.25								
1400418	0.16								
1400440	1.31								
1400480	0.49								
1400500	0.15								
1401010	0.31								
1401032	0.21								
1401036	0.16								

Road	Miles	Subsurface Intercepts	Drainage Network Enhancement	Slope Hazard	Wetland Connectivity	Recurring Road Maintencance	Surface Erosion	B10 Allocation	Notes
1401038	0.70								
1401040	0.23								
1401059	0.15								
1401060	0.13								
1401078	0.16								
1401079	0.12								
1401080	0.69								
1401122	1.25								
1401140	0.30								
1401180	0.40								
1401190	0.44								
1401212	1.59								
1401386	0.28								
1401388	0.26								
1401400	0.48								
1414124	0.62								
1509043	0.31								
1509516	0.17								
1509518	0.42								
1509519	0.15								
2000014	0.22								
2000017	0.34								
2000019	0.25								
2000020	0.31								
2000022	0.16								
2000024	0.09								
2000037	0.37								
2000038	0.69								
2000039	0.12								
2000040	0.20								
2000041	0.19								

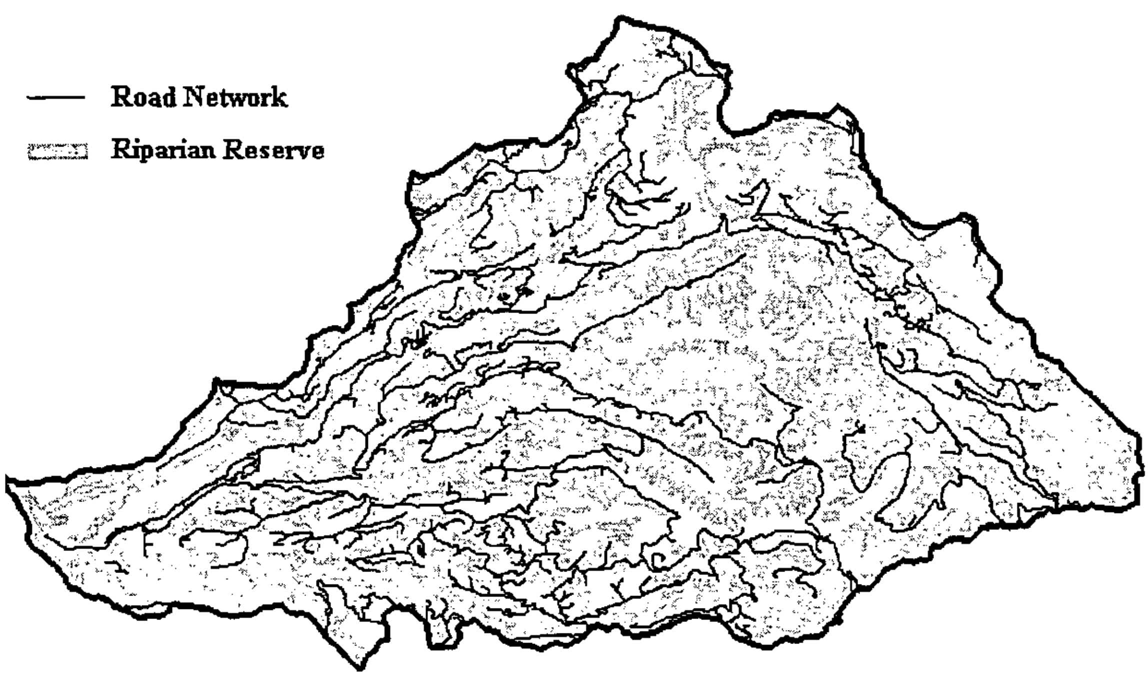
Road	Miles	Subsurface Intercepts	Drainage Network Enhancement	Slope Hazard	Wetland Connectivity	Recurring Road Maintencance	Surface Erosion	B10 Allocation	Notes
2000053	0.10								
2000055	0.28								
2000056	0.05								
2000057	0.21								
2000062	0.26								
2000063	0.11								
2000065	0.15								
2000101	0.89								
2000110	2.36								
2000111	0.47								
2000115	0.70								
2000130	0.20								
2000132	0.57								
2000140	0.05								
2000200	1.56								
2000204	0.56								
2000207	0.28								
2000210	1.08								
2000215	1.00								
2000222	1.50								
2030021	0.09								
2030023	0.62								
2030042	0.33								
2030045	0.14								
2030047	0.08								
2030048	0.22								
2030135	0.05								
2030223	0.07								
2503155	0.09								
2503200	0.23								

Road Conditions Not Listed in Table 6-14 or Table 6-15

Additional considerations developed during this Watershed Analysis for prioritizing road maintenance or restoration include:

- Roads currently classified as operational Maintenance Level 1
- Decade of original road construction (see Chapter Four, Road Construction History)
- Low traffic roads where alder is preventing travel by colonizing ditchlines and roadbeds
- Roads in Riparian Reserves
- Reduction in site productivity of compacted surfaces

Figure 6-9 -- Roads in Riparian Reserves



Recommendations

This Watershed Analysis document has described several direct and indirect effects of roads on the Bull Run Watershed's physical and biological resources. Roads have disturbed the watershed's lands and altered their productivity and function.

This analysis has revealed and illustrated that -- to varying degrees -- the watershed's roads have:

- Affected natural runoff and drainage patterns.
- Altered stream channel morphology and flows.
- Contributed to a small increase in erosion and sediment production.

Field reconnaissance in the Bull Run Watershed by LaHusen (1994) found that stream channel processes were the dominant sources of sediment in the watershed. (See also Chapter 4, Stream Geomorphology, Stream Stability). In contrast, roads and harvest units were not found to be large contributors to the watershed's sediment budget. One exception noted by LaHusen, however, were steep, unvegetated road cuts adjacent to stream crossings.

Because roads have affected a wide variety of physical processes, no single, simple "fix" to restoring roads exists. Therefore, to adequately restore roads, the variety of conditions they affect must be addressed.

As a Tier 2 Key Watershed, the analysis area is a restoration priority. One objective for Key Watersheds is the reduction of road miles through decommissioning (ROD B-19). Thus, the goal of this section of the Watershed Analysis: to provide the contextual basis for a road network design that will pose minimal risk to watershed resources (ROD B-23).

Research on roads in forested watersheds suggests regular maintenance is essential and that road condition problems should be promptly identified and corrected. In addition, to minimize the effects of roads on watershed conditions, preventive maintenance should be practiced on all roads -- not just the actively used roads (Furniss et al, 1991).

Previous sections of this analysis described the altered natural conditions that this analysis's suggested restoration efforts propose to address. Table 6-16 is styled after Table V-J-1 (FEMAT). It outlines measures that have the ability to effectively restore these altered natural conditions.

