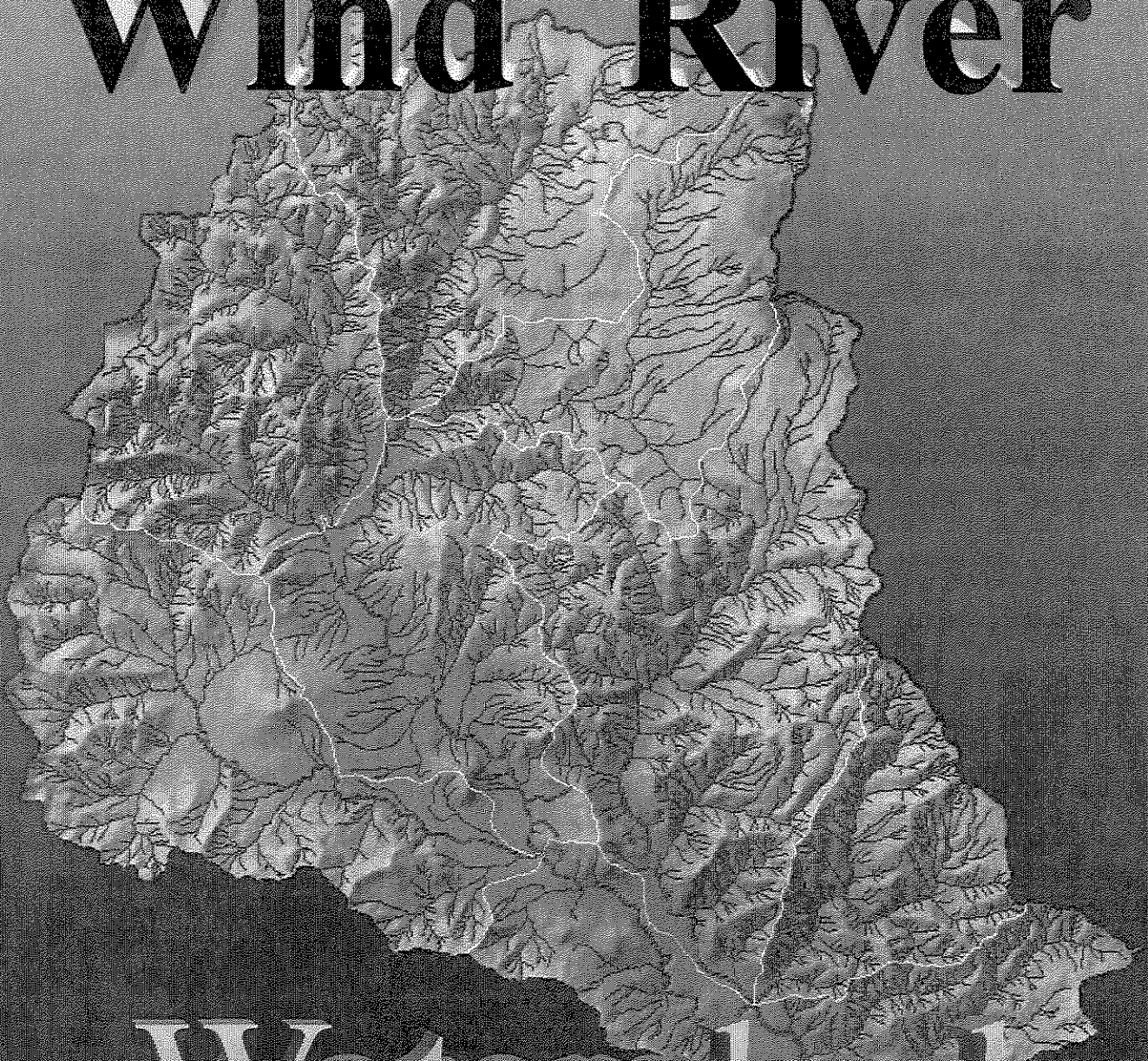


# Wind River



## Watershed Analysis (Second Iteration)

*Mt. Adams Ranger District  
December 2001*

# Wind River Watershed Analysis— Second Iteration

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# INTRODUCTION

This report represents the second iteration of the Wind River Watershed Analysis (WRWA). The report is not intended to be a revision of the initial Watershed Analysis on the Wind River (USDA 1996), but will supplement that analysis, adding new information where it is available, and describing changes that have occurred since the first iteration. As such this report does not follow the six-step process for watershed analysis, nor does it reiterate information provided in the initial WRWA, except where needed to provide context or to show change over the five years that have elapsed between the two analyses.

The second iteration of the WRWA was conducted in accordance with direction provided in the Northwest Forest Plan (USDA 1994), and the Federal Guide for Watershed Analysis (Federal Guide)(RIEC 1995). The Federal Guide states that "Watershed Analysis is an incremental approach..." and that updates to watershed analyses are to be conducted as needed following the initial analyses. Some of the changes that might trigger the need for a second iteration analysis according to the Federal Guide include:

- New information becomes available
- Ecological conditions, management needs, or social issues change
- Major disturbances occur in the watershed
- New monitoring or research results become available
- New management objectives
- Different regulatory requirements
- Fill critical data gaps

Some of the key drivers for conducting the second iteration of the Wind River Watershed Analysis include:

- Wind River steelhead were listed as Threatened under the Federal Endangered Species Act in 1998
- Additional Wind River fish are proposed for listing (cutthroat, chum)
- Lynx is expected to be listed (Wind River watershed has secondary habitat)
- Bear Creek and Eightmile Creek were listed on the Washington State Department of Ecology's 1998 303(d) list
- Additional water quality data have been collected in the watershed
- February 1996 flood was the largest flood on record for the Wind River
- Substantial restoration has been done subsequent to the initial WRWA
- Significant monitoring has been done to evaluate past restoration efforts
- Vegetation conditions have changed through growth, harvest, planting
- Forest wide Late Successional Reserve Assessment has been completed
- A new model has been developed to evaluate spotted owl habitat

## **Analysis Objectives**

Watershed conditions, functions, and key processes were described in some detail in the initial Wind River Watershed Analysis. The focus of this analysis is to build on the earlier work, updating condition assessments where possible and appropriate, and providing further data and analysis to support ongoing or planned work. Priorities for this analysis include providing support work for the Water Quality Restoration Plan for the Wind River, identifying habitat needs and concerns associated with Threatened or Endangered Species (TES) in the watershed, providing an assessment of the road network that describes both the need and environmental effects of the roads, and providing updated assessments to support other restoration activities, timber harvest, and other District work.

# Analysis Summary

The scope of this analysis was dictated largely by funding levels. With limited funds, the analysis team listed, prioritized, then narrowed the analysis items to the most important, those that were feasible, and those that would be most helpful to District planning and work emphasis areas. Following is a list of the analysis items included in this report, along with some of the rationale for including each.

## Watershed and Subwatershed Designation Update

This section of the report summarizes updates to the watershed layer including the resizing, renaming, and in some cases redelineating of 5<sup>th</sup> and 6<sup>th</sup> field watersheds and subwatersheds. This was required by the Regional Ecosystem Office (REO), with the intent of bringing the Gifford Pinchot National Forest watershed layer into compliance with new federal protocols regarding watershed size, delineation, and naming; and to make Forest Service watersheds consistent with those of other federal agencies. The outer boundary of the Wind River watershed was changed in very small ways as a result of this process, but the 6<sup>th</sup> field subwatersheds within the Wind River watershed were modified substantially to meet new size protocols. The 6<sup>th</sup> field subwatersheds used in the previous version of the WRWA, and that have been used for years on the Gifford Pinchot National Forest were much smaller than the new protocols allow, so they were aggregated to larger units.

## Roads Analysis

Over 50 miles of road have been decommissioned in the Wind River watershed since the initial Access and Travel Management Plan was completed for the Wind River (USDA 1994). In addition, road maintenance funds have continued to decline, to the point where funds are sufficient to maintain only a fraction of the roads currently in existence in the watershed. For these reasons, analysis of the current road network was found to be a high priority for this second iteration watershed analysis. New Forest Service guidance on conducting Roads Analysis was followed. The following are some emphasis areas treated under this roads analysis:

- Road needs in the Matrix
- Road needs in the LSR
- Landscape sensitivity and road-related risks to aquatic and terrestrial resources

*(The Roads Analysis became a significant document of its own, so is only summarized in this Watershed Analysis. The entire Roads Analysis is available on request from the Mt Adams Ranger District.)*

## Water Quality Restoration Plan

The Water Quality Restoration Plan (WQRP) was conducted in tandem with the second iteration Watershed Analysis, and is summarized in this report. The WQRP is an assessment and plan for improving water temperatures in streams draining National Forest lands in the watershed. It was initiated because two streams in the Wind River watershed were included on the 1998 version of the 303(d) list published by the Washington State Department of Ecology (DOE). The 303(d) list identifies water bodies that do not meet state water quality standards. Washington DOE requires that plans be developed to improve water quality in watersheds with streams that are listed on the 303(d) list. *(The Water Quality Restoration Plan is available in its full length on request from the Gifford Pinchot National Forest Headquarters.)*

## Riparian Reserve Assessment

Because of the amount of activity that has been conducted in the Riparian Reserves to date and the fact that additional restoration and harvest is proposed, the analysis team felt it was prudent to conduct some watershed-scale analysis of the Riparian Reserves. The Riparian Reserve analysis focuses on the following areas:

- Connectivity
- Snags/snag decay and recruitment
- Coarse woody debris

- Stand composition—age and species, layering

## **Updated Assessments from Original Wind River Watershed Analysis**

The initial WRWA described key processes and conditions associated with seven core topical areas. The following sections of this report update assessments from the initial WRWA for the following resource areas.

### **Hydrology**

- Characterization of hydrologic variability across the watershed
- Update of water temperature conditions
- Analysis of current water rights in the watershed
- Summary of past restoration efforts and their effects
- Summary of monitoring associated with past restoration
- Recommendations for future restoration
- Update of watershed conditions for use in project planning

### **Fisheries**

- Update of fish status in the watershed
- Update of fish habitat conditions
- Update of restoration and monitoring results
- Productivity and carrying capacity for fish and aquatic organisms
- Supporting documentation for fish consultation
- Results of Ecological Diagnostic Template (EDT) run on the Wind River
- Recommendations for future restoration

### **Vegetation**

- Update of vegetation conditions in the watershed
- Update of available options for future vegetation management

### **Wildlife**

- Update of habitat conditions in the Late Successional Reserve (LSR)
- Habitat connectivity assessment
- Update on survey species (TES, Survey and Manage)
- Management recommendations

## Extended Analysis Team

A large number of individuals contributed to the analyses summarized in this report, including partners from other agencies. The following list identifies the primary contributors and their affiliations. Forest Service employees are not identified by affiliation in the list.

Contributor (Affiliation)	Subject Matter	Analysis
Brian Bair	Fisheries	Watershed Analysis; Roads Analysis
Gail Bouchard	Silviculture	<b>Roads Analysis</b>
Bruce Burke	Engineering	Roads Analysis
Jim Chamberlin	Geology/GIS	Watershed Analysis; Roads Analysis
Sally Claggett	Botany/Riparian Reserves	Watershed Analysis
Charlie Cochran (WDF&W)	Fisheries	Watershed Analysis—Fisheries Consultant
Bengt Coffin	Hydrology/Team Leader	Watershed Analysis; Roads Analysis, WQRP
Pat Connolly (USGS)	Fisheries	Watershed Analysis—Fisheries Consultant
Cathy Flick	Wildlife/Riparian Reserves	Watershed Analysis; Roads Analysis
John Forsberg	Silviculture	Watershed Analysis; Roads Analysis, WQRP
Rico George	Fire/Fuels	Roads Analysis
Ian Jezorek (USGS)	Fisheries	Watershed Analysis—Fisheries Consultant
Tim LaMarr (USFWS)	Wildlife/Riparian Reserves	Watershed Analysis; Roads Analysis
Tom Linde	Recreation	Roads Analysis
Mandy Muller	GIS	Watershed Analysis; Roads Analysis
Jim Nielson	Logging Systems	Roads Analysis
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WDF&W = Washington Department of Fish and Wildlife

USGS = United States Geological Survey

USFWS = United States Fish and Wildlife Service

GIS = Geographic Information Systems

WQRP = Water Quality Restoration Plan

# WATERSHED AND SUBWATERSHED DESIGNATIONS--UPDATE

Since publication of the original Wind River Watershed Analysis, the Forest Service has gone through a process of re-naming, re-numbering, and in some cases re-delineating hydrologic units including watersheds and subwatersheds. The purpose of this effort was to achieve consistency with other federal and state agencies, tribes, and other organizations in terms of the definitions, terminology, and mapping of watersheds, with the hope of more effectively sharing information and resources across organizational boundaries. The new watershed and subwatershed boundaries follow federal standards for delineation of hydrologic unit boundaries.

In general this process resulted in fewer, larger 6<sup>th</sup> field subwatersheds within the Wind River watershed (with the new 6<sup>th</sup> field subwatersheds typically being simple aggregations of the "old" 6<sup>th</sup> field subwatersheds), and new names and numbers for each subwatershed. In addition, the Wind River (5<sup>th</sup> field) watershed was given a new identification number to be consistent with the new numbering conventions described in the federal guidance document titled "Federal Standards for Delineation of Hydrologic Boundaries" (FGDC, draft copy dated September 12, 2000). The total land area within the Wind River 5<sup>th</sup> field watershed was not significantly changed through this process.

The watershed delineation process included four general types of changes to the watershed layer: 1) changes in watershed boundaries to more accurately follow topography; 2) changes in watershed boundaries to reflect new protocols that specify where lines should be drawn relative to topographic or hydrologic features; 3) changes in the grouping of smaller hydrologic units to comply with the new protocols that specify the number of sub-watersheds that can be contained within larger watersheds; and 4) changes in the naming and numbering of watersheds and subwatersheds.

At the 5<sup>th</sup> field watershed scale, this process resulted in the following changes to the Wind River watershed:

- 1) mapping linework was corrected to more accurately follow topography on the northern and western boundaries of the watershed;
- 2) mapping linework at the mouth of the watershed was extended to the centerline of the Columbia River in accordance with the new protocols;
- 3) the 5<sup>th</sup> field watershed number was changed from 1707010509 to the new number, 1707010512.

The name of the watershed (Wind River) was not changed.

At the 6<sup>th</sup> field subwatershed scale, the process resulted in the following changes within the Wind River watershed:

- 1) mapping linework was corrected as described in items 1) and 2) in the preceding paragraph;
- 2) groups of 6<sup>th</sup> field subwatersheds were aggregated together to form the new 6<sup>th</sup> field subwatersheds, reducing the total number of 6<sup>th</sup> fields from 26 to just 8 (Table WDU-1); and
- 3) 6<sup>th</sup> field subwatersheds were all renamed and given two-digit numbers instead of the old alphabetical designation.

Changes at the 5<sup>th</sup> field and 6<sup>th</sup> field level are summarized in Table WDU-1 and shown graphically in Figure WDU-1.

Table WDU-1. Comparison of new 6<sup>th</sup> field subwatersheds with previous 6<sup>th</sup> fields in the Wind River watershed.

New 6 <sup>th</sup> Field Number	New 6 <sup>th</sup> Field Name	New Acres	Previous 6 <sup>th</sup> Field Number	Previous 6 <sup>th</sup> Field Name	Previous Acres
01	Upper Wind River	20,093			
			W	Pete's Gulch	3,498
			B	Headwaters Wind	8,363
			A	Paradise	5,416
			V	Upper Wind	3,509
	(Sum of acres:	20,786)			
02	Falls Creek	13,891			
			P	Upper Falls	5,777
			C	Lower Falls	8,110
	(Sum of acres:	13,887)			
03	Dry Creek	17,381			
			F	Dry Creek	5,754
			E	Big Hollow	4,121
			D	Trapper	7,417
	(Sum of acres:	17,292)			
04	Middle Wind	17,222			
			J	Middle Wind	13,051
			G	Ninemile	3,501
	(Sum of Acres:	16,552)			
05	Trout Creek	21,735			
			N	Lower Trout	8,244
			M	Layout	3,552
			I	Upper Trout	6,146
			H	Compass/Crater	3,790
	(Sum of Acres:	21,732)			
06	Panther Creek	26,467			
			L	Upper Panther	10,372
			K	Eightmile	2,356
			R	Mouse	2,580
			S	Cedar	3,974
			Q	Lower Panther	7,184
	(Sum of acres:	26,466)			
07	Bear Creek	9,515			
			O	Lower Bear	2,045
			T	North Fork Bear	3,719
			X	East Fork Bear	3,751
	(Sum of Acres:	9,515)			
08	Lower Wind River	17,375			
			U	Lower Wind	9,465
			Y	Brush Creek	1,876
			Z	Little Wind	5,931
	(Sum of Acres:	17,272)			
(Sum of	acres:)	143,679		Entire wshed acres:	143,502

Although not reflecting any change in actual watershed conditions, the change in 6<sup>th</sup> field subwatersheds in the Wind River watershed is an important change affecting how data is reported. To provide continuity with the initial watershed analysis, this document includes both the new and old subwatershed names and numbers in data summaries.

# Wind River Watershed

## Subwatersheds



Watershed Boundary

### Current Subwatersheds

- Upper Wind River (01)
- Falls Creek (02)
- Dry Creek (03)
- Middle Wind River (04)
- Trout Creek (05)
- Panther Creek (06)
- Bear Creek (07)
- Lower Wind River (08)



### 1996 Subwatershed Boundaries

- 09A - Paradise
- 09B - Headwaters Wind
- 09V - Upper Wind
- 09W - Pate's Gulch
- 09C - Lower Falls
- 09P - Upper Falls
- 09D - Trapper
- 09E - Big Hollow
- 09F - Dry
- 09G - Ninemile
- 09J - Middle Wind
- 09H - Compass/Crater
- 09I - Upper Trout
- 09M - Layout
- 09N - Lower Trout
- 09K - Eightmile
- 09L - Upper Panther
- 09R - Mouse
- 09S - Cedar
- 09Q - Lower Panther
- 09O - Lower Bear
- 09T - North Fork Bear
- 09X - East Fork Bear
- 09U - Lower Wind
- 09Y - Brush
- 09Z - Little Wind

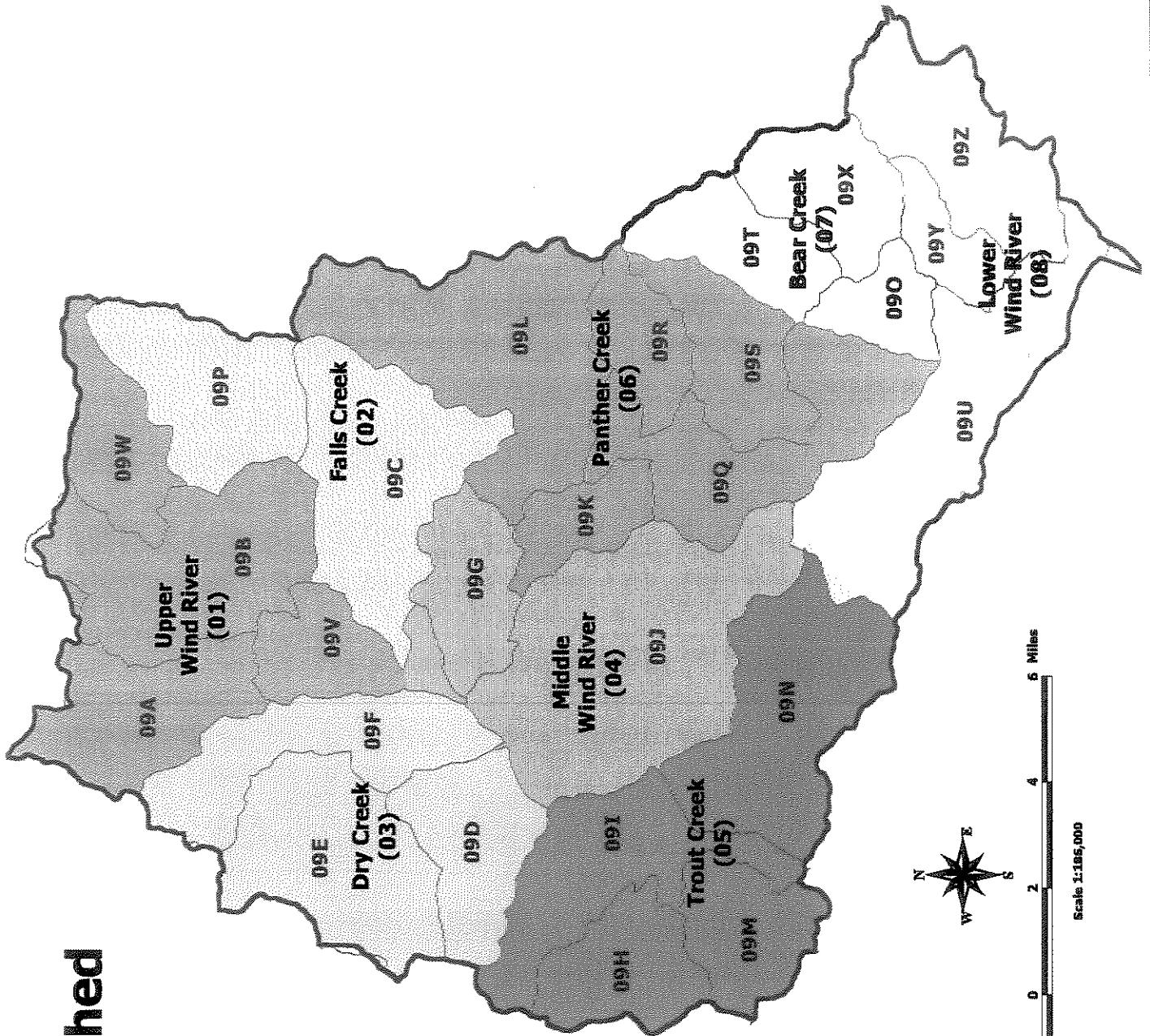


Figure WDU-1. Subwatersheds in the Wind River watershed, including new 6th field subwatersheds

# ROADS ANALYSIS--SUMMARY

## **Introduction**

This chapter summarizes the Wind River Roads Analysis (USDA 2001), which was completed as part of this second iteration watershed analysis. The full content of the Roads Analysis is in a separately bound document that can be obtained from the Mt Adams Ranger District. The roads analysis generally followed the six steps outlined in the Forest Service publication "Roads Analysis: Informing Decisions About Managing the National Forest Transportation System" (USDA 1999). An interdisciplinary team representing all of the program areas and resource interests on the District conducted the analysis.

## **Background**

Over the past decade, road maintenance funds have declined to the point that there is now insufficient funding available to conduct routine maintenance on the entire road network. Lower level roads typically receive no maintenance at all, because funds are prioritized for use on higher-level roads that must be maintained for passenger car traffic. The decrease in road maintenance has led to concerns about safety, due to the reductions in surface maintenance, brush cutting, and traffic sign maintenance. In addition, resource protection measures are often not getting done—particularly on lower level roads that are not commonly visited. During the 1996 flood, numerous failures occurred on the road system, many of which may have been prevented had culverts been cleaned and drainage structures adequately maintained prior to the event. The Wind River Roads Analysis (WRRRA) was intended to assess the continued need for each road in the watershed, to characterize the aquatic and terrestrial risk of each road, and to make recommendations for treatment priorities.

There are currently about 498 miles of road in the watershed. Approximately 80 miles of Forest Service road have been decommissioned over the past several years. This roads analysis focuses on that portion of the existing road system managed by the Gifford Pinchot National Forest, which totals approximately 343 miles of road.

## **Objectives**

The purpose of the analysis was to provide information that would allow the District to develop and maintain a road network that over the long term:

- Is safe and responsive to public needs and desires;
- Is affordable and efficiently managed;
- Has minimal ecological effects on the land and water; and
- Is in balance with available funding for needed management actions.

Specific objectives of the analysis included the following:

- 1) Identify and evaluate the District and public needs for each Forest Service road in the Wind River watershed;
- 2) Assess the relative potential for environmental impact from those roads;
- 3) Determine which roads are essential to maintain or upgrade, which roads should be considered for decommissioning, stormproofing, or other treatment, and which roads need to be evaluated at a more site specific scale prior to making a firm recommendation; and
- 4) Provide some ranking of roads from a resource risk standpoint to help prioritize future restoration work and subsequent road assessments.

# Analysis Methodology

The analysis identified issues related to the *benefits* or uses of roads in the watershed (socioeconomic issues), and the *resource implications* or effects of the roads (aquatic and terrestrial resource issues). Each road segment in the watershed was evaluated by the interdisciplinary team for each of the identified issues to determine which roads have a greater or lesser benefit to the users of the road, and which are more important contributors to environmental concerns. The following issues were evaluated:

- 1) **Socio-Economic** issues related to the *benefits* of road system:
  - Administrative Uses
  - Fire Suppression Uses
  - Recreational Uses
  - Timber Harvest Uses
  - Timber Stand Improvement Uses
  - Late Successional Reserve Stewardship Uses
  - Miscellaneous Forest Products Uses
- 2) **Aquatic** issues related to the aquatic *risks or impacts* associated with roads:
  - Surface Erosion
  - Mass Wasting
  - Riparian Reserves
  - Stream Crossings
  - Cumulative Effects/Streamflow Modification
- 3) **Terrestrial** issues related to the terrestrial habitat *risks or impacts* associated with the roads:
  - Unique Habitats
  - Fragmentation of Interior Forest Habitat
  - Riparian Reserves
  - Threatened and Endangered Species
  - Deer and Elk Biological Winter Range

The analysis began by assessing the relative importance of each road in the watershed to each District program area, and to non-Forest Service users of the road. A representative of each program area and road use-group (i.e. Administrative uses, Fire Suppression uses, Recreation uses, Timber uses, etc.) evaluated each road segment in the watershed—some 400+ segments—on a scale of High, Moderate, or Low. The evaluations were to reflect the relative importance of each road segment to that user group. For example, a road segment is rated as “High” for Fire Suppression if that segment is essential to the work of the Fire Suppression program. It is rated “Low” for Fire Suppression if the Fire program has no need for that particular segment. In this way, each of the more than 400 road segments in the watershed was evaluated by each District program area and road user-group representative. Road segments were evaluated similarly for their risk or effect to aquatic and terrestrial resources, with “High” ratings given to road segments that posed a relatively large risk or impact, and “Low” ratings given to roads that had little or no effect on the resource parameter being analyzed.

## Analysis Findings

Figure RA-1 summarizes the results of the evaluations done for road uses.

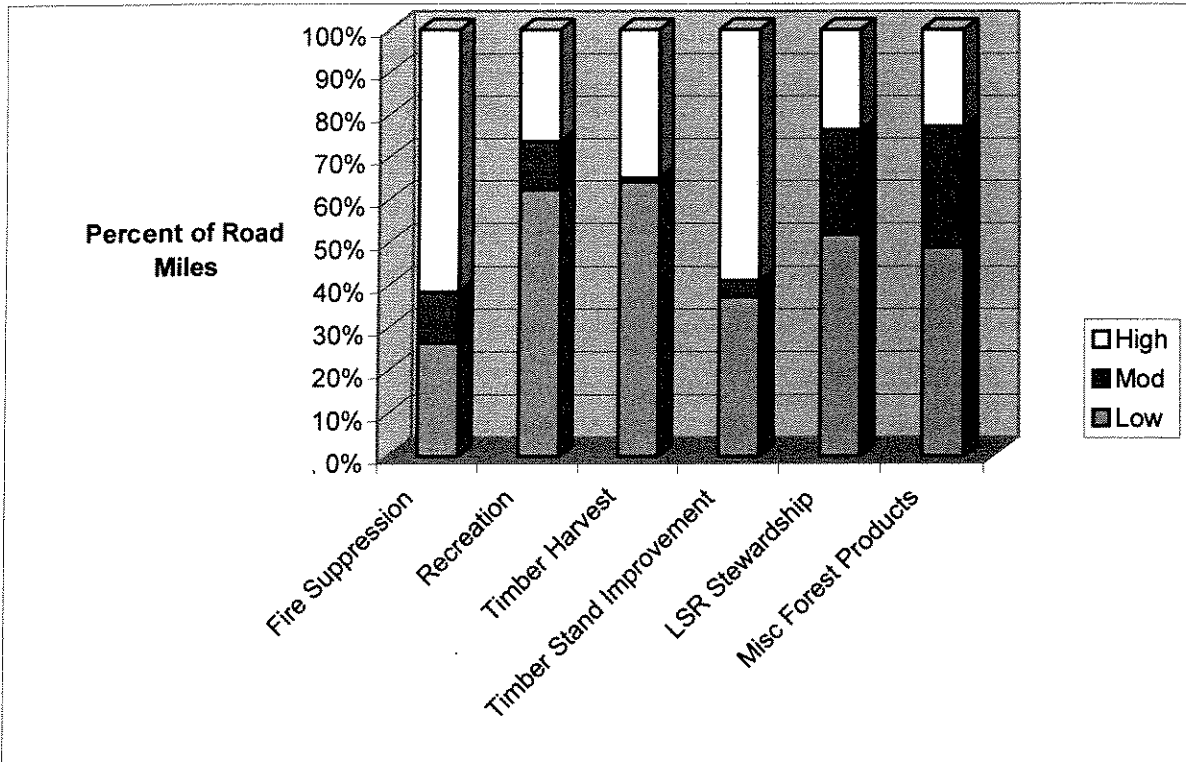


Figure RA-1. Summary of road evaluations conducted for six major road use categories.

- Evaluations of the road system for fire prevention and suppression activities indicate that nearly two thirds of the existing roads in the watershed (62%) are essential for carrying out fire prevention and suppression activities.
- With respect to timber stand improvement, over one half of the roads (59%) were found to be essential for providing access to forest stands needing some form of improvement work.
- Just over one third of the roads (35%) access forest stands that may be identified for timber harvest within the next ten years.
- Approximately one quarter of the roads in the watershed (26%) were identified as accessing important recreation sites;
- Approximately one quarter (24%) were identified as essential for conducting LSR stewardship functions;
- Nearly one quarter (23%) access high value areas of forest product gathering.
- There is substantial overlap where roads essential for one purpose are also essential for some other purpose, or several other purposes.
- There are also cases in which a road segment is essential for one purpose only, and is not needed for other purposes.
- Based on the sum of scores for the six major use categories, each road segment was classified into one of eight categories of road use as described below.
  - **Administrative Use:** These are roads needed by the District for Administrative purposes, including mainline roads, access to developed sites, and administrative sites. Roads needed for Administrative access were assumed to be essential to the District, so were not included in the evaluations summarized above.
  - **Multi Purpose:** These are roads that have a high value for multiple District functions and/or for public use.
  - **Single Purpose--Fire:** These are single purpose roads needed for fire management.

- **Single Purpose--LSR:** These are single purpose roads needed for LSR management.
  - **Single Purpose--Rec:** These are single purpose roads needed for public access to developed and dispersed recreation sites, and for activities including camping, hunting, or other forms of recreation.
  - **Single Purpose--Timber:** These are single purpose roads needed for management of Matrix lands for timber production.
  - **Single Purpose--TSI:** These are single purpose roads needed to manage forest plantations.
  - **Non Essential:** These are roads that were not identified as essential to any of the road use categories.
- Figure RA-2 summarizes the proportion of the road network in each of these categories, and Figure RA-3 shows how the roads are distributed across the watershed.

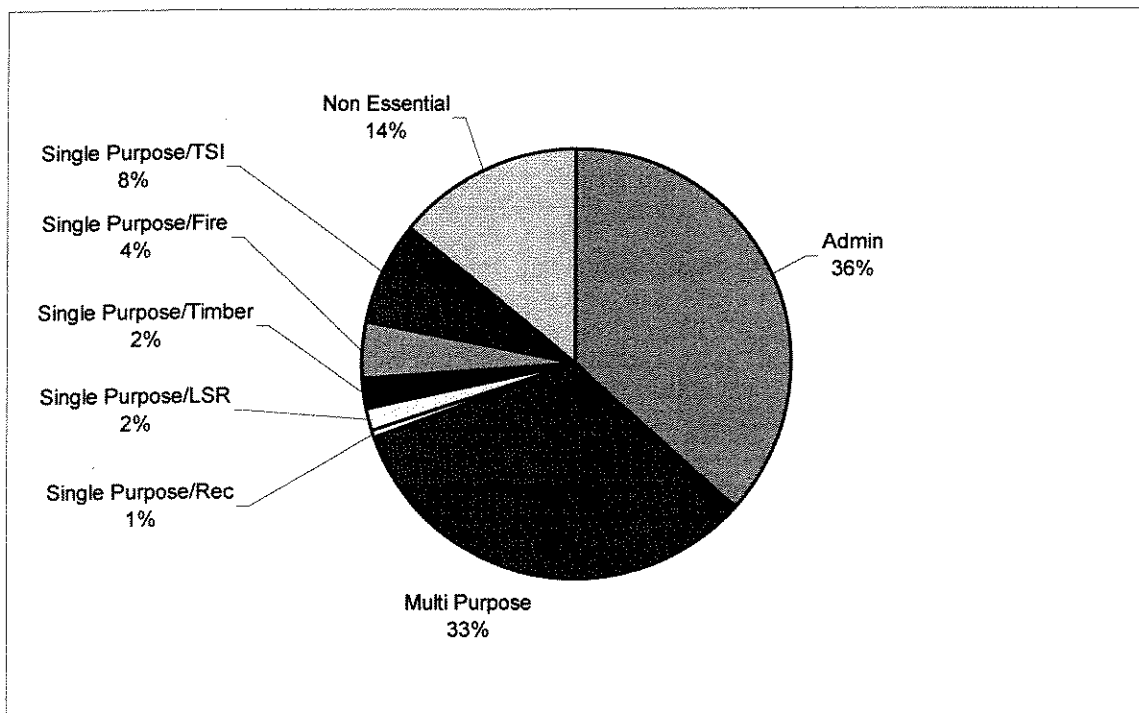


Figure RA-2. Proportion of road network in various use classes.

- Figure RA-2 shows that a majority of the road miles in the watershed are either used for Administrative purposes or are Multi Purpose roads. These two categories together comprise 69% of the road miles in the watershed and represent the bulk of the roads that the District would like to retain over the long term
- 14% of the road miles in the watershed are rated as “non essential” to any functional area or for public use. These roads are candidates for abandonment, closure, or decommissioning since they are not vital for any of the human uses.
- Roads in the Single Purpose categories combine to represent approximately 17% of the road network. Although these roads are identified as “essential” to one program area or for public uses, their importance is limited for other uses.
- Table RA-1 summarizes the miles of road in each category.