Table 6-16 -- Road Restoration and Upgrading Practices

ALTERED CONDITION	RESTORATION SOLUTION	UPGRADING SOLUTION
High slope hazard	• remove fill materials • decompact road bed to restore infiltration • restore natural drainage patterns • revegetate road bed, cuts and fills • promote establishment of deeply rooted, woody vegetation	• replace unstable fills • control drainage to prevent saturation of fills
Drainage network expansion	• decompact road beds to promote infiltration • restore natural drainage patterns • reestablish subsurface flows • scarify and revegetate road bed, cuts and fills	• outslope road to slow routing of surface runoff
Subsurface intercepts	• decompact road bed to promote infiltration • restore natural drainage patterns • reestablish subsurface flows • scarify and revegetate road bed, cuts and fills	• outslope road to disperse runoff
Special habitat and wetland disturbance	• decompact road bed to promote infiltration • restore natural drainage patterns • restore natural surface and subsurface hydrologic conditions • restore native plant community	• relocate where practical to restore hydrologic and biologic function
Recurring road maintenance		
cutslope erosion	• stabilize erosive slopes through a combination of vegetative and mechanical means (bioengineer)	• stabilize erosive slopes through a combination of vegetative and mechanical means (bioengineer)
slumps and slides	• remove unstable fills • promote subsurface drainage	• replace unstable fills • control drainage to prevent saturation of fills
bare soil	• reduce slope gradient and length	• reduce slope gradient and length

ALTERED CONDITION	RESTORATION SOLUTION	UPGRADING SOLUTION
inadequate bridges	• stabilize with effective vegetative cover • employ alternate equipment such as spyder walking excavator to complete road decommissioning	• stabilize with effective vegetative cover • employ alternate equipment such as spyder walking excavator to provide regular maintenance
Deer and Elk winter range	• decompact road beds to promote infiltration • restore natural drainage patterns • reestablish subsurface flows • scarify surfaces, revegetate road bed, cuts and fills	• reduce open road miles
Barriers to fish passage	• locate, remove and restore natural channel configuration	• Locate and replace culverts consider species requirements for water velocity, water depth in culverts, turbulent flow patterns, resting pools (Furniss et al, 1991)
Surface erosion hazard	• decompact road beds to promote infiltration • restore natural drainage patterns • reestablish subsurface flows • scarify surfaces, revegetate road bed, cuts and fills	• redirect surface overland flows • reduce slope gradient and slope length • stabilize with effective vegetative cover
Operational maintenance level 1 roads	• restore natural drainage patterns, • direct water away from roadway • scarify surfaces • revegetate road bed, cuts and fills	• restore natural drainage patterns, • direct water away from roadway • scarify surfaces • revegetate road bed, cuts and fills
Decade of road construction	• remove unstable and potentially unstable fill material prior to closure	• replace unstable fill materials as needed
Alder revegetation	• inspect drainageways and clear alder where necessary to perform decommissioning[4]	• annual inspection and brushing[5]
Site Productivity	• decompact road bed • restore natural drainage patterns • revegetate road bed, cuts and fills	• revegetate road cuts and fills • reduce traveled way widths

[4] Brush removal is essential to proper maintenance or stabilization prior to road closures (Harr and Nichols, 1993). Because revegetation rates are high on these sites, brush removal is necessary in the short-term to prevent long-term potential for catastrophic road drainage failure.

[5] During the February, 1996 storm event, culverts plugged with alder saplings were observed to pond water and route it across the road surface.

Timing and Implementation of Road Restoration and Upgrading

1. From the Watershed Analysis, identify the subwatersheds in which roads have potentially affected water quality and flow regime. Next, prioritize subwatersheds within the Bull Run Watershed Management Unit and Key Watershed for site specific inventory.

2. Inventory the watershed's roads and collect site-specific information on road conditions (previously described in this Key Question #6 section).

3. For road closures, prioritize inventory and restoration of abandoned and operational Maintenance Level 1 roads.

4. For the long-term, open road network: prioritize inventory, and upgrading of roads with recurring maintenance needs.

5. For each road segment, specify restoration or upgrading practices needed, and estimate costs.

6. Develop a timeline for implementation that disperses activities through time and space, while focusing on the subwatersheds identified in #1 above.

7. Develop a methodology for determining a threshold for "equivalent obliterated area." (Equivalent obliterated area: a measure of ground disturbance intensity and site recovery over time that is consistent with water quality objectives.)

8. Complete environmental documentation for road decommissioning.

Supporting Management Direction:

FEMAT (1993) Forest Ecosystem Management: An Ecological, Economic, and Social Assessment p. V-57:

- The capacity of the Forest Service and the Bureau of Land Management to maintain roads has declined dramatically as both appropriated and traffic-generated funds for maintenance and timber-purchaser-conducted maintenance have been reduced. Without an active program to identify and correct road problems, habitat damage will continue for decades.

- Well-established practices to control road-generated erosion and peak flows can drastically reduce risks of future habitat damage. In watersheds with high quality habitat and limited road networks, large amounts of habitat can be secured with small expenditures to upgrade and remove roads (Harr and Nichols, 1993).

- Road treatments range from full decommissioning (closing and stabilizing a road to eliminate potential for storm damage and need for maintenance) to simple road upgrading, which leaves the road open. Upgrading can involve: removal of earth from locations with high potential to trigger landslides, modifying road drainage systems to reduce the extent the road functions as an extension of the stream network, reconstructing stream crossings to reduce the risk and consequences of failure.

FEMAT (1993) Forest Ecosystem Management: An Ecological, Economic, and Social Assessment. Appendix V-J. Restoration of Watersheds and Riparian Ecosystems.

Record of Decision, (1994):

Key Watersheds

- The amount of existing system and non-system roads within Key Watersheds should be reduced through the decommissioning of roads. Road closures with gates or barriers do not qualify as decommissioning or a reduction in road mileage. If funding is insufficient to implement reductions, there will be no net increase in the amount of roads in Key Watersheds (p. B-19).

- Key watersheds are the highest priority for restoration (p. B-19).

Watershed Analysis

- This information will support decisions for implementing management prescriptions, including developing restoration strategies and priorities. Watershed analysis is the appropriate level for analyzing the effects of transportation systems on aquatic and riparian habitats within the target watershed (p. B-21).

- Watershed analysis provides the contextual basis at the site level for decision makers to design road transportation networks that pose minimal risk (p. B-23).

Watershed Restoration

- Road treatments range from full decommissioning (closing and stabilizing a road to eliminate potential for storm damage and the need for maintenance) to simple road upgrading, which leaves the road open (ROD B-31).

- The decision to apply a given treatment depends on the value and sensitivity of downstream uses, transportation needs, social expectations, assessment of probable outcomes for success at correcting problems, costs, and other factors (ROD B-31).

- Riparian Reserve Standards and Guidelines (p. C-32 and C-33).

Chapter 7

Recommendations

Chapter 7 -- Recommendations

Introduction

This chapter will focus on guidance and recommendations for project-level planning and overall land management planning, based on the findings presented and discussed in previous chapters.

This chapter will present recommendations for:

- Setting and refining Riparian Reserve boundaries
- Late Successional Reserve Assessment
- Restoration Strategy
- Monitoring Strategy
- General Management

Also included in this chapter are:

- Data and Analysis gaps
- Altered Processes consistent with management objectives

Recommended Riparian Reserves

Riparian Reserves, a key element of the Aquatic Conservation Strategy (ACS), provide areas along streams, wetlands, ponds, lakes, and unstable and potentially unstable areas where riparian-dependent resources receive primary emphasis. Riparian Reserves are also important to the terrestrial ecosystem, serving as dispersal habitat for certain terrestrial species and connectivity corridors among late successional habitats.

To provide effective habitat connectivity within the watershed, as well as to address a variety of landscape level concerns, it is recommended that Riparian Reserve widths be consistent throughout the major vegetation zones. Delineating Riparian Reserves in this manner will eliminate small-scale variations, while ensuring larger-scale connectivity and function. Additionally, this method will facilitate administration, analysis and mapping.

The Bull Run Watershed Analysis recommends the following reserve widths by vegetation zone (Table 7-1). Assumptions for establishing the site potential tree height and the supporting documentation from the watershed analysis is also presented in this table. Final Riparian Reserve boundaries are prescribed during site specific analysis and through the National Environmental Protection Act (NEPA) decision-making process (ROD B-13).

Table 7-1 -- Recommended Riparian Reserve Widths

STREAM/RIPARIAN ZONE TYPE	WESTERN HEMLOCK ZONE	PACIFIC SILVER FIR ZONE	MOUNTAIN HEMLOCK ZONE
Fish bearing streams (2 site-potential tree heights)	420'/side 840' total	340'/side 680' total	300'/side 600' total
Non-fish bearing, permanently flowing streams, reservoirs (1 site-potential tree height)	210'/side 420' total	170'/side 340' total	150'/side 300' total
Seasonally flowing or intermittent streams (1 site potential tree height)	210'/side 420' total	170'/side 340' total	100'/side 200' total
Lakes and natural ponds (2 site potential tree heights)	420' surrounding	340' surrounding	300' surrounding
Wetlands (1 site-potential tree height)	210' surrounding	170' surrounding	150' surrounding
Unstable and potentially unstable areas (see note below) (1 site-potential tree height)	210' surrounding	170' surrounding	100' surrounding
Key Site Riparian	See comment below		

Key Site Riparian

Key Site Riparian designations of the LRMP (DA9) are incorporated into the Riparian Reserve network. 86 acres of Key Site Riparian, however, extend beyond the widths in Table 7-1. In such instances, these Riparian Reserve widths would be increased to include these additional acres.

Unstable and Potentially Unstable Lands

It is recommended that when unstable and potentially unstable lands are encountered, a geologist or soil scientist field verify the extent of instability.

The Riparian Reserve width will begin at the edge of the instability and will include the entire extent of the unstable area or areas. The analysis file includes tools to identify unstable conditions within the watershed that will trigger additional field investigation.

Supporting Documentation for Riparian Reserve Recommendations

Determination of Riparian Reserve Widths

Direction for designating Riparian Reserve widths is stated in the ROD (Standards and Guidelines, pages C-30 and C-31). Riparian Reserve widths are discussed in terms of site potential tree height, or a given slope distance -- whichever is greater. For the Bull Run Watershed, *measured* site-potential tree heights were used to delineate the recommended width as the measured heights reflect the greatest distance.

A site potential tree is defined as the average maximum height of the tallest dominant trees (200 years or older) for a given site class. Nancy Diaz, Mt. Hood NF Area Ecologist, compared two approaches to determine average maximum tree heights. The first approach averaged site indices and then determined the maximum height for the average site index. The second approach averaged actual heights of older site index quality trees measured on plots (with Douglas-fir used as the predominant species).

It was found that averaging site indices provided a significantly lower tree height than actually measured on the plots. This may be due to the productivity of the riparian zone. (Reference: Riparian Tree Height Information from Ecology Plots, Nancy Diaz, Mt. Hood National Forest.) The measured tree heights method yields a more applicable estimate of buffer width and will be used for both the Western Hemlock Zone and the Pacific Silver Fir Zone.

For the Mountain Hemlock Zone, the recommendation is to use slope distances from the ROD since there were too few plots measured in this zone to accurately ascertain average maximum tree height. It is also thought the smaller tree heights of higher elevation species would be best approximated by the ROD distances.

Based on this process, the site potential tree heights are listed in Table 7-2 below.

Table 7-2 -- Site Potential Tree Heights

WESTERN HEMLOCK ZONE	Douglas fir measured tree ht. 210'
PACIFIC SILVER FIR ZONE	Douglas fir measured tree ht. 170'
MOUNTAIN HEMLOCK ZONE	Limited measured data Use recommended widths (table 7-1)

Analysis of conditions and trends within the Bull Run Watershed reveals the processes and existing effects important to riparian habitat within the watershed. The discussion of Key Question #2 details watershed conditions with respect to the ACS objectives. Additional key questions identify terrestrial processes and functions supported by Riparian Reserves. Key points from these analyses that support the recommendation of consistent Riparian Reserve widths are summarized below. (For an extensive discussion of the analysis, consult the appropriate sections of this document.)

Current Conditions

The standards and guidelines for Riparian Reserves are described in the ROD (pages C-31 through C-38). In general, when current conditions within Riparian Reserves retard or prevent attainment of the Aquatic Conservation Strategy Objectives (see Key Question #2), efforts should be taken to modify or mitigate the detrimental conditions.

Structure and Function

Riparian vegetation serves an important function in a number of processes

- Regulates the exchange of nutrients and material from upland forests to streams
- Determines levels of large woody debris loading
- Moderates stream temperatures and light levels

- Stabilizes banks, allowing development and maintenance of undercut banks, and protects banks during large storm flows
- Contributes leaves, twigs, and other forms of fine litter that are an important component of the aquatic ecosystem food base
- Important for riparian-dependent organisms including amphibians, arthropods, mammals, birds, and bats (FEMAT).
- Provides for greater connectivity of late-successional forests within and among LSR's for dispersal of mobile species, and serve as refugia for species that disperse short distances (ROD 5, 7, B-13)

Based on current conditions, the Riparian Reserves in the Bull Run Watershed may not be fully providing these functions as envisioned by the Northwest Forest Plan and the ACS.

Chart 7-1 Riparian Area Seral Stage

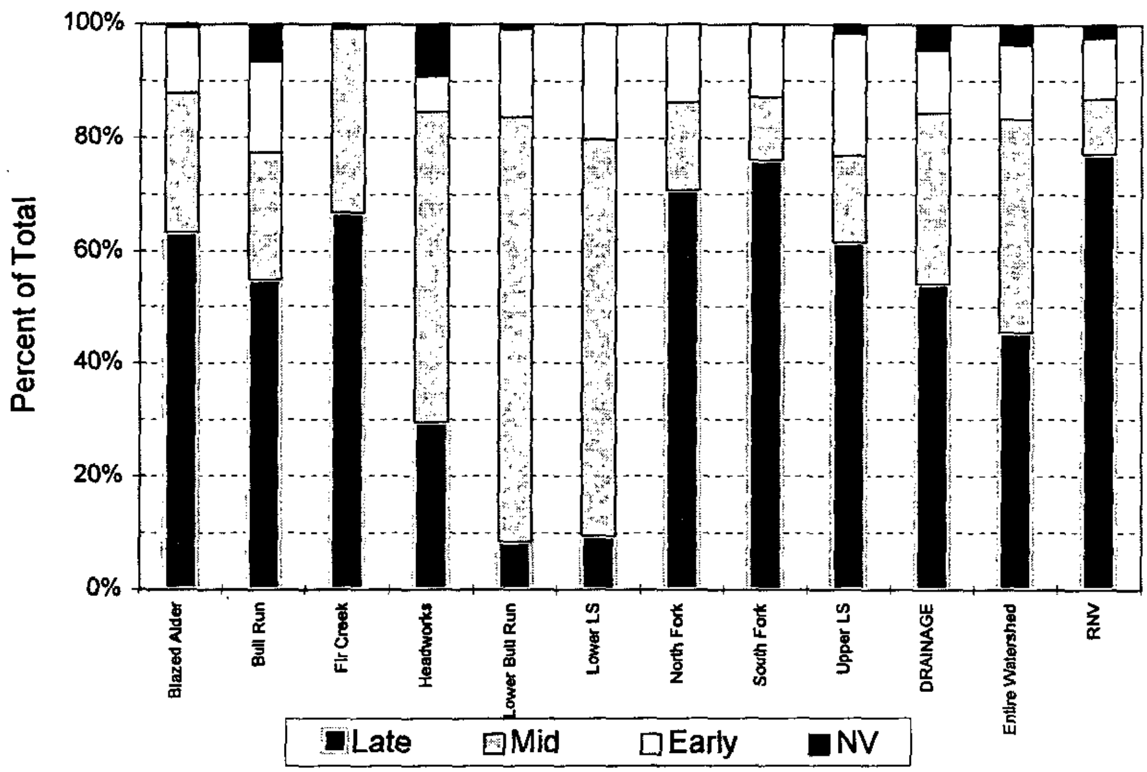


Table 7-3 Riparian Area[1] Seral Stage

(percent of Riparian Area by subwatershed)

Subwatershed	% of Area in Late Seral Stands	RNV Late Seral Stands[2]
Blazed Alder	63	78 (74-84)
Bull Run	55	78 (74-84)
Fir Creek	67	78 (74-84)
Headworks	29	78 (74-84)
Lower Bull Run	8	78 (74-84)
Lower LS	9	78 (74-84)
North Fork	71	78 (74-84)
South Fork	76	78 (74-84)
Upper LS	62	78 (74-84)
DRAINAGE	54	78 (74-84)
Entire Watershed	45	78 (74-84)

Late seral stand structure is well below the RNV for the Headworks, Lower Bull Run, and Lower Little Sandy Subwatersheds. The water supply drainage is also below the RNV with 54% of the area in Riparian Reserves classified as late seral. This has resulted in:

- Lowered large woody debris recruitment potential due to the lack of large trees in the riparian areas especially in the Lower Bull Run, Lower Little Sandy, Upper Little Sandy, Headworks and Otter Creek subwatersheds.