# Wind River Watershed

## Road Use Classes

- Administrative
- Multi-Purpose
- Non-Essential
- Single Purpose-Fire
- Single Purpose-LSR
- Single Purpose-Rec
- Single Purpose-Timber
- Single Purpose-TSI
- Roads not Analyzed

## Designated Areas

- ▨ Administratively Withdrawn
- ▨ Congressionally Withdrawn
- ▨ Late Successional Reserve
- ▨ Matrix
- ▨ Other Ownership

## Watershed and Subwatershed Boundaries

- Subwatershed Boundaries (6th Field)
- 01 - Upper Wind River
  - 02 - Falls Creek
  - 03 - Dry Creek
  - 04 - Middle Wind River
  - 05 - Trout Creek
  - 06 - Panther Creek
  - 07 - Bear Creek
  - 08 - Lower Wind River

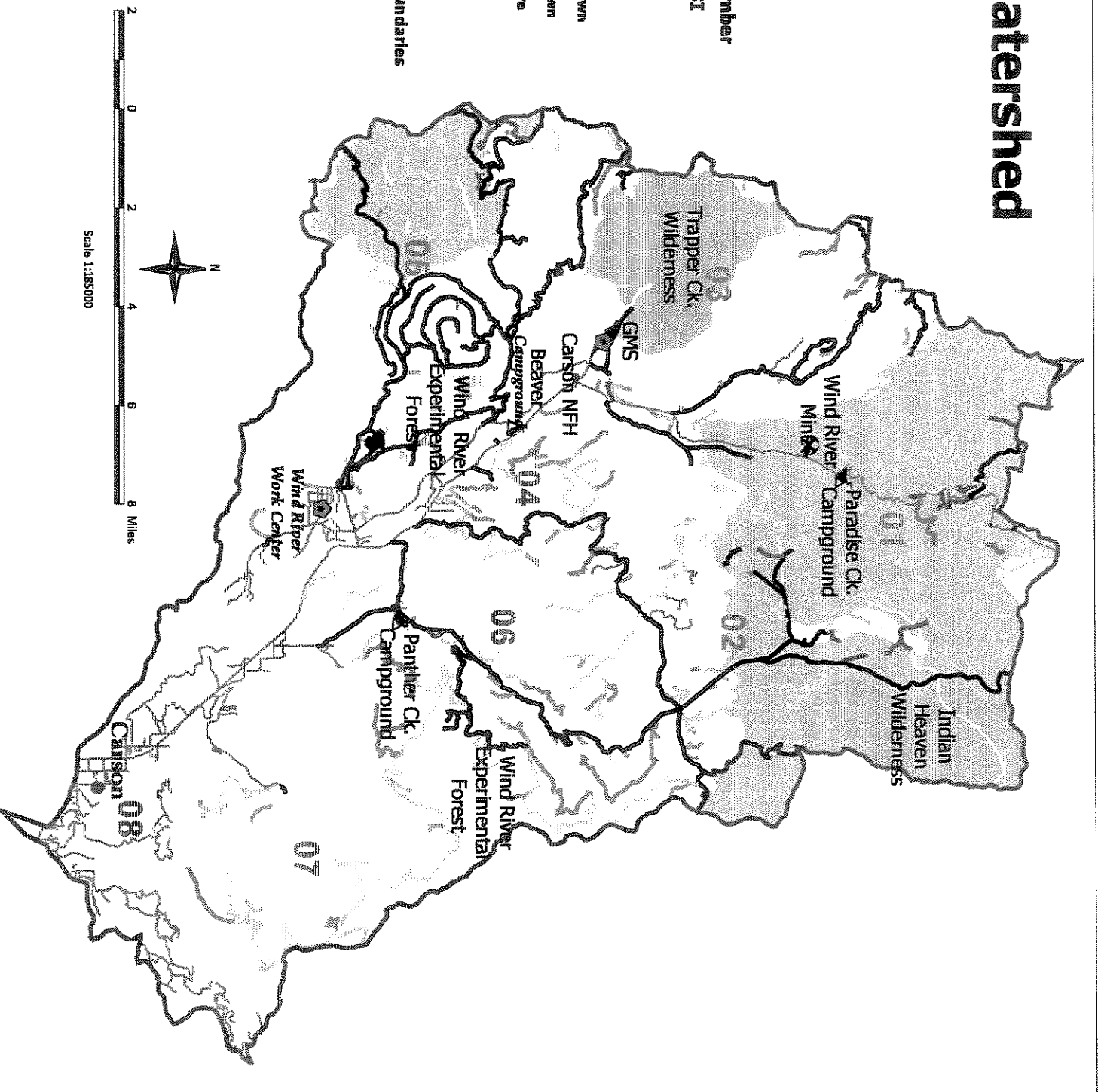


Figure RA-2. Roads in the Wind River watershed, identified by road use class.

Table RA-1. Miles of road in each of eight road use categories.

Road Use Category	Miles of Road
Administrative Use	126
Multi Purpose	113
Single Purpose/Fire	14
Single Purpose/LSR	6
Single Purpose/Rec	2
Single Purpose/Timber	8
Single Purpose/TSI	27
Non Essential	49
Total	345

### Resource problems and risks of the current road system

- Similar to the evaluations done above for the benefits of each road segment, the roads were evaluated in terms of their risk or impact to aquatic and terrestrial resource values.
- Each road segment was evaluated for its effect to each of the aquatic and terrestrial resource issues.
- Figure RA-4 summarizes results of evaluations done to assess aquatic impacts or risk.

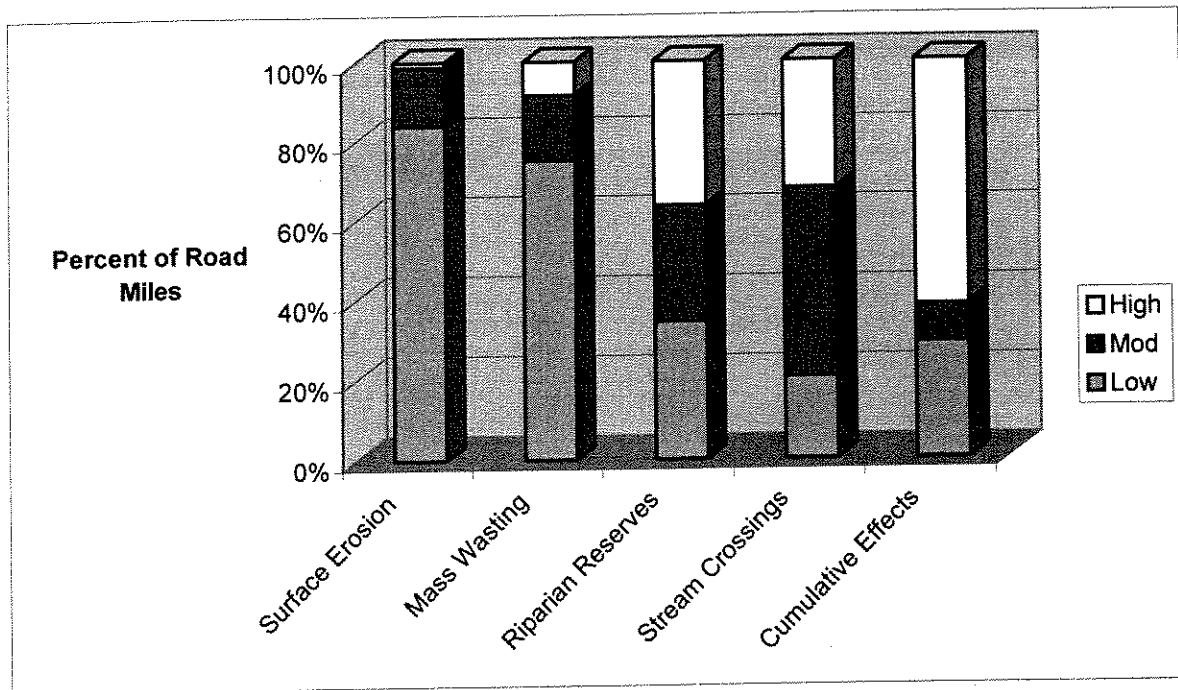


Figure RA-4. Summary of road segment evaluations by issue: **Aquatic Impacts and Risk**

- A large majority of the roads (86%) are shown to have a low impact in terms of surface erosion. Just 1% of the roads were identified as having high levels of surface erosion. These results raise questions as to the validity of the surface erosion analysis, given that no local soils data were available for use in the model. However, other factors that influence this rating are the topographic relief in the watershed, the gradient of the roads, and the limited number of native surface roads.

- A relatively small share of the roads (8%) are identified as having a high risk of failure due to slope stability in this watershed. This reflects the relatively stable landforms found in the watershed.
- Evaluation of riparian areas found that 35% of the roads had a relatively low impact to Riparian Reserves, 29% were moderate, and 36% had a high impact.
- Evaluations for stream crossings found 20% of the roads had a relatively low impact, 47% were moderate, and 33% were rated high.
- Nearly two thirds of the roads in the watershed (64%) are in subwatersheds where there is a relatively high potential for cumulative effects from the combination of high road densities and past timber harvest. In contrast, only 30% of the subwatersheds in the Wind River are rated as having a high risk of cumulative effect impacts to streamflows. This indicates that nearly two thirds of the roads in the watershed lie in under one third of the watershed area.
- Figure RA-5 summarizes the results of evaluations done to assess terrestrial habitat impacts.

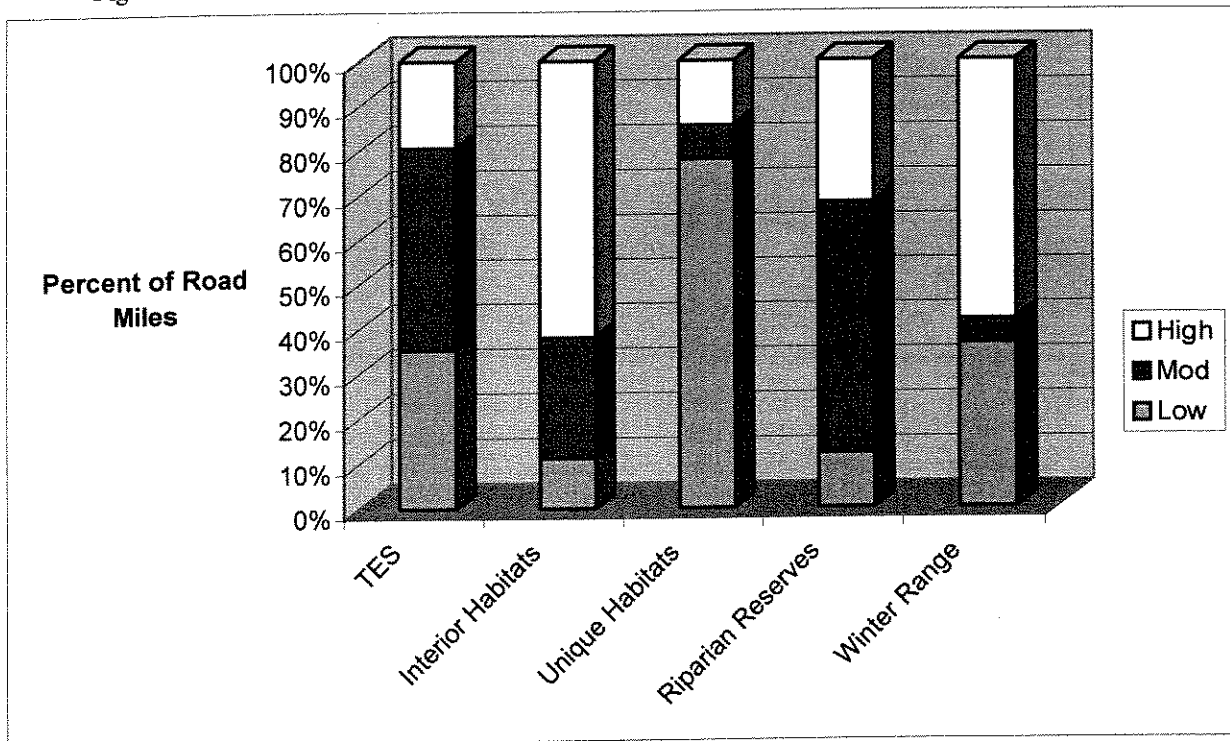


Figure RA-5. Summary of road segment evaluations by issue: **Terrestrial Habitats**

- Nearly one fifth, or 19% of the roads pose a high risk to Threatened and Endangered Species
- The greatest share of road impacts to terrestrial habitats occur in interior habitats and winter range:
  - 63% of the roads were found to have a high impact to interior habitats;
  - 60% were rated as having a high impact to winter range.
- Approximately one third (32%) of the roads have a high impact to Riparian Reserves.
- Just 14% of the roads have a high impact to unique habitats, possibly reflecting the limited numbers of these habitats in the watershed

## Opportunities for Addressing Problems and Risks

- Combining the road use class and the aquatic impact scores across all road segments yields the data summarized in Figures RA-5 and RA-6.

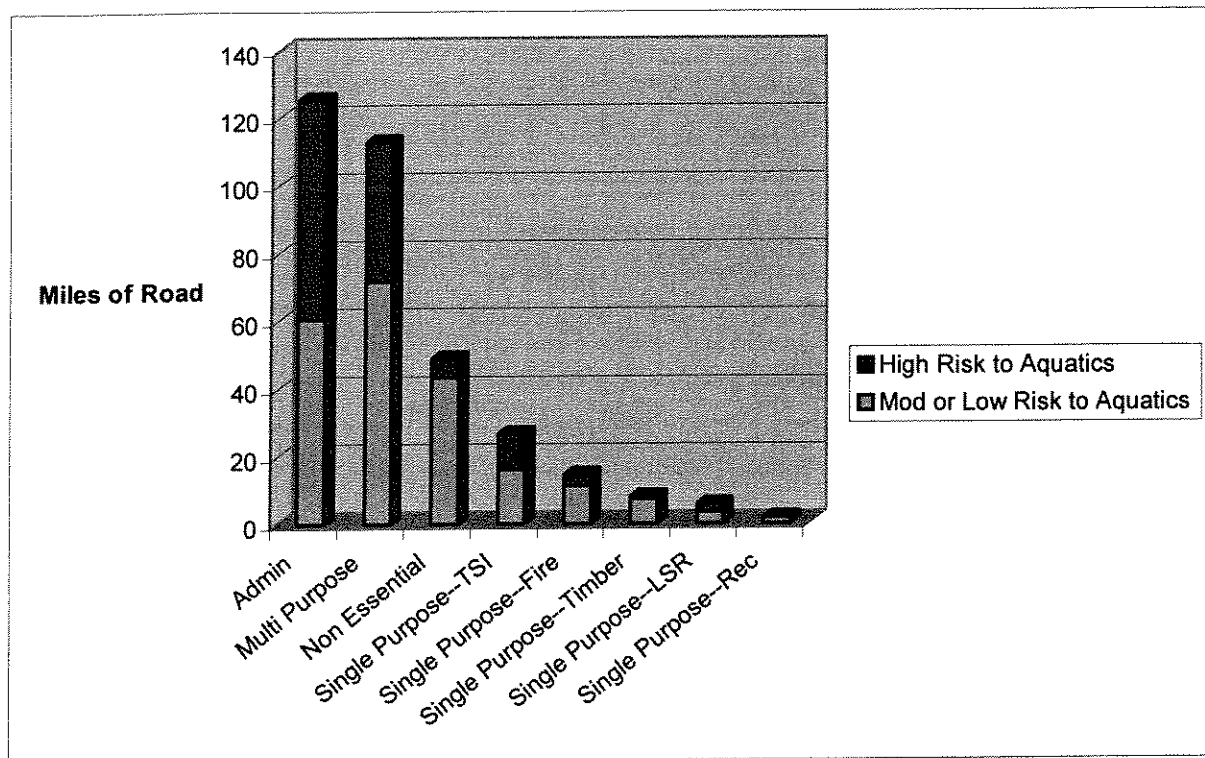


Figure RA-5. Miles of road in road use classes, with high impact aquatic roads highlighted.

- Figure RA-5 illustrates that a large majority of the road segments that have a high impact to aquatic resources are in the Administrative and Multi Purpose categories.
  - 83% of the roads scored as having a high impact to aquatic resources are in either the Administrative or Multi Purpose road use category.
  - Just over half the roads in the Administrative Use category (52%) are rated as having a high impact to aquatics, and 36% of roads in the Multi Purpose category are rated as having a high impact to aquatics.
- If the Administrative and Multi Purpose roads are to remain on the road system as permanent roads, then those having a high impact to aquatic resources should be prioritized for upgrades, improvements, or reconstruction to reduce their impacts on aquatic resources.
- A relatively small portion (11%) of the roads in the Non Essential category pose a high risk to aquatic values.
- Roads in the Non Essential category will in all likelihood not remain on the road system for the long term since they are not needed for District activities or for public use. Roads in this category that are rated as high impact to aquatics should be prioritized for decommissioning. Those scoring moderate or low for aquatic impact should be considered for decommissioning, or possibly for closure and abandonment. Field surveys must be conducted prior to development of final treatment prescriptions to determine if the roads have culverts or other elements that re-route water and pose a risk to aquatic resources.
- Approximately 13% of all roads scored as high risk to aquatics are in the Single Purpose road use categories.
- Roads scored as having a high impact to aquatics comprise:
  - 40% of roads in the Single Purpose-TSI category;
  - 23% of roads in the Single Purpose-Fire category;
  - 8% of roads in the Single Purpose-Timber category;
  - 39% of roads in the Single Purpose-LSR category; and
  - <1% of roads in the Single Purpose-Recreation category.