- Increased water temperatures in the Little Sandy River

- Increased water temperatures in the Bull Run and South Fork rivers, however, it is not clear if this is due to riparian stand conditions in this area or if it is the natural condition.

Effects to riparian habitat for plant and animal species of concern include:

- Water temperatures are outside the optimum range for rainbow trout in the Little Sandy River.

-

[1] Riparian Reserves on Forest Service and Bureau of land Management lands plus delination of Riparian Reserve widths on private lands
[2] Based on fire history data from 1700-1948

Connectivity

Extensive aggregated openings reduce connectivity for some riparian dependent species in the Otter creek, Blazed Alder / Nanny creek, and Cedar creek areas within the watershed.

Due to an extensive stream drainage network, there are a high number of road and stream intersections within the watershed. Road and stream intersections can reduce connectivity for some terrestrial and aquatic species.

Non-federal lands are *not* subject to the ACS objectives. As a result, riparian areas on non-federal lands within the watershed may be afforded lesser aquatic habitat protection. The location of private lands within the watershed may contribute to reduced connectivity within and between lands in the lower watershed.

LSR Assessment and Recommendations

Assessment

The ROD states that "a management assessment should be prepared for each Late Successional Reserve (LSR) ,or group of smaller LSRs, before habitat manipulation activities are designed and implemented" (ROD C-11). A management assessment for the Bull Run LSR will be scheduled in the future.

Information derived from the Bull Run Watershed Analysis is recommended to be carried forward in support of the overall LSR assessment.

Late-Successional Reserve assessments should generally include (ROD C-11):

1. A history and inventory of overall vegetative conditions within the reserve.
2. A list of identified late-successional associated species known to exist within the Late-Successional Reserve and information on their locations.
3. A history and description of current land uses within the reserve.

4. A fire management plan.
5. Criteria for developing appropriate treatments.
6. Identification of specific areas that could be treated under those criteria.
7. A proposed implementation schedule tiered to higher order (i.e., larger scale) plans.
8. Proposed monitoring and evaluation components to help evaluate if future activities are carried out as intended and achieve desired results.

Watershed analysis products with particular relevance to preparation of a management assessment for the LSR lands include:

- Chapter 2 -- General Management Objectives
- Chapter 4 -- Seral Stage, Stand Structure and Landscape Pattern discussions
- Chapter 4 -- Disturbance from Wind and Fire
- Chapter 4 -- Botany and Wildlife
- Chapter 5 -- Future Landscape Pattern and Future Seral Stage
- Chapter 6 -- Key Question 3; How do conditions of the watershed influence habitat for species dependent on late-successional habitat

In addition there are databases and GIS coverages developed for this analysis that detail vegetative structure, fire history, windthrow, sensitive plants, suitable owl habitat, red tree vole habitat, future landscape pattern, future seral stage.

Recommendations

Silvicultural treatments used within the LSR must benefit the creation and maintenance of late-successional conditions and may only occur in stands up to 80 years old (ROD, p. C-12). Thinning of densely stocked plantations is recommended to encourage the development of late-successional characteristics. Thinning recommendations that pertain to the LSR may occur only in that portion outside the Oregon Resource Conservation Act which generally prohibits the cutting of trees (1064 acres).

B5 Pileated Woodpecker and Pine Marten Area Recommendations

No retention is recommended for all of the B-5 areas within the Bull Run Watershed.

Page C-3 of the ROD states that: "Administratively Withdrawn Areas that are specified in current Forest Plans to benefit American martens, pileated woodpeckers, and other late-successional species are returned to the matrix unless local knowledge indicates that other allocations and these standards and guidelines will not meet the objectives for these species."

All nine of the B-5 areas were immediately adjacent to late-successional reserves or administratively withdrawn areas. Therefore, the Forest-wide analysis recommended that none of the B-5 areas within Matrix lands within the Bull Run Watershed be retained. These management areas are therefore returned to the underlying Mt. Hood Forest Plan allocations. District biologists have concurred with this recommendation.

Restoration Opportunities

Introduction

Guidance for assembling this section came from: the Aquatic Conservation and Late Successional Reserve strategies in the ROD; the Interagency Watershed Restoration Strategy (Regional Ecosystem Office, October, 1994); the Report of the Forest Ecosystem Management Assessment Team (1993) and analysis of the current watershed condition and trends.

The need for restoration projects result from altered landscape processes affecting beneficial uses. Projects were identified where opportunities for restoration projects were consistent with overall management objectives. Primary restoration projects are those that are located within the Key Watershed and/or Late Successional Reserve boundaries, provide the greatest immediate benefit to watershed resources and would bring an altered landscape process toward or within the range of natural variability.

Secondary restoration needs were selected to move the watershed toward the objectives described by the conceptual landscape design.

Recommendations for timing and implementation of road restoration and upgrading is addressed in Key Question #6.

ALTERED PROCESS	RESTORATION OBJECTIVE	RESTORATION PROJECT	WATERSHED LOCATION
Reduced site productivity	Restore site productivity through road reclamation	Decompact road beds and revegetate surfaces	Roads not identified for long term use.
Simplification of stand structure over large areas	Improve stand structure (large trees, layered canopy, snags, LWD, patchiness of stands)	Thin managed stands to create patchiness and larger trees. Maintain and create snags, LWD.	Lower Little Sandy
Reduced connectivity of late-seral habitat in riparian reserves	Promote late seral connectivity within riparian reserves	Natural recovery and riparian silviculture to accelerate late successional development (multi-storied canopy, snags, LWD) Maintain late successional stands adjacent to riparian reserves until riparian habitat recovers	Lower Little Sandy,
Aquatic habitat	Restore habitat connectivity	Replace barrier culvert	FS Road 14 near spillway
Altered biodiversity through the introduction of noxious weeds and invasive, non-native plants	Prevent introduction and spread of noxious weeds, Reduce noxious weed populations; Secure viability and distribution of native plants Reduce size of existing populations Reestablish native plant communities in weed-dominated areas	Minimize areas of disturbed soil in project work, Clean construction equipment prior to entry in the watershed Use certified weed free seed for all seed and mulch Pull all knapweeds Use manual and biocontrol to reduce Scotch broom populations (outlier sites are first priority) Plant trees and shrubs at Scotch broom removal sites to shade out seedlings	Plantations and roads in the LSR Riparian Reserves Roads 10, 1015, 12, 1211, 1210, 1400, 410, 14, 1010, 20 Powerline corridor
Water Quality: Stream Temperature	Maintain water quality to meet State standards and life cycle requirements for aquatic species	Increase stream shade by riparian tree plantings	Little Sandy
Decreased structure and composition of riparian vegetation	Restore structure and composition of riparian vegetation Increase LWD recruitment potential where current levels are below forest plan standards	Riparian tree plantings, natural regeneration and riparian silviculture to move stands from moderate and low LWD recruitment potential to high LWD recruitment potential	Lower Little Sandy, Lower Bull Run, Headworks and Upper Little Sandy subwatersheds