# Wind River Watershed

## High Aquatic Rating

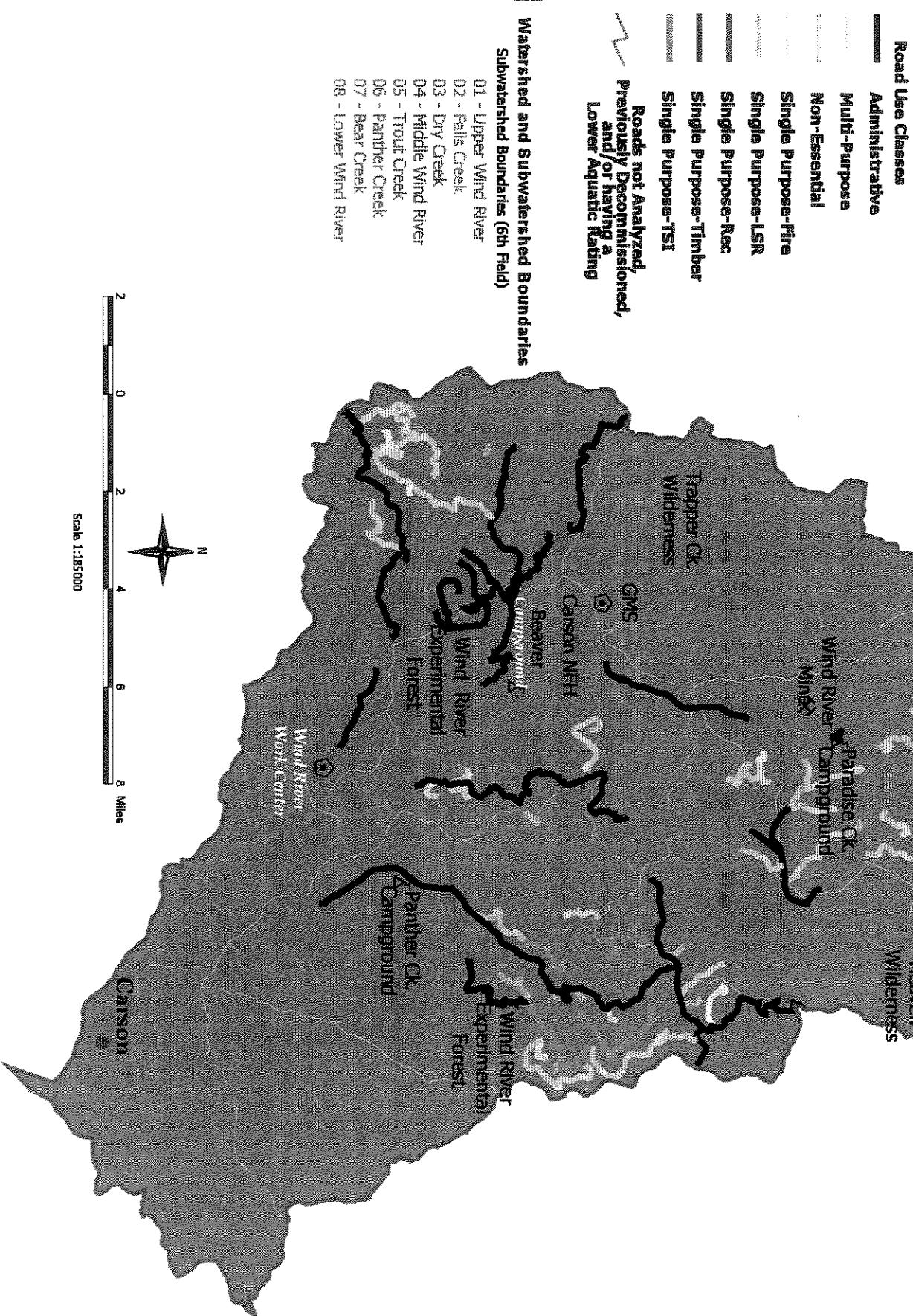
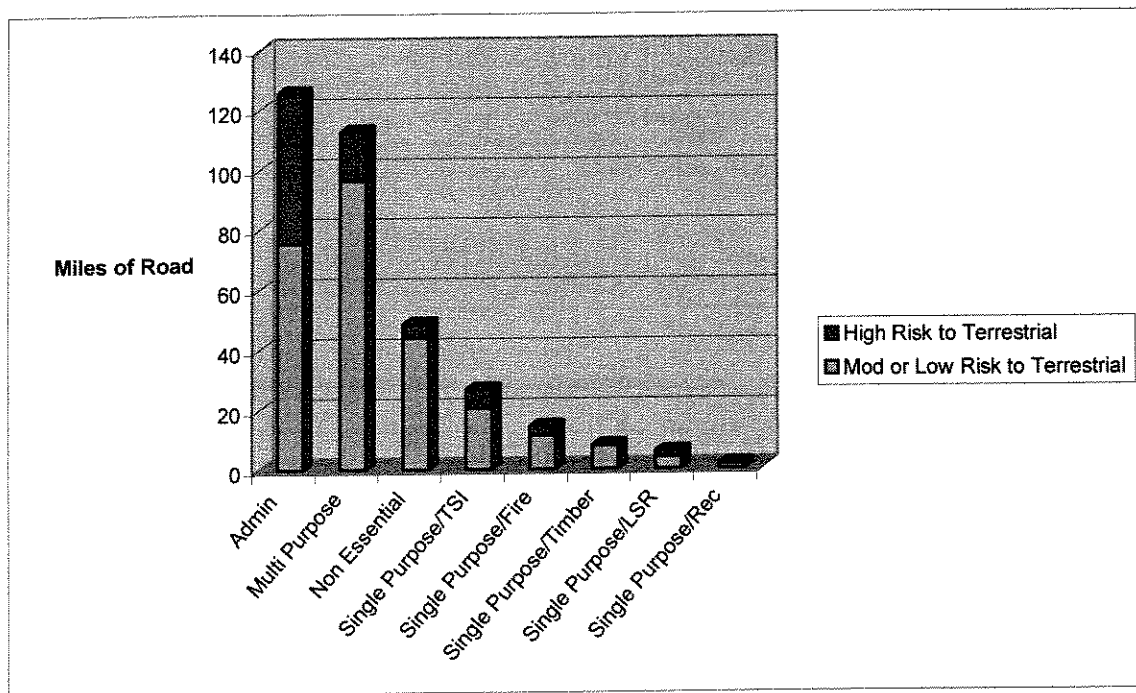


Figure RA-6. Roads with a "High" aquatic rating in the Wind River watershed.

- Single purpose roads that are to be maintained on the system indefinitely could be either upgraded, stormproofed, and/or closed to traffic to reduce the aquatic impacts. If the single purpose of a road is to allow one functional area to accomplish work, then that functional area could be held responsible for covering the costs of maintaining the road.
- Single purpose roads needed for just one entry should be used in the near future if possible, and then decommissioned. The scheduling of the use of these roads should be used as a prioritization criteria for project work wherever feasible, so that these roads should be treated as soon as possible.
- Results from the terrestrial analysis are similar to those described for aquatic impacts in that a majority of the high risk roads (80%) are in the Administrative Use and Multi Purpose road use categories (Figure RA-7).



RA-7. Miles of road in road use classes, with high impact terrestrial roads highlighted.

- 40% of the Administrative Use roads, and 15% of the Multi Purpose roads are rated as high impact to terrestrial resources. If they are to remain on the system as permanent roads, these roads could be managed to reduce their impact on wildlife. Perhaps by prohibiting road use during a specific season, or limiting use throughout the entire year.
- The proportion of Non Essential roads that are identified as posing a high risk to terrestrial resources is relatively low at approximately 11%.
- Non essential roads identified as posing a high risk to terrestrial resources can be prioritized for decommissioning or closed to public travel to reduce impacts to terrestrial resources.

## Recommendations

- The following assumptions were used in developing recommendations:
  - Eliminating a road that is considered “essential” for some District function or for public use would prevent that functional area from being able to get its job done or to effectively and efficiently meet its objectives.
  - Roads described as being a high risk to aquatic values can in some cases be improved by increased maintenance, stormproofing, or upgrading. However, there are some roads that

- would continue to be a concern for aquatic resources unless they are eliminated (e.g. high risk roads in subwatersheds with high road densities).
- Roads identified as being a high risk to terrestrial values can often be improved by simply closing the road to vehicular access, since the source of the concern is based around noise and disturbance to wildlife.
  - Done at the watershed scale, this analysis lacks the depth of site-specific data to support making recommendations to close or eliminate roads that were identified as “essential” for District work activities or for public uses. Consequently, recommendations from this watershed-scale analysis do not immediately result in a road network that is commensurate in size with existing road maintenance budgets.
  - As a result, it is assumed that subsequent project level analysis will continue looking for opportunities to reduce the maintenance burden by reducing the size of the road network and reducing maintenance needs wherever practical.
- Recommendations were developed using the following rationale:
    - Retain all high value, multiple purpose roads in the watershed and those roads that provide access to administrative sites.
    - Eliminate roads with limited value to current District management or to public uses.
    - Prioritize for decommissioning those roads that have a high resource impact.
    - At a more site-specific scale, re-evaluate the need and resource impact of roads that provide a single purpose function to the District or for public use, prioritizing roads with a high resource impact for possible decommissioning.
    - For roads that will be retained on the system, prioritize roads with high resource impact for maintenance, possible upgrading, or for special management.
    - Conduct on-the-ground surveys to evaluate site-scale conditions and to prioritize roads for decommissioning, increased maintenance levels, stormproofing or closure.

## Specific Recommendations

- **Retain** those roads in the Administrative Use and Multi Purpose categories.
  - During subsequent project-level analysis, verify that these roads continue to be needed for Administrative purposes or other multiple uses.
  - Roads in these categories that are rated as high impact to aquatic resources should be prioritized for maintenance and upgrading where needed.
  - Roads in these categories that are rated as high impact to terrestrial resources should be examined for possible closure during seasons of greatest impact.
- **Decommission, stormproof and close, or abandon** roads in the Non Essential category.
  - Prioritize for decommissioning those roads that were rated as high impact to aquatic resource values.
  - Make final determinations as to treatment prescriptions after conducting field reviews and evaluating site conditions.
- **Defer** making a final recommendation on roads in the Single Purpose categories until *project-scale analysis and associated fieldwork* can more specifically and accurately confirm the need for these roads and their impacts.
  - Prioritize for examination those roads that were rated as high impact to aquatic and/or terrestrial resources.
  - Where single purpose roads are needed for a single entry, schedule that work early so that these roads can be treated and/or closed.
  - Where work cannot be scheduled in the near future on single purpose roads with high resource impact, stormproof and close those roads until such time as they are needed.

- **Evaluate** results of this watershed-scale assessment during project-level planning.
  - Verify that assumptions were/are accurate in terms of the need for the roads for administrative, multiple, or single purpose uses.
  - Verify that resource assessments reflect on-the-ground conditions.
- **Conduct Field Surveys** of all roads during project-level analysis and/or prior to making final treatment prescriptions.
  - Field surveys must be conducted to *assess actual road conditions* and to ascertain which roads are in the greatest need of treatment.
- Table RA-2 summarizes recommendations by road use class and by resource impact.

Table RA-2. Summary of recommendations: road miles in each road use class and resource impact class.

Road Use Class	High Aquatic	High Terrestrial	High Aquatic and Terrestrial	Low or Mod for Aquatic and Terrestrial	Total Miles	Recommend
Admin	34.6	19.8	30.4	40.6	125.5	Retain
Multi Purpose	36.4	11.8	4.7	59.8	112.7	Retain
Non Essential	2.8	2.1	2.6	41.1	48.6	Decom/Close
SP—Fire	2.7	2.4	0.6	8.7	14.4	Defer/Review
SP—TSI	6.6	2.0	4.1	14.0	26.6	Defer/Review
SP—Timber	0.4	0	0.2	7.3	8.0	Defer/Review
SP—Rec	0	0.4	0	1.3	1.7	Defer/Review
SP—LSR	1.7	1.4	0.5	2.2	5.8	Defer/Review
<b>Total Miles</b>	<b>85.3</b>	<b>40.0</b>	<b>43.2</b>	<b>175.0</b>	<b>343.5</b>	

(SP = Single Purpose)

- Table RA-3 summarizes the recommendations by subwatershed for roads evaluated as high risk to aquatic resources.

Table RA-3. Roads analysis outcomes for roads with high risk to aquatic resources.

Subwatershed	Total Road Miles	Road Miles w/High Risk to Aquatics*	High Risk Roads Available for Decommissioning	High Risk Roads To Be Retained For Access Needs
Bear Creek	12.98	0	0	0
Dry Creek	26.21	0	0	0
Falls Creek	25.46	11.83	0.41	11.42
Lower Wind River	24.16	3.3	0	3.3
Middle Wind River	52.93	21.44	0.41	21.03
Panther Creek	68.72	27.49	2.05	25.44
Trout Creek	72.72	51.03	0.28	50.75
Upper Wind River	57.97	42.41	1.98	40.43
<b>Totals</b>	<b>341.15</b>	<b>157.5</b>	<b>5.13</b>	<b>152.37</b>

# WATER QUALITY RESTORATION PLAN--SUMMARY

## Introduction

This chapter summarizes the water quality restoration plan (WQRP) developed for the Wind River watershed. The plan is required by the Department of Ecology and the Environmental Protection Agency for all streams that have impaired water quality. Because there are several streams exceeding state water quality standards in the Wind River watershed, the WQRP addresses the entire Forest Service portion of the watershed. The WQRP is a stand-alone report, and is summarized here.

## Background

Summer water temperatures in the Wind River and several of its tributaries frequently exceed state water quality standards for maximum water temperature during the summer months. Water temperature concerns in the watershed are documented in some detail elsewhere in this report (Hydrology section), in the initial Wind River Watershed Analysis, and in the full version of the WQRP. In 1998, the Department of Ecology included Bear Creek and Eightmile Creek on its 303(d) list of impaired waterbodies, which brought about the eventual need for a water quality restoration plan.

The WQRP is an analysis focused on identifying sources of heating in streams in the Wind River watershed, and potential restoration treatments to correct water temperature exceedances. This analysis focused on three potential sources of heating that may have been directly caused, or modified by human activities: stream shading, changes in channel form (stream widening), and water withdrawals.

## Findings

### Stream Shading

Stream shading was modeled using vegetation data from the Gifford Pinchot Geographic Information System and channel form data collected during stream surveys. The model assessed current shade levels, and predicted the potential shade levels under conditions of fully mature forest cover in riparian areas. Due to insufficient data, substantial portions of Trout Creek and the Middle Wind River were not modeled in this effort. Table WQRP-1 summarizes the findings of the shade analysis.

Table WQRP-1. Existing shade, potential shade, and current shade loss for subwatersheds in the Wind River watershed.

Subwatershed	Riparian Area Modeled (acres)	Percent of Stream Federally Managed	Flow Contribution (%)	Existing Shade (%)	Potential Shade when trees reach 160 feet (%)	Current Shade Loss (%)
Upper Wind	215	100	14	70	79	9
Falls Creek	94	100	10	63	68	5
Trapper/Dry	167	100	12	76	83	7
Middle Wind	173	69	12	63	78	15
Trout Creek	283	92	15	59	77	18
Panther Creek	276	87	18	69	79	10
Bear Creek	129	92	7	81	84	3
Lower Wind	51	18	12	26	79	50

According to this analysis, current shade levels are lower than the potential shade levels in every subwatershed. The smallest deviation between current and potential shade levels is in the Bear Creek subwatershed, where current shading is just 3% lower than potential shade. In contrast, current shade levels in the Lower Wind River subwatershed are 50% lower than modeled potential shade. In Trout Creek, the stream system with the most significant temperature problem, the model indicates that current shade levels are 18% lower than the potential shade in modeled reaches.

## Channel Widening

Channel form is incorporated into the shade modeling described above. However, changes occurring in channel width over the past few decades were evaluated by examining air photo sequences for that time period. The intent was to identify which channels exhibited widening during the period of the photo record, and to begin assessing the potential causes for visible changes in channel width. Presumably, those channels exhibiting widening as a result of human-caused disturbance would be potential locations for channel restoration. This analysis identified changes in channel width in about 2/3 of the stream reaches examined (Table WQRP-2).

Table WQRP-2. Number of analyzed reaches showing a change in channel width over three analysis periods.

Type of Change	Number of Channel Reaches Showing a Change Over the Identified Period of Analysis		
	1959-1979	1979-1989	1989-1999
No Change	6	6	5
Widened	8	0	9
Narrowed	1	10	1
No Data	1	0	1

Changes in channel width included both widening and narrowing, with widening occurring more often in decades with large floods, and narrowing occurring in the intervening decade. The widening was attributed to a combination of natural processes associated with flooding and landslides in some streams, and to riparian timber harvest and removal of instream woody structure (and subsequent flooding) in others. Streams where human activities were most apparently involved in channel widening included Trout Creek, Lower Eightmile Creek, the mainstem of the upper Wind River, and possibly Dry Creek.

## Water Withdrawals

Department of Ecology records on existing water rights in the watershed were used to assess the potential effect of water withdrawals on water temperatures. In general, this analysis found that the subwatersheds with the greatest potential for temperature increases occurring in response to water withdrawals were in the Bear Creek and Trout Creek systems (Table WQRP-3). Although water withdrawals have actually decreased in Trout Creek over the past decade due to the decommissioning of the Wind River Nursery, withdrawals in Bear Creek have likely remained the same or increased, as Bear Creek represents the municipal water source for the city of Carson. More in depth coverage of the water withdrawal analysis is provided in the Water Uses section of this Watershed Analysis.