ALTERED PROCESS	RESTORATION OBJECTIVE	RESTORATION PROJECT	WATERSHED LOCATION
Stream drainage network expansion	Reduce stream drainage network expansion	Reduce road and stream crossings such that the drainage network expansion is less than 10% by subwatershed	Headworks and Otter Creek subwatersheds
Subsurface Intercepts	Reduce subsurface interception	Decompact roadbeds to promote infiltration	Otter Creek, Upper Bull Run, Upper Little Sandy
Sediment Regime: road drainage effectiveness	Restore natural drainage patterns	Increase culvert spacing to restore natural drainage patterns. Remove culverts on closed roads when possible	
Loon habitat	Improve nesting conditions for loons	Create areas of nesting habitat	Bull Run lake
Deer and Elk Winter Range	Reduce road densities to meet Forest Plan Standard for Deer and Elk Winter Range (B10) of 1.5 miles per square mile	Decommission roads not identified in the conceptual road network and close other roads as needed to meet Forest Plan Standard	Deer and Elk Winter Range Allocation

Data and Analysis Gaps

Data gaps were identified as missing or incomplete information needed to assess a watershed process. Analysis gaps were identified when time, budget, resources or data were limiting. In the process of implementing the NW Forest Plan and ecosystem management it would be appropriate for the districts or forest to address these data and analysis gaps.

PROCESS	DATA GAP	ANALYSIS GAP
Anadromous fish habitat		Role of Bull Run watershed in Sandy basin habitat relationships
Anadromous fish habitat	RNV side channel habitat, Lower Bull Run river	
Fish Habitat: Channel Substrate	RNV for Lower Bull Run and Lower Little Sandy rivers	
Fish Habitat: In-channel large woody debris	RNV for Lower Bull Run and Lower Little Sandy	
Fish habitat	Pool quality for Upper Bull Run river Cutthroat trout	
Water Quality: Stream Temperature	Influences of natural and management conditions; Little Sandy river	Quantification of stream temperatures with SHADOW model
Water Quality: Stream Temperature	Numbers of Fish affected by increased temperatures in Lower Bull Run and Little Sandy rivers	
Soil Interpretations: Windthrow Hazard		How well is effective soil depth represented by Stephens (1964) soil mapping?
Hillslope Processes: Erosion rates	What is the rate of natural sediment production within the watershed? What is the increase in erosion due to management activities?	
Disturbance Regime: Fire		Extend fire disturbance study to areas directly adjacent to watershed
Distrubance Regime: Windthrow		Extend windthrow disturbance study to Little Sandy
Plant Species of Concern	Historical distribution of Indian rice (*Fritillaria camschatcensis)* in Latourelle Prairie prior to creation of Lake Boody.	
Plant Species of Concern	Location of lesser bladderwort (*Utricularia minor*) - on plant list but no location	

PROCESS	DATA GAP	ANALYSIS GAP
Distribution and abundance of Strickland's taushia (*Taushia stricklandii)* in wet meadows in the watershed	Presence, numbers and distribution.	
Distribution of Howell's daisy (*Erigeron howellii)* in the watershed?	Presence, numbers and distribution	
Presence and population viability of redband trout	Genetics, presence, numbers and distribution of redband trout	Quantitative viability modeling for redband trout
Presence and population viability of unique genetic population of cutthroat trout	Genetics, presence, numbers and distribution of cutthroat trout	Quantitative viability modeling for cutthroat trout
Historical presence and abundance of bull trout	Historical presence, numbers, and distribution of bull trout.	
Presence of exotic fish species (brook trout)	Presence, numbers and distribution of brook trout	
Presence and population viability of Apatania or Lyrogryus populations	Presence, numbers and distribution of Apatania or Lyrogryus populations	
Water quantity base flows: fog drip	1) the aerial distribution of fog drip throughout the Bull Run Watershed; 2) whether reduced fog drip is at least partially offset by increased fog drip in the adjacent downwind stand; (3) at what age a newly established forest begins to intercept substantial amounts of fog; (4) if there is a reliable relationship between annual precipitation and annual fog drip.	
Water quantity base flows:		Assess low flows in the Bull Run River by removing augmented flows from Bull Run Lake. Assess the effect of reducted seepage from Bull Run Lake at lower lake levels following releases.
Water Quantity peak flows		What are the combined effects of created openings and the road network on the timing and magnitude of peak streamflows

Monitoring

Under the Northwest Forest Plan, (ROD B-32, E-1) the objectives of monitoring are to evaluate the relative success of management strategies. Monitoring is an essential component of the management actions supported by watershed analysis (ROD B-32).

The purpose of this section is to identify monitoring opportunities associated with key processes and functions within the watershed. The processes and functions identified are critical to maintaining or restoring the key attributes.

Table 7-4 Monitoring Recommendations

PROCESS	MONITORING QUESTION	MONITORING OPPORTUNITY	WATERSHED LOCATION
Wind currents	What are the winter wind speeds and gusts within the watershed?	Monitor wind at RAWS station during winter months	Log creek
Water Quality: Stream Temperatures	Do the stream temperatures in the Little Sandy River meet the needs of the aquatic species present and current State Water Quality Standards?	Install continuous stream temperature monitoring equipment.	Little Sandy River
Water Quality: turbidity, suspended solids, nitrogen, and temperature	*Do statistically* significant trends from this analysis with very small magnitude of change have potential for water quality impacts over the long term?	*Complete Season* Kendall Trends analysis every five years	*Stream Key Stations*
Noxious Weeds	Has the abundance and distribution of noxious weeds changed since the last watershed survey in 1991?	Ask Oregon Dept. of Agriculture to perform second survey. Enter results into GIS	Roadsides and other potential weed habitat in watershed
Plant species of concern	Is the viability of krushea (*Streptopus streptopoides*) being maintained in the watershed?	Annual monitoring of selected sites from Draft Species Management Guide for *Streptopus streptopoides*	Mt. Talapus west of Cedar Creek; North of Latourelle Prairie; North of Eagle Butte; South of Bull Run river; Nanny creek
LSR Effectiveness	Ability of the LSR to provide for late successional species ?	Monitor spotted owl pairs	LSR

Ongoing Monitoring

There are a number of ongoing monitoring projects that are independent of implementation of the NW Forest Plan that tie in with monitoring recommendations from this analysis. These projects include:

- Bull Run Water Quality Standards Monitoring
- How do harvest methods and environmental conditions affect chanterelle (*Cantharellus formosus*) production?
- How do land use practices within the watershed affect habitat for neotropical migratory birds?
- Do releases of water from Bull Run Lake affect the known Apatania or Lyrogryus populations?
- Assessment of the reproductive status of Bald Eagles and Common Loons

Altered Processes

This section presents a list of altered physical or biological processes that have been recognized in the watershed analysis as outside the range of natural variation. These altered processes generally stem from the use of the watershed for municipal water supply and hydroelectric power. These uses are consistent with the overriding management direction or regulations for the watershed. Restoration opportunities are therefore not identified.

These altered processes generally stem from the use of the watershed for municipal water supply and hydroelectric power.