Table WQRP-3. Estimated low flow discharge and water withdrawals by subwatershed.

Subwatershed	Mean Monthly Discharge* in cubic feet per second (cfs) September 1935-1977	Minimum Recorded Discharge* 1935-1977 (cfs)	Estimated Consumptive Water Uses for Surface Waters (cfs)	Proportion of Mean Lowflow Stream Discharge Appropriated To Water Uses (%)	Proportion of Minimum Lowflow Stream Discharge Appropriated to Water Uses (%)
Upper Wind	32.8	17.6	0.5	2	3
Falls Creek	22.7	12.2	0	0	0
Dry Creek	28.4	15.2	0.1	<1	1
Middle Wind	28.1	15.1	3.8	14	25
Trout Creek	23.4	12.6	23.5	101**	187**
Panther Creek	43.2	23.2	0.4	1	2
Bear Creek	15.5	8.3	2.032	13	24
Lower Wind	28.4	15.2	12.952	46	85
Watershed	234.5	126.0	43.359	18	34

\* Discharge records are from the USGS stream gauging station located on the Wind River near Carson. Tributary discharges are estimated based on their proportional drainage area within the watershed, except for Trout Creek, which has had its own stream gauge. Trout Creek gauge measurements indicate that discharge in Trout Creek represents approximately 10% of the entire Wind River flow during low flow conditions. Data presented in this analysis do not necessarily define the lowest discharges that occur on these streams. For example, District records indicate that low flows on Trout Creek have reached less than 5 cubic feet per second (cfs) during some late summers, and on Bear Creek have been recorded at less than 2 cfs.

\*\* Water rights in Trout Creek are conditioned with an 8 cfs minimum instream flow requirement, so not all of the flow of Trout Creek can be diverted as suggested in this table.

## Summary of Findings and Recommendations

Analysis of three potential anthropogenic sources contributing to increases in stream temperatures indicate that Trout Creek and the Middle Wind subwatersheds are influenced to some degree by all three sources; reduced shade, increased channel widths, and water withdrawal (Table WQRP-4). Limited shade and particularly wide, shallow channels are probably the largest contributors to the current temperature conditions in those streams. In Bear Creek, shade and channel form both appear to be in relatively good condition, but water withdrawals in the lower portions of Bear Creek may facilitate increased heating in the reach below the City of Carson municipal water intake. Eightmile Creek, the other stream listed as impaired on the 303(d) list, lies in the Panther Creek subwatershed but represents a relatively small portion of that drainage. Hence, conditions in Eightmile Creek are masked in this analysis by the remainder of the Panther Creek drainage. Site-specific analysis of Eightmile Creek indicates that temperatures there are influenced by the wide canopy opening along the lower riparian area of Eightmile Creek that resulted from a debris torrent. The debris torrent was initiated by a landslide that entered the stream from an old timber harvest unit, during the February 1996 flood.

Restoration treatments to diminish the effects of the lack of shade and widened channels will be targeted to the Trout Creek and Middle Wind River subwatersheds since these are subwatersheds that combine the most significant temperature problems with the most apparent anthropogenic sources of heating on streams within the National Forest. Shade restoration projects within Trout Creek, Middle Wind, and Falls Creek will be given highest priority. Channel restoration projects within Trout Creek, Middle Wind, Upper Wind, Panther (including Eightmile Creek) and Dry/Trapper Creek subwatersheds have been identified and will be prioritized for implementation as described in the Fisheries section of this Watershed Analysis. Trout Creek and Bear Creek will be monitored to identify any water withdrawal effects on temperature in those streams.

Table WQRP-4. Sources contributing to increases in stream temperature for each subwatershed in the Wind River Watershed.

Subwatershed	Temperature	Existing Shade	Response Channel Width Changes (1959-1999)	Reaches with Low Flow Width to Depth Ratio Greater than 12	Road Densities Greater than 2 miles per square mile	Percent Water Withdrawals Affecting base flows
Upper Wind	High Temperatures	70%	Widening during decades with Floods No Change	Yes	Yes	<12
Falls Creek	Limited High Temperatures, multiple years	63%	No Change	No data	Yes	<12
Trapper/Dry Creek	Limited High Temperatures, multiple years	76%	Widening during decades with Floods	Yes	No	<12
Middle Wind	High Temperatures, multiple years	63%	No Change	Yes	Yes	14
Trout Creek	High Sustained Temperatures, multiple years	59%	Widening during decades with Floods	Yes	Yes	76
Panther Creek	Cool Temperatures	69%	Widening during one decade with Floods No Change	No	Yes	<12
Bear Creek	Limited High Temperatures, multiple years	81%	No Change	No	No	13

# AQUATICS ASSESSMENT

## HYDROLOGY

### Introduction

An understanding of the hydrology of the watershed is essential for developing proposals for aquatic habitat restoration and for the design of any project that has the potential to affect aquatic resources. The initial Wind River WA (WRWA) described the dominant hydrologic characteristics of the Wind River at the watershed scale. This section of the report begins with a brief characterization of hydrology at the watershed scale, then describes some of the variability in hydrologic character of three major tributaries within the watershed.

### General Characterization

The average annual hydrograph for the Wind River and precipitation hyetograph from data collected at the Carson National Fish Hatchery summarize the general timing and amount of precipitation and runoff in the Wind River watershed (Figure H-1).

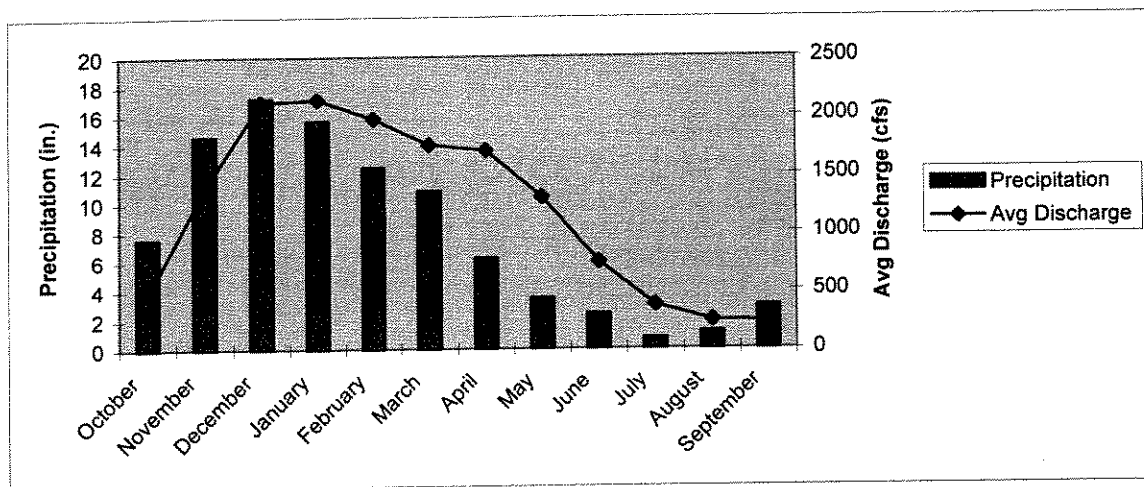


Figure H-1. Average monthly precipitation (from Carson National Fish Hatchery) and discharge on the Wind River near Carson.

Average annual precipitation ranges from less than 60" per year in the southeast portion of the watershed to over 120" per year in the west and northwest. Approximately 75% of the annual precipitation falls between November and March. Because the watershed lies in the western Cascades at elevations ranging from less than 100 feet to nearly 4,000 feet, both rain and snow are common during the winter months. Average daily flows are greatest during the winter months, peaking in January at a mean of 2,168 cubic feet per second (cfs). The largest peak flows similarly occur in winter, often in response to a combination of rainfall and snowmelt during warm, marine-influenced storms. The peak flow of record on the Wind River occurred on February 8, 1996, when discharge reached 53,600 cfs at the U.S. Geological Survey (USGS) gauge near Carson. The USGS estimated the recurrence interval for a flood of this magnitude to be in the neighborhood of 125 years on the Wind River. Summer flows on the river are typically lowest in September, when average daily discharge drops to a mean of 236 cfs.

# Hydrologic Variability Within the Wind River Watershed

Within the Wind River watershed, individual tributaries exhibit their own hydrologic character that results from differences in the amount, timing, or form of precipitation at different locations within the watershed, and differences in the physical characteristics of each subwatershed that affect how precipitation is processed. Some of the important characteristics that may vary by subwatershed and that can affect hydrologic response include: elevation, underlying geology, topographic relief, soils, drainage network planform, and spatial orientation within the watershed.

Availability of concurrent streamflow data from three tributaries to the Wind River allows for some interesting comparisons between these tributaries and the drainages that they are formed in, and offers insights to some of the varied ways that different portions of the Wind River watershed process precipitation. The three tributaries that are described here are Trout Creek, Falls Creek, and Panther Creek. The data used for this analysis is from the 1945 and 1946 water years. These years were selected for analysis simply because there was good overlap of data for the three streams in these years. There is no reason to believe that the general discharge characteristics seen here would not hold for other years.

## Description and Physical Characteristics of Three Subwatersheds

Trout Creek lies on the western edge of the Wind River watershed, while both Falls Creek and Upper Panther Creek enter the Wind from the east (Figure H-2). The Trout Creek and Panther Creek subwatersheds are nearly identical in size, affording an excellent opportunity to compare flows directly between these two, while Falls Creek is somewhat smaller. The three subwatersheds have other physical differences including elevation, orientation, geology, topography and other factors. Some of the differences for which data is available are listed below and quantified in Table H-1.

### Drainage Area:

- Trout Creek and Panther Creek have essentially the same drainage area.
- Falls Creek drains an area approximately 72% as large as Trout or Panther.

### Elevation:

- Falls Creek has the highest base, peak, and average elevation.
- Trout and Panther Creeks have similar average elevations, but Panther drains a much wider range of elevations.

### Precipitation:

- Trout Creek receives an estimated 20% more precipitation annually than either Panther or Falls Creek due to its location on the west side of the watershed.

Table H-1. Physical characteristics of the Trout Creek, Falls Creek, and Panther Creek subwatersheds (as drawn above discharge measurement stations).

Subwatershed	Drainage Area (sq. miles)*	Elevation of Stream Gauge (Feet)	Peak Elev. (Feet)	Average Elevation (Feet)	Average Annual Precipitation (Inches)	% of Land Area in Wet Meadows/Mesic
Trout Creek	30.3	1000	4222	2330	109	2
Panther Creek	30.1	800	4965	2310	92	<1
Falls Creek	21.7	1400	5368	3153	91	3

\*Drainage areas are defined by the location of USGS stream gauge sites, so do not necessarily correspond to 6<sup>th</sup> field subwatershed acreages.

# Wind River Watershed

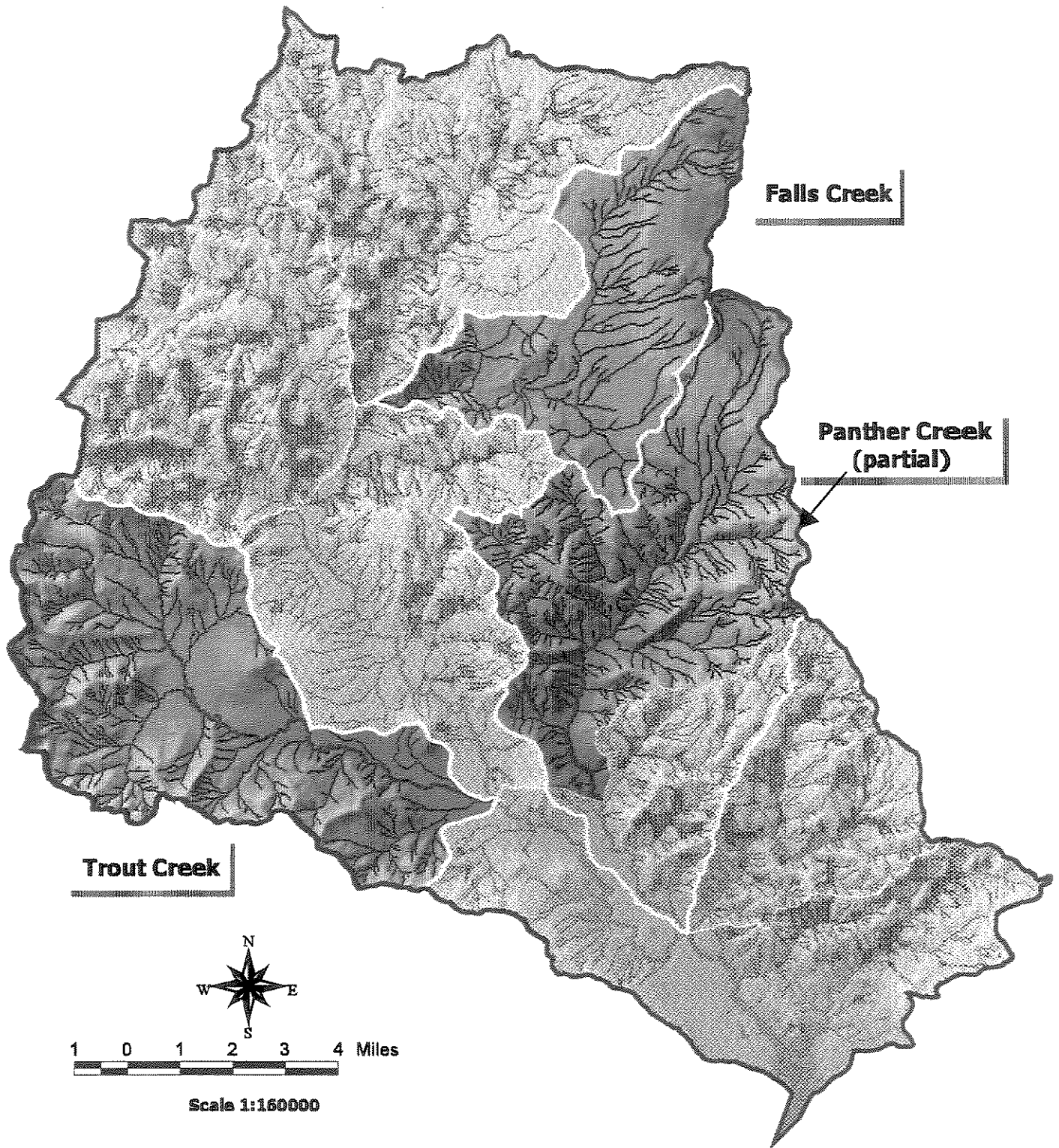


Figure H-2. Trout Creek, Panther Creek, and Falls Creek subwatersheds.

## Annual Discharge and Timing of Streamflows

Annual hydrographs for the 1946 water year are presented in Figure H-3 for each of the three streams. It is important to note that the charts cover the same time period across the horizontal axis, but have different scales on the vertical axis; so while the timing of flows are directly comparable across the charts, the magnitude of the flows are actually exaggerated in the chart for Falls Creek and to a lesser extent in the Panther Creek chart as compared to the Trout Creek chart.

The hydrographs for these three streams are similar in that the largest flows of the year on each stream occur during winter storms, and exhibit fairly steep rising limbs, indicative of rapid response to rainfall and possibly snowmelt driven by rain-on-snow. In addition, the lowest flows of the year on each of these tributaries occur in the late summer months. The Trout Creek and Panther Creek hydrographs are quite similar in form throughout the year, and are nearly identical during the winter months when both show sharp runoff peaks with steep rising and falling limbs. Although the form of the hydrographs continue to be similar during the summer months, actual discharge levels on Panther Creek are maintained at higher levels throughout the summer, compared to Trout Creek.

The Falls Creek hydrograph differs from the Trout Creek and Panther Creek hydrographs in both the form and relative magnitude of runoff peaks. During the winter months, Falls Creek exhibits the same steep rise to peak as seen in the other two streams, but appears to have a slightly more drawn out falling limb during individual storms, and in particular during storms occurring later in the winter. More significant is the magnitude of the winter peaks in Falls Creek, which are just a fraction of the magnitude Trout and Panther Creek peak flows. Although it is expected that the discharge would be lower in Falls Creek due to differences in drainage area and in precipitation, the peak discharge in Falls Creek for the largest storm of the year was just 23% of the size of the same flood in Trout Creek, and 29% of the size of the peak on Panther Creek—significantly lower than would be predicted based on drainage area and precipitation differences.

During spring months, differences in the hydrographs of Falls Creek and the other two streams are even more distinct. While both Trout Creek and Panther Creek show a limited spring snowmelt peak, the spring melt in Falls Creek is pronounced, extending for nearly four months, and reaching a peak of nearly one half the size of the largest winter peak on Falls Creek. For comparison, the spring snowmelt peak in Trout Creek is less than one fifth the size of the annual peak on Trout Creek. In the 1946 water year, nearly half (44%) of the annual discharge in Falls Creek occurred during this spring snowmelt period, from April through July. During the same time period, discharge from Trout Creek and Panther Creek accounted for just 27% and 26% of the annual discharge on those streams.

Over the 1946 water year, Falls Creek had a total water discharge of just 46% of that measured in Trout Creek, and 57% of that measured in Panther Creek. The lower annual discharges in Falls Creek are largely explained by differences in drainage area and precipitation, but may also be a function of other factors present in that subwatershed. Table H-2 summarizes the differences in total annual discharge among the three tributaries, and in discharge per unit of drainage area.