Table 7-5 Altered Processes Consistent with Management Direction

ALTERED PROCESS	WATERSHED LOCATION
Decreased Baseflow	Below reservoir #2 and Little Sandy diversion
Decreased Peakflow	Little Sandy below diversion
Altered baseflow regime from peaking associated with operation of Bull Run power plant	Bull Run River below Bull Run power plant
Increased turbidity from mixing glacially influenced waters of the Little Sandy and Sandy rivers with Lower Bull Run river	Lower Bull Run River below Bull Run power plant
False attraction of anadromous fish	Lower Bull Run River
Increased water temperatures Decrease water quality	Isolated pools in Lower Bull Run river
Fish passage barriers	Bull Run dams at reservoirs # 1 and #2, Little Sandy dam
Connectivity of cutthroat spawning tributaries	Bull Run Lake
Decreased inputs of large woody debris to stream channels	Log jams downstream of reservoirs
Altered baseflow regime	Bull Run River during Bull Run Lake releases
Water temperature	Reservoirs #1 and #2
Riverine aquatic ecosystem	Reservoirs #1 and #2
Altered stand structure and composition in powerline corridors	Powerline corridors

Additional Management Considerations

Complete Interim Landscape Analysis and Design (LAD) steps, defining opportunities and constraints, describing the recommended landscape pattern and infrastructure, and developing projects to move from the current condition to the desired future condition.

Develop an interim road plan for roads identified in the Conceptual Landscape Design. Develop road maintenance and decommissioning criteria. Field survey each road in the watershed and develop a plan for maintenance or decommissioning.

Revise PIG standards for in-channel large woody debris and pools to reflect Range of Natural Variation

Obtain documented locations for lichens and bryophytes

- For nitrogen fixing arboreal species: maintain 10-40 acre patches of old growth trees for microclimate and dispersal. 200+ year old trees with large lateral branches and emergent crowns are important (Appendix J2 pg. 228-234).
- For riparian species: maintain a diversity of hardwoods in stands, especially large big leaf maple.
- For rock species: maintain shading and microclimate.

Fire Recommendations:

- Maintain an aggressive detection and initial attack program to extinguish fires as soon as they are detected to meet the 10 acre control strategy in the Management Unit.
- Maintain some road access throughout the watershed to reduce travel time.
- Increase levels of detection during east wind events (aerial, road patrol, etc.).
- Include areas outside the watershed in detection, prevention, and initial attack planning efforts.
- Consider stand level treatments for hazard reduction such as: removing or breaking up the continuity of fine fuels near high risk areas; removing fuels in strategic areas to augment natural barriers; and , keeping stands health and vigorous
- Evaluate cost of upgrading Rd 2030 to provide access for fire detection and suppression
- Rerun NFMAS model to include resource values other than timber

Chapter 8

References

Chapter 8 - References

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Chapter 9

Acknowledgments

Chapter 9 -- Acknowledgments

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Chapter 10

Changes Between Draft and Final

Chapter 10 - Changes Between Draft and Final Document

This section summarizes significant revisions incorporated in the Final Bull Run Watershed Analysis based on review comments received in March, 1997. It is important to note that watershed analysis is an ongoing, iterative process. This report is a dynamic document and is intended to be revised and updated as new information becomes available.

Review Comments Not Incorporated

The City of Portland and its Water Quality Advisory Committee, as well as several other groups and individuals, provided watershed analysis review comments that the Forest Service should adhere to City Council Resolution No. 35203 and prohibit timber harvesting in the Little Sandy Watershed. Watershed Analysis is a tool for implementing the Northwest Forest Plan and its existing land allocations. It therefore considers public desires for future conditions within the framework of the standards and guidelines of the Northwest Forest Plan, the Mt. Hood Forest Plan, and laws regulating usage in the area including PL95-200 and the Oregon Resource Conservation Act. This Watershed Analysis, as previously stated, is not a decision document. Rather, it provides a technical assessment of watershed conditions and provides recommendations at the landscape level to improve aquatic and terrestrial conditions. It is not within the scope of the watershed analysis to change land allocations. For these reasons, Resolution No. 35203 and its provisions were discussed in Chapter 4 Social/Historical, but not incorporated further in the analysis.

The upcoming Little Sandy Study, as required by the Oregon Resource Conservation Act, will provide both legislative and regulatory recommendations from the Secretary of Agriculture to Congress on future management of the Little Sandy Watershed that is within the Bull Run Watershed Management Unit. Public recommendations for this study will be from two sources: the City of Portland through its Water Quality Advisory Committee and public input to that advisory committee; and from the Willamette Provincial Advisory Committee (PAC). The PAC is a public advisory group sanctioned by the Federal Advisory Committee Act and includes members of local, state, tribal and federal governments, as well as citizens representing a broad variety of interests.

Review Comments Incorporated by Chapter

General Changes

Legend corrections in stream stability, seral stage, and blowdown and harvest maps. Clarified several citations or sources of information, including references. Included additional assumptions of methodologies or sources in response to specific review comments. Added a glossary for technical terminology. Corrected grammatical, spelling, or format errors as noticed.

Chapter 1

Clarified source of isohyetal map and accuracy/source of acreage figures. Minor adjustments to administrative boundaries map. Added ORCA Little Sandy Study Area to administrative boundaries definitions. Added an acreage summary table of land ownership by administrative unit. Included a general vicinity map and a mylar location overlay map.

Chapter 2

Clarified status of Bureau of Land Management District Designated Reserve allocation. Added footnote on Congressionally Reserved versus Administratively Withdrawn allocations since ORCA. Kept Riparian Reserve width along reservoirs to one site potential tree height according to the Northwest Forest Plan and ACS objectives.

Chapter 4

Social/Historical: Revised or added text in cultural heritage, City Council Resolutions, and Water Supply Sources sections. Added City of Portland's hydroelectric project description and updated power generation figures for both City of Portland and PGE. Included information on upcoming Little Sandy Study.

Geology: Clarified sediment production model source and purpose.

Disturbance from Fire: Incorporated comments from Dr. Jim Agee and City of Portland regarding average fire frequency, season of high fire danger, and draft Federal Fire Management Policy. Deleted fire regime map. Added pie charts on size and cause of recent fires.

Disturbance from Wind: Incorporated review comments from Associate Professor Julia Jones and colleagues regarding aging of clearcut edges, windthrow risk, and windthrow generating storm predictions. Clarified Watershed Analysis Team interpretations, conclusions, and inherent windthrow risk map.

Wildlife: Revised portions of the common loon discussion and references.

Peak flow trends: The decreasing trend in peak flow magnitude of 4.6 cfs per year observed in the Little Sandy River was investigated in more detail due to City of Portland Water Bureau personnel's concern about the persistence of the trend over the entire period of record (64 years) for the Little Sandy streamflow gage.

Base flows: The section on base flows detailing fog drip studies was modified to incorporate the publication "Streamflow After Patch Logging in Small Drainages Within the Bull Run Municipal Watershed, Oregon" (Harr 1980) and comments on the draft Bull Run Watershed Analysis by Julia A. Jones Associate Professor Department of Geosciences Oregon State University.

Peaking and base flows: The section of the document discussing peaking operations associated with operations of the Bull Run powerplant was modified based on input from Portland General Electric. Peaking associated with summer low flow streamflows attributed to normal operations of the powerplant was modified to reflect that the peaking in 1995 and 1996 was due to non-routine major equipment work. Portland General Electric's policy is passing natural flows through the plant during low flow periods to minimize impacts to fish and other aquatic resources.

Water quality: Bull Run's unique status as an unfiltered surface water supply and the regulatory context of unfiltered systems in the Safe Water Drinking Act and EPA's Surface Water Treatment Rule were recognized.

Fish Distribution Maps: Areas of known and suspected fish populations were delineated on the maps..

Chapter 6

Probable Sale Quantity: A section was added to key question 5 to validate the assumptions used in probable sale quantity modeling associated with the NW Forest Plan.

Glossary

Accelerated Erosion and Sediment Yield - The increase in erosion and sediment yield above natural levels as caused by human activities.

Aggradation - The up-building performed by a stream in order to establish or maintain uniformity of grade or slope.

Alluvial - Deposited by a stream or running water.

Aquatic Ecosystem - A water based ecosystem (see ecosystem). An interacting system of water with aquatic organisms (plants and animals).

Anadromous - Fish that swim from the ocean up streams to spawn.

Biodiversity - see Biological Diversity

Biological Diversity - The variety of life and its processes, including the variety in genes, species, ecosystems, and the ecological processes that connect everything in ecosystems.

Biomass - The total mass of living organisms in a biological system. The above-ground portions of shrubs and trees, excluding material that meets commercial sawlog specifications.

Biota - All the species of plants and animals occurring within an area or region.

Catastrophic Event - A large-scale, high-intensity natural disturbance that occurs infrequently.

Channel (watercourse) - An open outlet either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. River, creek, run, branch, and tributary are some of the terms used to describe natural channels. Natural channels may be single or braided.

Climax Community - The final or stable biotic community in a successional series which is self-perpetuating and in dynamic equilibrium with the physical habitat.

Community - An aggregation of living organisms having mutual relationships among themselves and to their environment.

Connectivity - see Landscape Connectivity

Corridor - Route that permits the movement of species from one Ecoregion, Province, landscape or ecosystem to another, or the landscape elements that connect similar patches through a dissimilar matrix or aggregation of patches.

Cumulative Effects Analysis - An analysis of the effects on the environment which results from the incremental impact of a proposed action when added to other past, present, and reasonable foreseeable future actions, regardless of what agency or person undertakes such other actions.

Cumulative Watershed Impacts - Impacts occurring away from the site of primary development which are transmitted through the fluvial system. The impacts occur through both increases in peak stream flows and through increased sediment levels. The effects generally are concentrated within stream channels which can lead to bank undercutting, channel aggradation, degradation and inner gorge mass wasting.

Debris Torrents - A mass wasting process which results from a debris slide or avalanche entering and flowing down a steep gradient stream channel. As the mass entrains more water, it scours and transports large quantities of organic material and sediment. This material is generally deposited as the channel gradient decreased or a significant obstruction is met. Torrents generally contribute to secondary mass wasting along the margins of the scoured channel.

Debris Slide/Avalanche - A mass wasting process characterized by a relatively shallow failure plane, which generally corresponds to the soil/bedrock interface. The distinction between an avalanche and a slide is that a slide moves slower, and retains more of a coherent slide mass. An avalanche generally fails rapidly, with the slide mass disaggregating, and sometimes flowing, depending on the water content.

Desired Condition - Objectives for physical and biological conditions within the watershed. They may be expressed in terms of current conditions, ecosystem potential, or social expectations. They describe the conditions that are to be achieved and are phrased in the present tense.

Desired Future Condition - see Desired Condition

Disturbance - A discrete event, either natural or human induced, that causes a change in the existing condition of an ecological system.

Diversity - The distribution and abundance of plant and animal species and communities in an area.

Drainage Area - The drainage area of a stream at a specified location is that area, measured in a horizontal plane, which is enclosed by a drainage divide.

Ecological Processes - see Ecosystem Functions

Ecology - The science of the interrelationships between organisms and their environments.

Ecosystem - The complex of a community of organisms and its environment functioning as an ecological unit in nature.

Ecosystem Functions - The major processes of ecosystems that regulate or influence the structure, composition and pattern. These include nutrient cycles, energy flows, trophic levels (food chains), diversity patterns in time/space development and evolution. cybernetics (control), hydrologic cycles and weathering processes.

Ecosystem Processes - see Ecosystem Functions

Ecosystem Management - Using an ecological approach to achieve the multiple-use management of national forests and grasslands by blending the needs of people and environmental values in such a way that national forests and grasslands represent diverse, healthy, productive, and sustainable ecosystems. The careful and skillful use of ecological, economic, social, and managerial principles in managing ecosystems to produce, restore, or sustain ecosystem integrity and desired conditions, uses, products, values, and services over the long-term.

Ecosystem Sustainability - The ability to sustain diversity, productivity, resilience to stress, health, renewability, and/or yields of desired values, resource uses, products, or services from an ecosystem while maintaining the integrity of the ecosystem over time.

Ecotone - A transition between two or more biotic communities.

Ecotype - A locally adapted population of a species which has a distinctive limit of tolerance to environmental factors: a genetically uniform population of a species resulting from natural selection by the special conditions of a particular habitat.

Endangered Species - A species which is in danger of extinction.

Endemic - Restricted to a specified region or locality.

Environment - The complex of climatic, soil and biotic factors that act upon an organism or ecological community and ultimately determine its form and survival.

Environmental Change - A shift in the rate or timing of a physical process or a shift in state of physical or biotic character.

Erosion - The group of processes whereby earthy or rock material is worn away, loosened or dissolved and removed from any part of the earth's surface. It includes the processes of weathering, solution, corrosion, and transportation. Erosion is often classified by: the eroding agent (wind, water, wave, or raindrop erosion); the appearance of the erosion (sheet, rill, or gully erosion); the location of the erosional activity (surface, or shoreline); and/or by the material being eroded (soil erosion or beach erosion).

Erosion Hazard Rating - A relative (not absolute) rating of the potential for soil loss due to sheet and rill erosion from a specific site. Commonly used to address erosion response expected from a given land management activity. Ratings are the result of a cumulative analysis of the following factors: soil, topography, climate, and vegetative and protective cover.

Eyrie - A raptor's cliff nest, such as a peregrine falcon.

Exotic Species - Non-native species which occur in a given area as the result of deliberate or accidental introduction of the species from a foreign country.

Fault Zone - A fault that is expressed as a zone of numerous small fractures.

Fauna - All animals, including birds, mammals, amphibians, reptiles, fish and invertebrates (clams, insects, etc.).

Fifth Field Watershed - Fifth largest level in watershed classification hierarchy. Generally refers to an area between 20-200 square miles. For the Bull Run Watershed the 4th field is the Sandy Subbasin and 5th field is the Bull Run Watershed.

Flora - All plants, including trees, shrubs, forbs, and grasses, and considered as a whole.

Fragmentation - Breaking up of contiguous areas into progressively smaller patches of increasing degrees of isolation.

Fuel Loading - The amount of combustible material present per unit of area, usually expressed in tons per acre.

Fuels - Any material capable of sustaining or carrying a forest fire, usually natural material, both live and dead.

Gap Analysis - Process to determine distribution and status of biological diversity and assess adequacy of existing management areas to protect biological diversity.

Geologic Province - Any large area or region considered as a whole, all parts of which are characterized by similar features or by a history differing significantly from that of adjacent areas.

Guild - A group of species that have similar habitat requirements. Can also be known as an assemblage.

Habitat Type - The collective land area in which one vegetation type is dominant or will come to be dominant as succession advances.

Habitat Connections - A network of habitat patches linked by areas of like habitat. The linkages connect habitat areas within the watershed to each other and to areas outside the watershed. These connections include riparian areas, mid-slopes, and ridges.

Home Range - The geographic area within which an animal travels to carry out its activities.

Increaser - A plant low in palatability which tends to increase in numbers or relative dominance under heavy grazing or site disturbance.

Key Questions - Questions that Watershed Analysis attempts to answer. These are the interdisciplinary team's expectations for the analysis. Key Questions are designed to: focus on ecosystem elements that influence and are influenced by potential management activities; be measured at the watershed scale; promote integration among elements.