Table H-2. Annual water discharge per unit land area for three subwatersheds.

	Annual Discharge, Water Year 1946	Discharge per Square Mile in 1946
Trout Creek	83,119 cfs	2,743 cfs/square mile
Panther Creek	67,296 cfs	2,236 cfs/square mile
Falls Creek	38,337 cfs	1,767 cfs/square mile

After accounting for drainage area differences, Falls Creek still delivers substantially less flow than do the other drainages over the course of the year. Much of the remaining difference can be attributed to the fact that the Falls Creek subwatershed receives less precipitation. But differences in elevation and geology may also play a role. The Falls Creek subwatershed is at higher elevations than either Trout or Panther Creek,

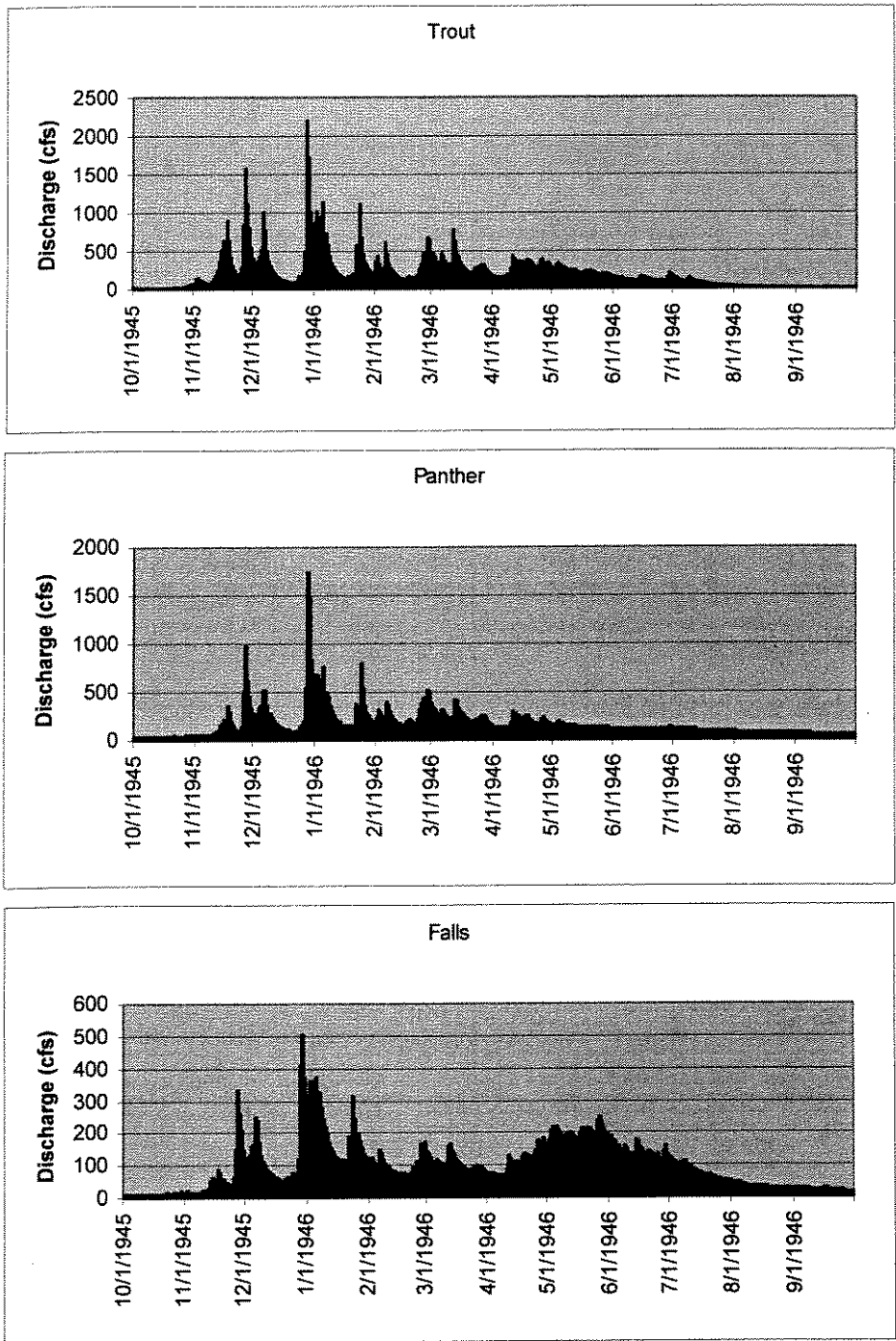


Figure H-3. Hydrographs for the 1946 water year on Trout Creek, Panther Creek, and Falls Creek. (Note that dates shown along the horizontal axes are common among the three figures, but vertical axes have different scales.)

so this subwatershed receives a larger share of its precipitation as snow, and retains a snowpack longer than do the other two subwatersheds. Direct sublimation from the snowpack and evapotranspiration may account for some of the differences in water yield from Falls Creek in comparison with the other two streams where runoff is temporally more closely tied to precipitation. Black Creek swamp, a complex of over 200 acres of wetlands, ponds, and wet meadows in the Falls Creek drainage may also be a source of significant evaporation during the summer months. In addition, the lava tubes, caves, and porous basalts

found throughout the Falls Creek subwatershed, combined with the relatively low density of surface stream channels suggest that subsurface flows may be significant in this drainage—and could contribute to the apparently low levels of discharge per unit of drainage area.

## Summer Low Flows

Discharge levels during summer months are important to aquatic life, both because higher flows provide more habitat, and because lower flows can be more easily heated above the range preferred by fish and other aquatic organisms. One of the significant results of the spring snowmelt that occurs in Falls Creek is the increased discharge levels that occur in Falls Creek and (subsequently) in the Upper Wind River as a result. Throughout the summer months, Falls Creek and Panther Creek both retain higher discharge levels than does Trout Creek. Figure H-4 compares summer discharge levels among the three streams for a six-month period in 1945. The chart spans a period including the last runoff-producing event in the spring through the first significant freshet of fall.

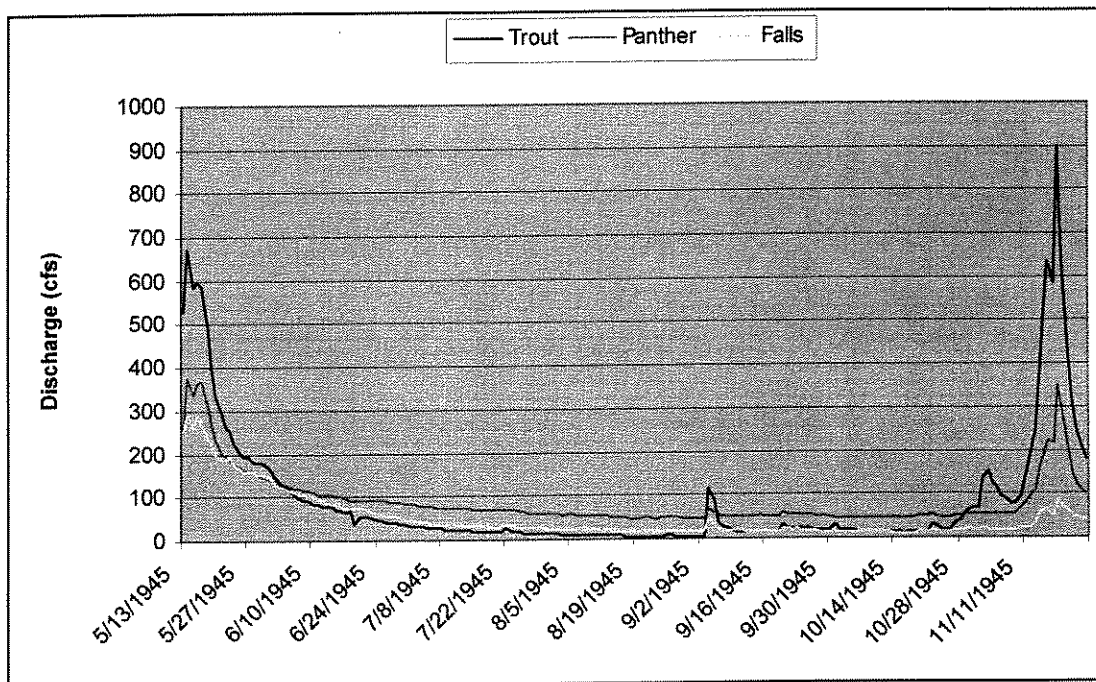


Figure H-4. Summer discharge on Trout, Panther, and Falls Creek, 1945.

From this chart, it is clear that during late spring and early fall, Trout Creek has discharge levels well above both Panther and Falls Creek. But as summer arrives and precipitation declines, discharge from Trout Creek drops much more rapidly and drops to lower levels than both Panther Creek and Falls Creek. By late summer of 1945, discharge on Panther Creek is nearly 10 times greater than that on Trout Creek. Even Falls Creek, which has a drainage area just 72% the size of Trout Creek, has a discharge of 3 times greater than the low flow discharge in Trout Creek.

The average and maximum elevation of both the Falls Creek and Panther Creek subwatersheds is greater than that of Trout Creek. As such, discharge levels in Falls and Panther Creeks are sustained longer into the summer from late season snowmelt occurring at the higher elevations. However, the continued presence of substantial streamflows in both upper Falls Creek and upper Panther Creek well after all snowpacks have been melted suggests that these subwatersheds have significant subsurface storage occurring high in the drainage, or that the geology there is such that water from outside the surface stream drainage boundary is being routed into these subwatersheds.

A number of other factors may also play a role in causing the increased summer flows in Falls and Panther Creek relative to Trout Creek. Lying near the subwatershed divide between Falls Creek and Panther Creek, Black Creek Swamp provides significant storage of water throughout the year, and is a source of discharge to Falls Creek and possibly to Panther Creek as well through the summer. In addition, the three subwatersheds have differences in slope, watershed shape, soil texture and soil depth, all of which can affect the travel routes, and rate of movement of water through a watershed. Slope gradients among these three subwatersheds would certainly appear to favor slower transport of water in the Falls Creek and Panther subwatersheds, due to the more gentle slopes in the upper portions of these drainages.

The importance of the sustained summer low flows in Panther and Falls Creeks becomes apparent when analyzing water temperature maximums across the watershed. With relatively high summer flow levels, Panther Creek also has some of the lowest water temperature maximums of any stream in the Wind River watershed. Similarly, Falls Creek has relatively high summer discharge, and maintains relatively low maximum water temperatures throughout the year. In fact, Falls Creek and Panther Creek have the lowest maximum water temperatures found in any stream of similar drainage area size in the Wind River watershed. The Trout Creek system in contrast, has relatively low summer discharge, and has the highest recorded water temperatures in the Wind River watershed (see Water Temperature section of this report). Clearly there are numerous variables affecting water temperatures in these streams, but discharge is an important factor. The amount of heat required to raise the temperature of water is inversely related to the volume of water in the channel. By sustaining relatively high late summer flow levels, both Falls Creek and Panther Creek remain cool throughout the year, and play important roles in maintaining or reducing water temperatures in the Wind River.

## **Peak Streamflows**

Much of the work done by streams in forming and modifying aquatic habitat and channel conditions occurs during peak flows approximating bankfull discharge. Channel beds are mobilized, sediments are redistributed, woody debris is shifted and transported, and channel banks are subject to scour during these events. Planning for instream restoration, road-related work around active streams, or for other projects that may directly or indirectly impact channels or streamflows all require some accounting for peak flows. An examination of the frequency, timing, and magnitude of peak flows is helpful in understanding processes associated with generating peak flows, and in determining the implications of changes in those processes, or changes in peak flows.

Using the same set of streamflow data for Trout Creek, Panther Creek, and Falls Creek, Figure H-5 shows the stormflow response in these streams to a series of precipitation events that occurred in November and December of 1945. Concurrent records of air temperature and precipitation are presented in Figure H-6 to help characterize the weather surrounding these events. Air temperature and precipitation data were taken at the Wind River Nursery, located at approximately 1,100 feet elevation in the Trout Creek subwatershed. A reconstruction of the meteorologic events provides an avenue for understanding the patterns of discharge seen on the three tributaries.

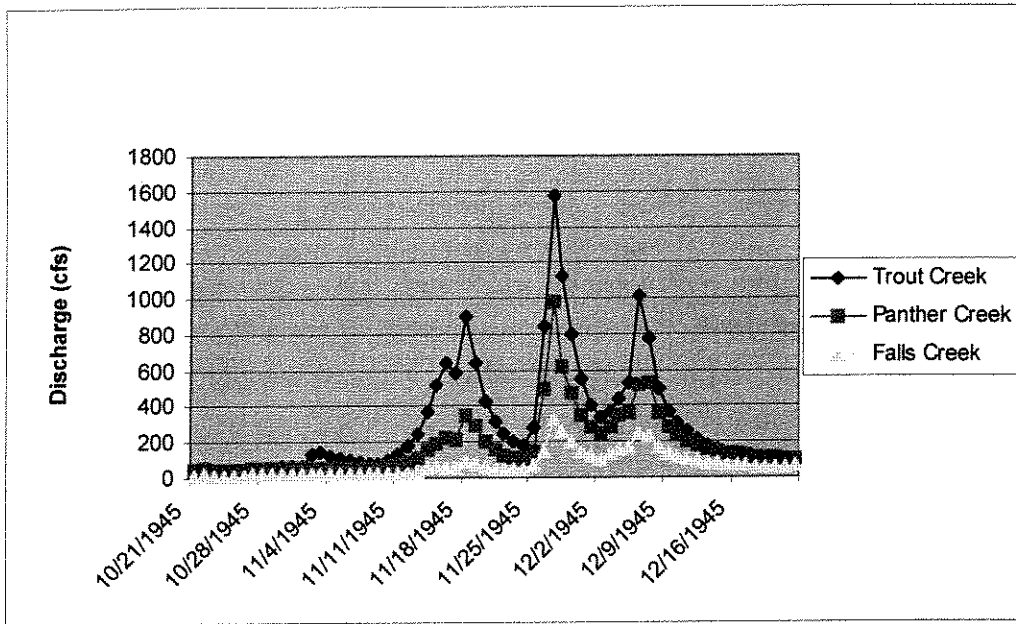


Figure H-5. Comparison of streamflows in Trout Creek, Panther Creek, and Falls Creek in response to a series of precipitation events occurring in November and December, 1945.

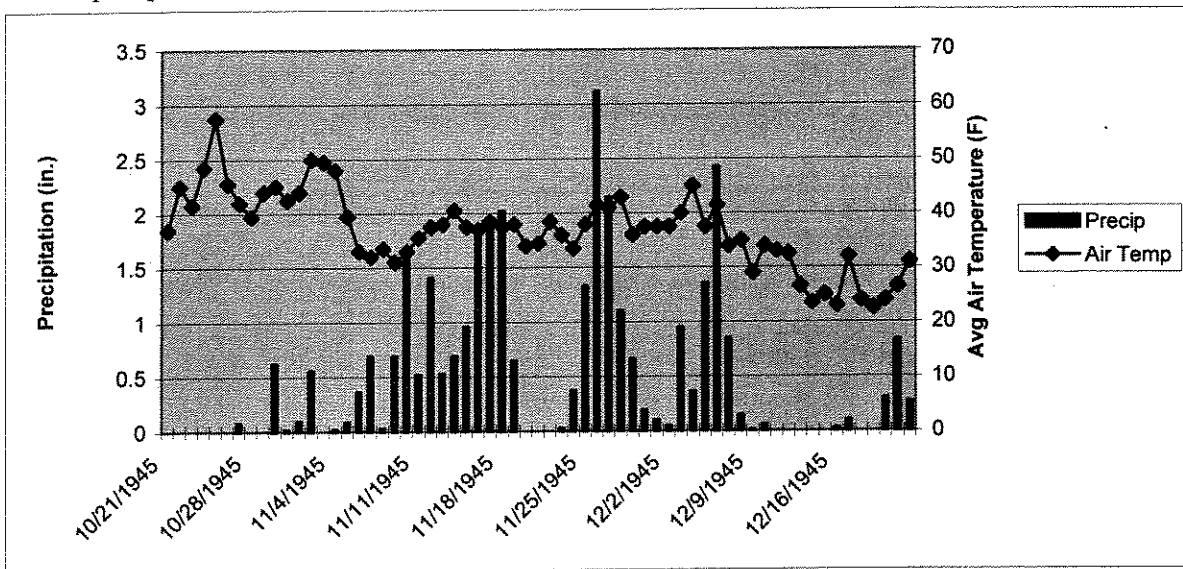


Figure H-6. Air temperature and precipitation at the Wind River nursery during the late fall and winter of 1945.

The first of the three precipitation events began in early November, dropping a total of nearly 14 inches of rain in the lower Trout Creek subwatershed over a period of about two weeks. This was the first precipitation event of any consequence in the 1945-46 water year, so it is assumed that there was no snow on the ground preceding the event.

Prior to this storm, air temperatures had begun dropping as the storm system approached. By the time the precipitation began, air temperatures were beginning to hit the freezing point at the elevation of the nursery in the lower Trout Creek subwatershed. Using a conservative value of 32°F as the breakpoint between what is most likely to be rain and what is most likely to be snow, it appears that precipitation occurring at the beginning of this storm likely fell as snow throughout much of the contributing area of all three

subwatersheds. As the storm continued and air temperatures climbed to 40°F at the nursery, the snow turned to rain at the lower and middle elevations.

During the first storm, the steep rising limb of the stormflow hydrograph on Trout Creek indicates that indeed rain was falling in the watershed. Snow that had fallen at lower elevations during the onset of this storm was likely melted as the storm persisted. At the same time, snow continued to fall at higher elevations that comprise much of the Falls Creek subwatershed and the upper portions of the Panther Creek drainage. The muted runoff response from Panther Creek, and especially from Falls Creek suggest that there was less precipitation occurring on the east side of the watershed, but also that the precipitation occurring at the higher elevations was occurring as snowfall and was accumulating in a snowpack instead of contributing to streamflow.

The second storm in this sequence began just days after the first one had passed. This event was characterized by two pulses of high intensity precipitation occurring over a two-to-three week time period. A total of approximately 15 inches of precipitation was dropped during this period, nearly identical to the total precipitation that occurred in the earlier storm. However, the higher intensity of the precipitation and the fact that air temperatures had by this time increased to a high of 45°F helped drive streamflows to substantially higher levels than the previous event, as rainfall runoff was augmented by increased snowmelt.

During all three events, discharge was greatest on Trout Creek. Over the course of the three runoff peaks, Trout Creek discharge was approximately 4.5 times greater than the discharge of Falls Creek, and 1.7 times greater than Panther Creek. Although Trout Creek drains an area of approximately 1.5 times the size of the Falls Creek drainage, peak discharge on Trout Creek was approximately 10 times greater than the peak of Falls Creek during the first runoff event, and nearly 5 times greater than Falls Creek during the second peak. Although Trout Creek and Panther Creek have drainage areas that are nearly identical in size, runoff peaks on Trout Creek were 2.6 and 1.6 times larger than the corresponding peaks on Panther Creek for the first and second peaks.

The increased total discharge and peak discharge on Trout Creek, and the higher discharge per unit of drainage area on Trout Creek can in large part be attributed to the increased precipitation that occurs on the western side of the Wind River watershed. But differences in stormflow peaks are also due to elevation differences between these drainages, and the effect that has on air temperature and the form of precipitation. The timing and magnitude of discharge levels in Trout Creek are more closely tied to the timing and intensity of precipitation there than is the case in Falls Creek, where a greater proportion of the precipitation occurs as snow.

The end result is that during winter storms, Trout Creek clearly experiences much flashier runoff—particularly in comparison with Falls Creek. From the streamflow records of these three streams, it is apparent that during winter storms, Trout Creek experiences significantly higher discharge than Falls Creek during peak flows, and probably experiences a greater number of significant peak flows during the winter season. As such, channels in Trout Creek are potentially exposed to much higher shear stresses on the channel bed and banks as a result of winter peak flows driven by rainfall and rain-on-snow. Panther Creek appears to experience flows of intermediate size relative to the other two streams.

The differences in winter peak flows between Trout Creek and Falls Creek are in part responsible for the different responses these streams have exhibited to past disturbance. Air photo analysis has shown that while timber harvest occurring in Trout Creek Flats in the 1950's and 60's contributed to extreme widening of those channels, similar (though less extensive) harvest of riparian areas in the low gradient reaches of Falls Creek had relatively little effect on channel geometries there. A number of factors are involved in these different channel responses, but some of the dissimilarity in channel response can be attributed to differences in peak streamflow characteristics of these two tributaries.

# WATER TEMPERATURE

## Introduction

This section updates water temperature conditions across the watershed since the initial WRWA, and provides a summary of the entire record of water temperature monitoring in the watershed. In addition, temperature conditions in Trout Creek and in the mainstem of the Wind River are described in some detail, since these are the two largest water bodies with temperature concerns in the watershed.

## Monitoring History

The Forest Service has measured summer water temperatures since the 1970's at four baseline monitoring stations across the watershed. Since the early 1990's, the Forest Service, U.S. Geological Survey (USGS), and Underwood Conservation District (UCD) established additional monitoring stations to characterize water temperatures in other parts of the watershed. Some 45 locations have been monitored for water temperature in the past five years. Table WT-1 lists all of the locations known to have had temperature monitoring at some time in the past, and Figure WT-1 shows how they are distributed across the watershed.

Maximum water temperatures have exceeded the state water quality standards at some point in time at over half of the stations monitored in the Wind River watershed. Some of the more consistent and substantial exceedances have occurred in the mainstem of Trout Creek and its tributaries, mainstem of the Wind River, and Eightmile Creek. It is noteworthy that even Trapper Creek, a stream draining a subwatershed that is entirely in Wilderness designation upstream of the monitoring location, has exceeded the state standard in 5 of 22 years of monitoring.

Forest Service baseline stations have the longest period of record for water temperature, and have been operated virtually every year since 1977. However, because much of the early data collection was done without the benefit of a quality control/quality assurance plan, confidence in this data is low. Since 1996, the Forest Service monitoring program has been conducted in accordance with an established quality control plan to improve data reliability.

Table WT-1. Summary of temperature monitoring stations in the Wind River watershed.  
(BL) denotes Forest Service baseline monitoring stations.

# on Map	Monitoring Location	Years Monitored	Year of Max Temp	Max Temp (°C)	Agency
14	Bear (BL) above Dam	1977-2000	1983, 1986, 1987	18	USFS
13	Bear Cr at FS boundary	1999-2000	2000	17.9	UCD
19	Cedar Cr at rd 2117	1997-1999	1998	16.9	USGS
38	Compass Cr at mouth	1993,1997-2000	1998	16.3	USFS, USGS
39	Crater Cr mouth	1993,1997-2000	1998	20	USFS, USGS
42	Dry Cr	2000	2000	15.2	USGS
20	Eightmile Cr at mouth	1997-2000	1999	20.7	USGS
21	Eightmile Cr, upper	1997-2000	1998	16.1	USGS
48-49	Falls Cr at mouth	1998-2000	1998	16.1	USFS, USGS
50	Falls Cr North Fork at 2400 elev	1999-2000	2000	11.3	USFS
52	Falls Cr South Fork abv Black Cr Swamp	1999	nd	nd	USFS
51	Falls Cr South Fork bel Black Cr Swamp	1999-2000	2000	17.9	USFS
35	Layout Cr at mouth	1993-1994,1998-2000	1994	19.5	USFS, USGS
36	Layout Cr, upper	1999-2000	2000	14.6	USGS
12	Little Wind R at mouth	1999-2000	2000	19.4	UCD
33	Martha Cr at expt'al forest boundary	1999-2000	1999	17	USGS
32	Martha Cr nursery	1998-1999	1998	21.2	USGS
44-47	Ninemile Cr	2000	2000	13.7	USGS
17	Panther Cr (BL) below rd 65 bridge	1996-2000	1998	12.4	USFS
18	Panther Cr at rd 6513	1999-2000	2000	9.4	USGS
15-16	Panther Cr near Old State Rd	1997,1999-2000	2000	14.3	USGS
53	Paradise Cr above rd 30 bridge	1993, 1996, 1997, 2000	1996	15.8	USFS, USGS
54	Pete's Gulch Cr at mouth	1999	1999	14.1	USFS
34	Planting Cr at mouth	1997-1999	1998	19.2	USGS
41	Trapper Cr (BL) above bridge	1977-1984, 1986-1997, 1999-2000	1981, 1986	18	USFS, USGS
40	Trapper Cr at mouth	1999-2000	2000	15.8	UCD
24	Trout Cr (BL) above Hemlock Lake	1977-1993, 1995-1997, 1999-2000	1990, 1992	25	USFS, USGS
31	Trout Cr abv Crater Cr	1997-1998	1998	8.5	UCD
22	Trout Cr at mouth	1999-2000	2000	21	UCD
30	Trout Cr at rd 33 bridge	1993, 1997-2000	1998	10.7	USFS, USGS
25	Trout Cr at rd 43 bridge	1993-1994, 1996-2000	1994	19.5	USFS, USGS
29	Trout Cr below Compass Cr	1993	1993	22	USFS
23	Trout Cr below Hemlock Dam	1999-2000	2000	22.6	USGS
26	Trout Cr below Layout Cr	1997	1997	18.5	USFS
37	Trout Cr East Fork	1999-2000	2000	19.2	USGS
27	Trout Cr Lower Old Growth	1999-2000	1999	16.1	USGS
28	Trout Cr Upper Old Growth	1998-2000	1998	15.9	USGS
3-4	Wind R (BL) at rd 3065 bridge	1978-2000	1980	23	USFS, USGS
11	Wind R (hw) above Pete's Gulch	1998-2000	1998	16.5	USFS
6-7	Wind R above Falls Cr	1993,1999-2000	1999	16.6	USFS, USGS
9-10	Wind R above Paradise Cr	1993, 1995-1997, 1999	1995	17.5	USFS
1	Wind R at base	1999-2000	2000	17.5	UCD
2	Wind R at Stabler br	1999-2000	2000	17.5	UCD
5	Wind R below Falls Cr	1999-2000	2000	15.6	UCD
8	Wind R below Paradise Cr	1999-2000	2000	17.1	USFS

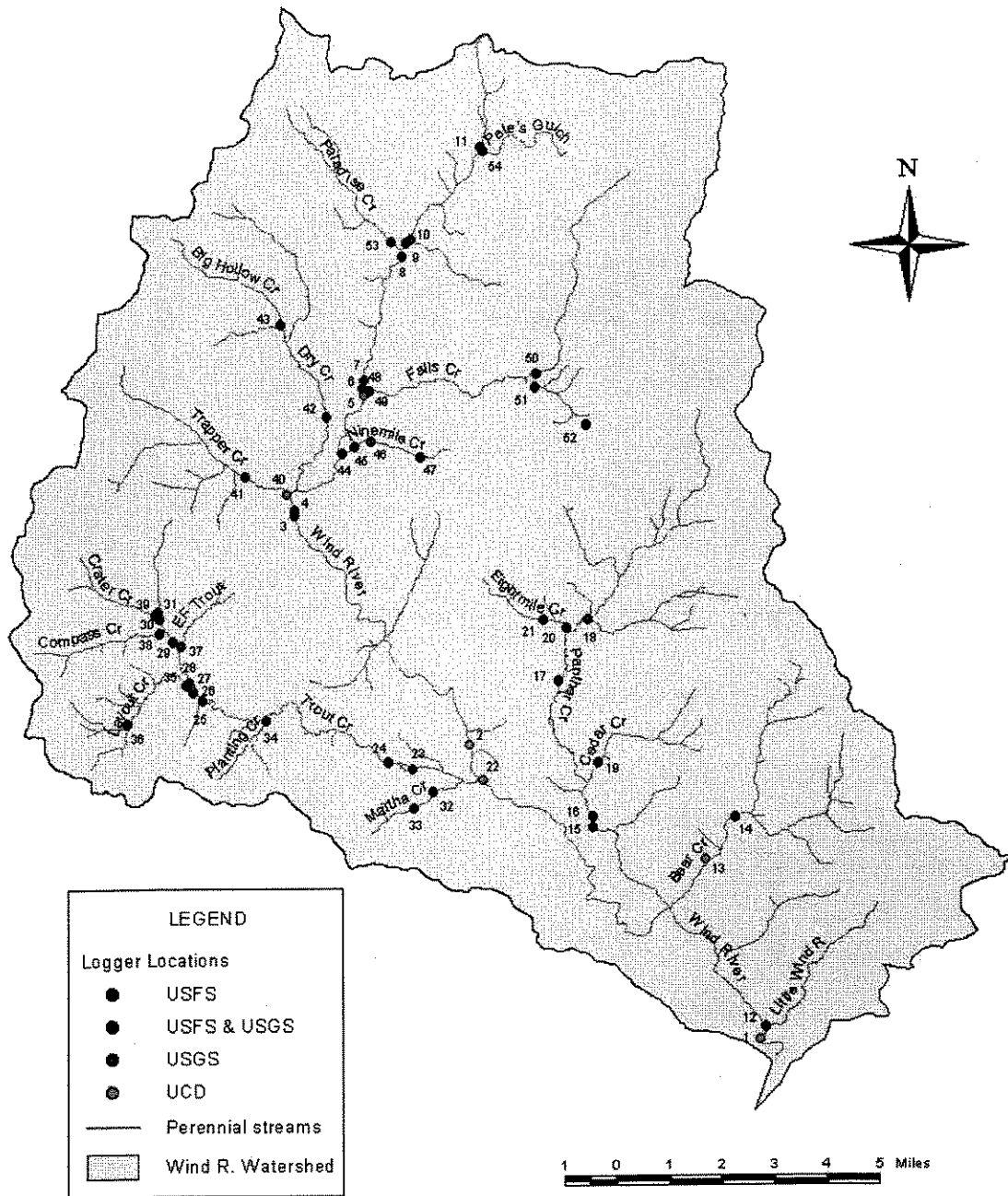


Figure WT-1. Water temperature monitoring stations in the Wind River watershed, and agencies involved in data collection.

## Results of Recent Monitoring

Over the past five years, three of five baseline monitoring stations exceeded the state standard for water temperature. Trout Creek exceeded the standard in each of the five years, reaching a maximum temperature of 23.2°C in 1998 (Figure WT-2). The Wind River and Bear Creek also exceeded the standard in 1998, reaching 17.8°C and 17.1°C respectively. Although Trapper Creek showed no exceedances over the four years of monitoring there, no data was collected at the Trapper Creek baseline station in 1998 (the warmest of the five years) due to instrument malfunction. Based on its temperature relationship with the other stations in other years, it appears that Trapper Creek would have been very near, if not over the standard in 1998. Panther Creek remained below the standard throughout this five-year period, reaching a maximum of 12.4°C in 1998.

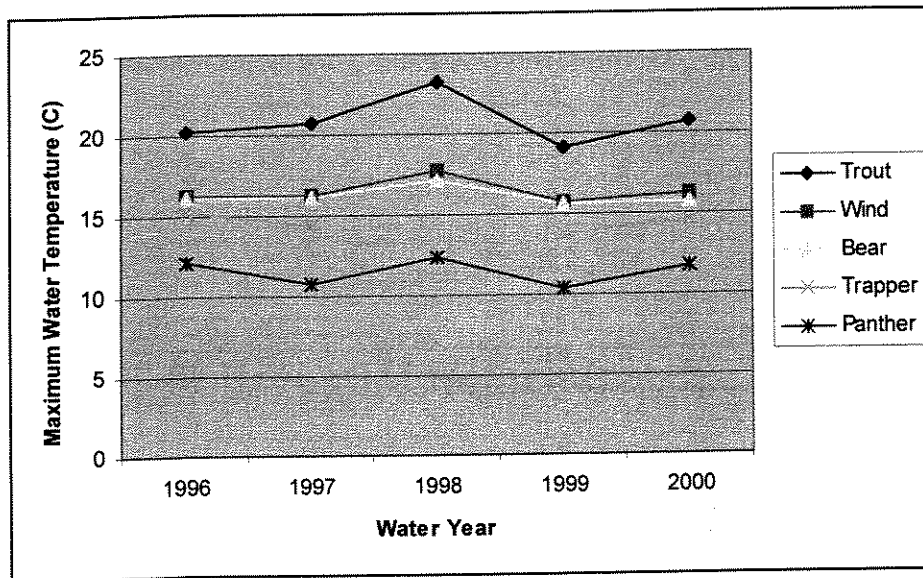


Figure WT-2. Maximum water temperatures at Forest Service baseline monitoring stations in the Wind River, 1996-2000.

With the exceptions of Falls Creek and Dry Creek, the baseline stations characterize water temperatures for each of the major tributary subwatersheds within the Wind River watershed. The baseline stations do not necessarily represent the warmest point on the streams they measure. They were established years ago with the intent of measuring the temperature of streams near where they leave a subwatershed, or where they leave the National Forest. As such, they were generally located either near the mouth of the stream they measure, or just upstream of the Forest Service boundary on those streams. Trapper Creek is the exception to this rule, being located upstream of the houses on Trapper Creek in an attempt to characterize water temperatures in an undisturbed subwatershed. Table WT-2 describes in narrative the location of these baseline stations.

Table WT-2. Location of the five Forest Service baseline monitoring stations in the Wind River watershed.

Monitoring Station	Location
Trout Creek	Immediately upstream of Hemlock Lake
Wind River	Approx .5 miles upstream of Carson National Fish Hatchery
Bear Creek	Immediately upstream of Carson's water diversion dam; (approx. 1.2 miles upstream of Forest Service boundary)
Trapper Creek	Immediately upstream of Government Mineral Springs houses
Panther Creek	Approximately 2 miles upstream of Forest Service boundary

Table WT-3 identifies the maximum water temperature reached on each stream monitored in the watershed over the past five years. The Trout Creek system clearly has the highest and most consistently high

Table WT-3. Maximum water temperatures at monitoring stations in the Wind River watershed, 1996-2000.