Landscape - The mixture of topographic, vegetative, and biologic attributes within an area. An area composed of interacting and interconnected patterns of habitats, that are repeated because of the geology, land forms, soils, climate, biota, and human influences throughout the area. Landscape structure is formed by patches, connections, and the matrix. Landscape function is based on disturbance events, successional development of landscape structure, and flows of energy and nutrients through the structure of the landscape.

Landscape Connectivity - The spatial contiguity within the landscape. A measure of how easy or difficult it is for organisms to move through the landscape without crossing habitat barriers.

Landscape Ecology - The study of spatial and temporal interactions and exchanges across heterogeneous landscapes, the influences of spatial heterogeneity on biotic and abiotic process, and the management of spatial heterogeneity.

Landscape Unit - A continuous geographic area with fairly consistent landform and vegetation communities.

Linkage - Route that permits movement of individual plant (by dispersal) and animals from a Landscape Unit and/or habitat type to another similar Landscape Unit and/or habitat type.

Lithology - The description of rocks on the basis of such characteristics as color, mineralogy, and grain size.

Mass wasting - A general term for the dislodgment and downslope transport of soil and rock material under the direct application of gravitational body stresses. In contrast to other erosional processes, the debris removed by mass wasting is not carried within, on or under any other medium. Mass wasting includes many processes, including relatively slow displacement, such as creep, or rapid movement such as rock falls, debris avalanches, or debris torrents.

Microsite - A rock outcrop, snag, seep, stream pool, or other small scale feature that is unique in character.

Monitoring - To watch, observe, or check, especially for a specific purpose, such as to keep track of, regulate, or control.

Naturalized - Naturally-reproducing populations of introduced and exotic species.

Natural Range of Variability- The spectrum of conditions possible in ecosystem composition, structure, and function considering both temporal and spatial factors.

Peak Streamflows - The highest level of streamflow in response to a rainstorm or period of snow melt.

Physical Process - The rate and timing of the interaction of biotic and abiotic ecosystem components.

Plant Association - A potential natural plant community of definite floristic composition and uniform appearance.

Population - A group of individuals of a species living in a certain area. They have a common ancestry and are much more likely to mate with one another than with individuals from another area.

Pool Frequency - The number (occurrence) of pools or a certain size pool within a general or selected stream reach.

Province - A continuous geographic area wherein species composition, both plant and animal, is more homogeneous than between adjacent areas.

Range of Variability (Natural Variability, Historic Variability) - The spectrum of conditions possible in ecosystem composition, structure, and function considering both temporal and spatial factors.

Rehabilitation - Returning of land to productivity in conformity with a prior land use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values.

Resilience - The ability of an ecosystem to maintain diversity, integrity and ecological processes following disturbance.

Restoration - The process of restoring site conditions as they were before a land disturbance.

Riparian Ecosystem - Ecosystems transitional between terrestrial and aquatic ecosystems. Streams, lakes, wet areas and adjacent vegetation communities and their associated soils which have free water at or near the surface.

Riparian Reserve - The area which encompasses streams, lakes, and wetlands and is designed to protect aquatic and riparian functions and values. The Riparian Reserve is a function of site characteristics, physical processes linked to the area, and the type and timing of activity proposed.

River Basin - An area, defined by physical boundaries, in which all surface water flows to a common point. River basins are associated with large river systems and are typically 1000s of square miles in size.

River Basin Analysis - The collection and organization of aquatic and fisheries issues and processes or condition.

SCCA, Species and Community Conservation Analysis 1994 --An analysis project undertaken on the Mt. Hood National Forest in 1993 to develop a methodology for synthesizing existing information so Forest Plan analysis and planning can be accomplished across disciplines on an ecological basis. SCCA also compiled a corporate database of existing information in a retrievable and useable way on distribution and habitat relationships of plants, fish, wildlife, invertebrates, and human use, and create habitat/community maps. Gaps in knowledge were also identified. The project also developed an analysis procedure that would allow the Forest to design and analyze alternatives for species and community diversity, including a Forest-wide GAP analysis to identify areas of high species diversity, and species and communities at risk. Finally, the SCCA developed a process to cover multiple scales appropriate to the species, habitat or community being analyzed. It tiered the analysis to Regional approaches such as GAP, REAP, SAT, NASA Landscape Pattern Analysis Project, and the Ecosystem Management Assessment Working Group (post-Forest Conference group).

Sediment - Fragmental material that originates from weathering of rocks and is transported by, suspended in, or deposited by water or air or is accumulated in beds by other natural agencies. (USGS, 1960)

Sensitive Species - A species not formally listed as endangered or threatened, but thought, by a Regional Forester, to be at risk.

Seral - A biotic community which is a developmental, transitory stage in an ecological succession.

Seral Stage - A biological community viewed as a single developmental or transitional stage in an ecological succession.

Sinuosity - Meander length and pattern of a stream. Stream length divided by valley length.

Site - An area described or defined by its biotic, climatic, and soil condition as related to its capacity to produce vegetation; an area sufficiently uniform in biotic, climatic, and soil conditions to produce a particular climax vegetation.

Soil Map Units - Groupings of soils that are too intricately mixed to be mapped discretely at the scale of soils survey mapping being conducted.

Spawning Sites - Graveled areas within a stream system having the appropriate attributes, i.e. dissolved oxygen, water depth, water velocity, water temperature, substrate composition, and cover that are selected as suitable for spawning by adult fish.

Special and Unique Habitats - A rock outcrop, snag, seep, stream pool, and other environmental features small in scale but unique in character.

Stochastic - Random or uncertain variation.

Stratification - The delineation of areas within a watershed which will respond relatively uniformly to a given process or set of conditions.

Stream Order - A method of numbering streams as part of a drainage basin network. The smallest unbranched mapped tributary is called first order, the stream receiving the tributary is called second order, and so on. It is usually necessary to specify the scale of the map used. A first-order stream on a l:62,500 map, may be a third-order stream on a 1:12,000 map. Tributaries which have no branches are designated as of the first order, streams which receives only first-order tributaries are of the second order, larger branches which receive only first-order and second-order tributaries are designated third order, and so on, the main stream being always of the highest order.

Succession - An orderly process of biotic community development that involves changes in species, structure and community processes with time. It is reasonably directional and therefore, predictable.

Sustainability - The ability to sustain diversity, productivity, resilience to stress, health, renewability, and/or yields of desired values, resource uses, products, or services from an ecosystem while maintaining the integrity of the ecosystem over time.

Terrestrial - Living primarily on land rather than in water.

Terrestrial Ecosystem - An interacting system of soil, geology, topography with plant and animal communities.

Threatened Species - A species which is likely to become an endangered species.

Threshold of Concern (TOC) - Used in cumulative watershed effects analyses to describe the point (in terms of percent equivalent road area) where the risk of watershed degradation is significant if mitigation measures are not employed.

Transient Snow Zone - The area between 2,500 and 5,000 feet elevation subject to rain-on-snow events during winter months.

Underburning - The prescribed use of fire beneath a forest canopy.

Valley Inner Gorge - A zone with slopes adjacent to stream channels, having slope gradients greater than 65 %, which are separated from the upslope area by a distinctive break in slope. Valley inner gorges are formed by mass wasting and therefore are noted for their instability.

Viability - The likelihood of continued existence in an area for some specified period of time.

Watershed - A region or area bounded peripherally by a water parting feature and draining ultimately to a particular watercourse or body of water. There are many watersheds within a river basin. Watershed areas range from 20 to 200 square miles in size.

Watershed Analysis - Development and documentation of a scientifically based understanding of the processes and interactions occurring within a watershed in order to make more sound management decisions.

Weir - An obstruction placed across a stream thereby causing the water to pass through a particular opening.

Wetland - An area at least periodically wet or flooded, an area where the water table stands at or above the land surface.