Monitoring Location	1996	1997	1998	1999	2000
Bear (BL) above Dam	16.1	16.1	17.1	15.6	15.8
Bear Cr at FS boundary				16.8	17.9
Cedar Cr at rd 2119		15.8	16.9	15.6	
Compass Cr at mouth		14.9	16.3	14.0	14.9
Crater Cr mouth		18.3	20.0	17.4	18.4
Dry Cr					15.2
Eightmile Cr, upper		15.3	16.1	14.9	15.3
Eightmile Cr at mouth		18.4	18.6	20.7	18.4
Falls Cr North Fork at 2400 elev				10.0	11.3
Falls Cr South Fork below Black Cr Swamp				17.0	17.9
Falls Cr at mouth			16.1	13.5	15.1
Layout Cr, upper			19.6	14.0	14.6
Layout Cr at mouth				17.4	14.6
Little Wind R at mouth				16.3	19.4
Martha Cr at experimental forest boundary				17.0	16.7
Martha Cr nursery			21.2	18.7	-
Ninemile Cr					13.7
Panther Cr near Old State Rd		13.9		13.5	14.3
Panther Cr at rd 6513				9.1	9.4
Panther Cr (BL) below rd 65 bridge	12.1	10.7	12.4	10.2	11.7
Paradise Cr above rd 30	15.8	15.6			15.7
Pete's Gulch Cr at mouth				14.1	
Planting Cr at mouth		18.7	19.2	19.0	
Trapper Cr (BL) above bridge	15.3	14.4		13.7	14.6
Trapper Cr at mouth				14.5	15.8
Trout Cr abv Crater Cr		8.3	8.5		
Trout Cr East Fork				19.0	19.2
Trout Cr at rd 33 bridge		10.1	10.7	9.0	10.6
Trout Cr below Layout Cr		18.5			
Trout Cr Upper Old Growth			15.9	13.5	14.4
Trout Cr Lower Old Growth				16.1	15.8
Trout Cr at rd 43 bridge	17.8	17.8	18.6	15.7	16.7
Trout Cr (BL) above Hemlock Lake	20.2	20.8	23.2	19.1	20.8
Trout Cr below Hemlock Dam				20.3	22.6
Trout Cr at mouth				18.2	21.0
Wind R (hw) above Pete's Gulch			16.5	14.9	14.9
Wind R above Falls Cr				16.6	16.3
Wind R below Falls Cr				14.1	15.6
Wind R above Paradise Cr	16.3	16.8		15.6	17.1*
Wind R below Paradise Cr				15.6	17.1
Wind R (BL) at rd 3065 bridge	16.3	16.3	17.8	15.8	16.3*
Wind R at Stabler br				16.4	17.5
Wind R at base				16.0	17.5

blue = Data source USFS  
purple = Data source USGS  
green = Data source UCD

temperatures of any major tributary to the Wind River. Outside of the Trout Creek drainage, the highest recorded water temperatures are in Eightmile Creek. Although Eightmile Creek has reached temperatures as high as 20.7°C, this stream drains a much smaller area than does Trout Creek, and it empties into Panther creek, a stream that to date has not shown any problems with excessively high temperatures. Moreover, the cause of the high temperatures in Eightmile Creek appear to relate in large part to the widening of the channel and riparian canopy opening that occurred in response to a major landslide in 1996. The situation in Trout Creek is much more pervasive, owing in large part to the poor channel conditions throughout much of the Trout Creek Flats.

Some of the *lowest* maximum water temperatures are also found in the Trout Creek subwatershed, in Upper Trout Creek, upstream of the confluence with Crater Creek. These stations are identified in Table WT-3 as “Trout Creek above Crater Creek” and “Trout Creek at the 33 Rd Bridge”. In four years of monitoring, maximum temperatures at these two locations have not exceeded 11.0°C. Other streams in the watershed with particularly *low* maximum water temperatures include Upper Falls Creek (“Falls Creek North Fork”), which reached a maximum of 11.3°C in two years of monitoring, and Panther Creek (at both the “Panther Creek at 6513 Rd” and “Panther Creek Baseline” stations), where a maximum temperature of 12.4°C was recorded in five years of monitoring.

It is noteworthy that although Panther Creek has some of the lowest maximum water temperatures in the watershed, the baseline monitoring station there is located just downstream of the mouth of Eightmile Creek, which has recorded some of the highest temperatures in the watershed. The difference in maximum temperature between the Panther Creek Baseline station and the Panther Creek at the 6513 Rd Bridge is due in part to the influence of the warm waters of Eightmile Creek, which enter Panther Creek between these two stations. In two years of concurrent monitoring of Panther Creek and Eightmile Creek, maximum temperatures in Eightmile Creek have been 11.6°C and 9.0°C greater than at the Panther Creek at 6513 Rd Bridge station. But water temperatures in Panther Creek have only increased by 1.1°C and 2.3°C in the reach that includes the mouth of Eightmile Creek in those two years. This illustrates the relatively minor contribution of discharge from Eightmile Creek during the summer months relative to the substantial flows that are maintained in Panther Creek.

## Temperature Conditions in Trout Creek

The highest measured water temperatures in the Wind River watershed occur in the Trout Creek system. In water temperature monitoring conducted since 1977 at the Trout Creek baseline station above Hemlock Lake, water temperatures have exceeded the state standard for temperature (16°C) in 22 of 23 years (Figure WT-3). Maximum water temperatures at that station have been recorded as high as 25°C (77°F) in late summer months, and have remained above state standards for as many as 75 days in a single summer.

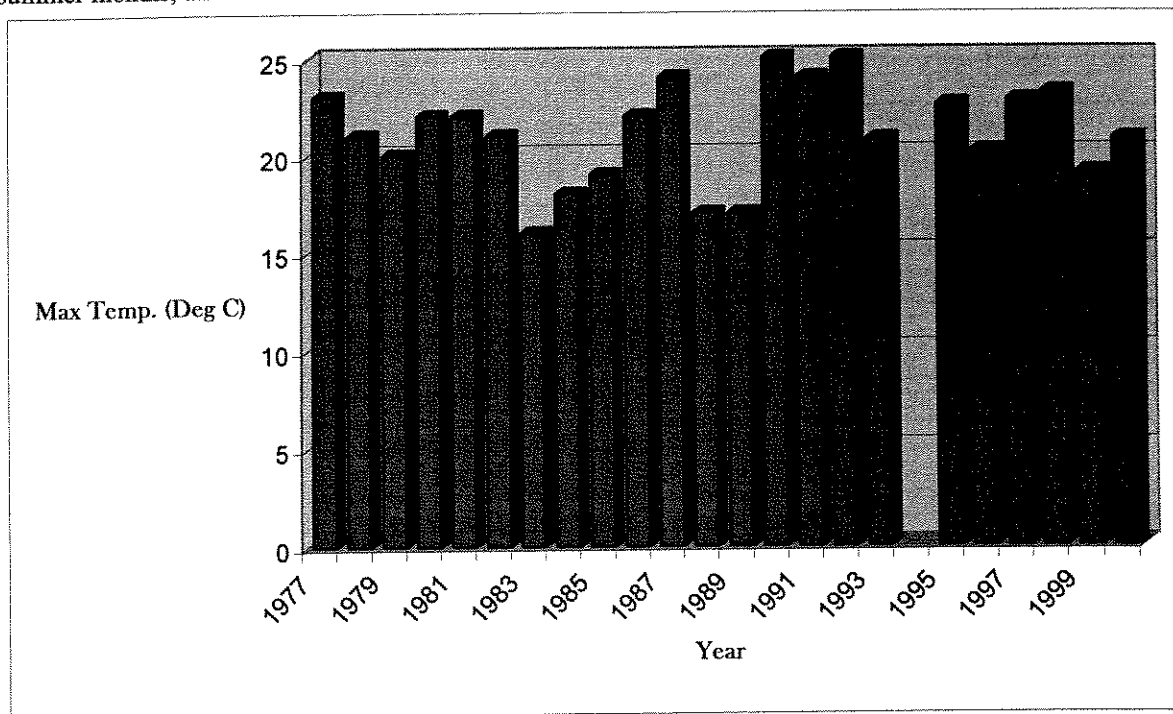


Figure WT-3. Maximum water temperatures in Trout Creek at the baseline station located upstream of Hemlock Lake (1977-2000).

Causes of high water temperatures in Trout Creek include: 1) wide, shallow, and poorly shaded channels in the upper watershed (Trout Creek Flats) caused in part by past logging of riparian areas and stream cleanouts of large woody debris; 2) large areas of shallow, slow moving or still water in the Trout Creek Flats area, created by natural ponds, wetlands and beaver impoundments; 3) warm water inputs from tributaries which were logged, and/or burned, and cleaned out of woody debris; 4) heating in the mainstem of Trout Creek below the Flats; and 5) heating occurring in Hemlock Lake, a reservoir formed behind the Hemlock Dam (heating occurring in Hemlock Lake would not affect the temperatures at the baseline station described above because the Lake is downstream of this monitoring station).

Figure WT-4 illustrates how water temperatures in the mainstem of Trout Creek change in a downstream direction. The data point at the left of the chart is from the monitoring station on Trout Creek just below Crater Creek (see Figure WT-1). This station is located near the upper end of the Trout Creek Flats. Moving to the right in the chart, the second data point is from the monitoring station located near the Road 4300 bridge, just downstream of the mouth of Layout Creek, which lies at the downstream end of the Trout Creek Flats. Between these two monitoring stations, water temperatures were increased by 6.1°C during the summer of 2000. This is the area of greatest heating in the mainstem. Heating in this reach occurs as a result of the channel conditions and large areas of exposed surface water in the Trout Creek Flats (items 1, 2, and 3 from the previous paragraph).

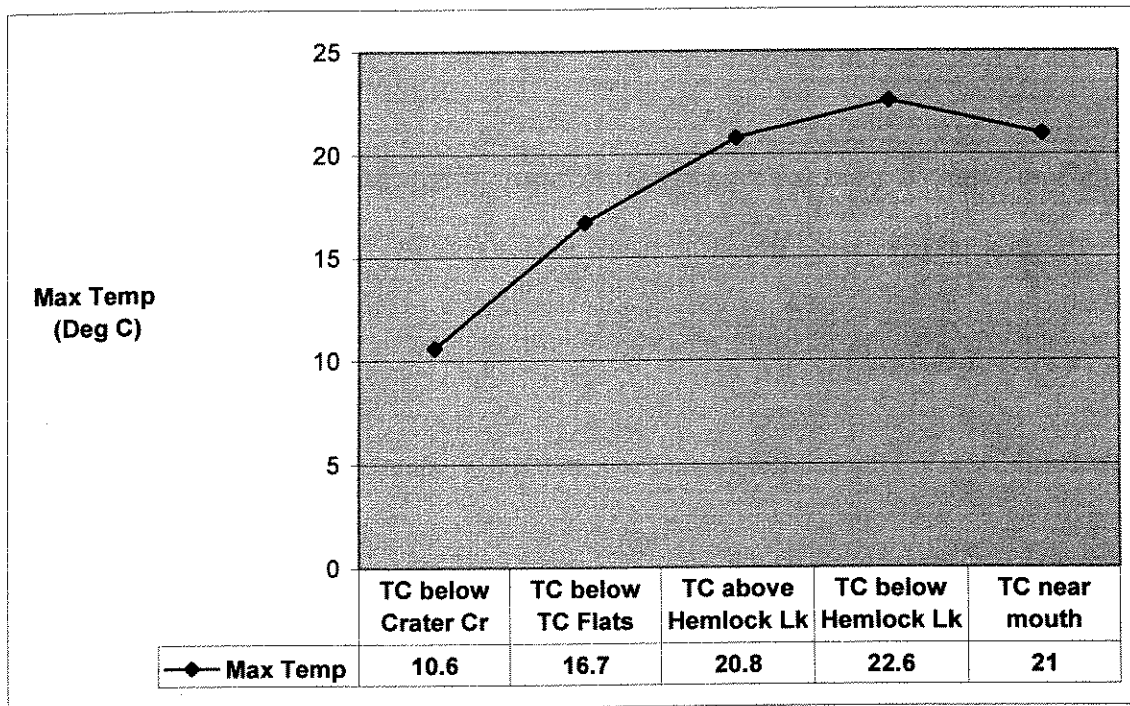


Figure WT-4. Maximum water temperatures at five locations on Trout Creek (TC). Data points are organized in a downstream direction from left to right. (Data from year 2000.)

In the second reach, from below the Trout Creek Flats to the monitoring station located just upstream of Hemlock Lake, water temperatures were increased by 4.1°C during this monitoring year. The amount of heating in this reach was somewhat unexpected, in that much of the reach is bounded by mature forest cover, and because the channel through this reach is relatively high gradient, largely bedrock and boulder controlled, and lies in an incised canyon. Part of the increase in temperature in this reach is attributable to warm water inputs from tributaries including Planting Creek, a small stream that has its source in a large pond, wetland complex. But additional heating appears to occur from direct inputs of solar radiation, and the transfer of absorbed heat from sun-warmed basalt bedrock and boulders in this reach.

The third reach is the reach that begins just upstream of Hemlock Lake and ends just below Hemlock Dam. Water temperatures were increased in this reach by 1.8°C in the summer of 2000. This increase is almost entirely attributable to heating occurring in the lake. Hemlock Lake is a wide, shallow, slow moving, and poorly shaded body of water. The temperature increase seen in this reach is relatively small in comparison with increases measured upstream on Trout Creek. The relatively small magnitude of the temperature increase in the lake occurs in part because water temperatures are at this point approaching ambient air temperatures. In the absence of significant heating upstream (i.e. if incoming water to the lake were at lower temperatures), it may be that temperature increases in the lake would be greater.

Within Hemlock Lake, temperatures vary with lake depth and location relative to the active channel flow. During a single day of spot monitoring in the lake, water temperatures from various locations in the lake differed by at most 3.0°C. Warmer temperatures were recorded in shallow areas of the lake and along the northern edge of the lake. The coolest temperatures were along the southern edge, and in the area just above the dam. Immediately below the dam, temperatures matched those measured in the pool just above the dam.

Below Hemlock Dam, Trout Creek again becomes a steep, bedrock and boulder controlled channel. The fourth reach shown in Figure WT-4 depicts temperatures at the station just below the dam, and those measured near the mouth of Trout Creek, approximately 1.5 miles downstream of the dam. Water temperatures in this reach actually decreased by 1.6°C during the summer of 2000.

The trend in maximum water temperatures shown in Figure WT-4 suggests that the majority of the heating of Trout Creek occurs in the Trout Creek Flats. However, an examination of the persistence of the high temperatures provides another perspective on the heating. Figure WT-5 shows the number of days water temperatures exceeded 16°C in Trout Creek at the same monitoring stations shown above in Figure WT-4.

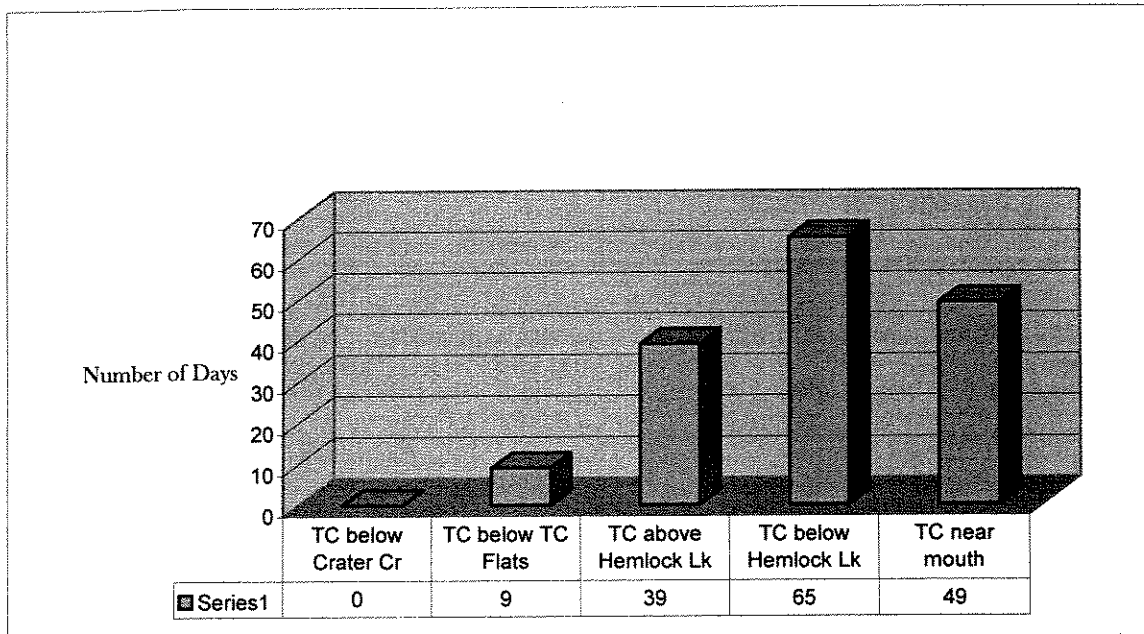


Figure WT-5. Number of days water temperature exceeded 16°C at five locations on Trout Creek (TC). Data are organized in a downstream direction going from left to right. (Data is from year 2000 monitoring.)

Figure WT-5 shows that although maximum water temperatures are most affected in the Trout Creek Flats, the increase in duration of temperatures in excess of the state standard is greatest in the reach below the Flats, followed closely by the reach including Hemlock Lake. For the year 2000, water temperatures exceeded 16°C on just 9 days in Trout Creek below the Trout Creek Flats, but for 65 days in the reach

including Hemlock Lake. Comparing data from the monitoring station just upstream of Hemlock Lake with the station located below Hemlock Dam, it appears that the reach including the Lake is responsible for nearly an additional month of exceedances of the state water temperature standard.

Although data were not available to analyze daily fluctuations in water temperature at these stations for the year 2000, examination of data from past years suggests that the diurnal fluctuation in water temperatures is greatest in the Trout Creek Flats reach during summer peak temperatures, but relatively small in the reach above the Flats, and in the reach above Hemlock Lake. Table WT-4 presents water temperatures at three stations on Trout Creek for the warmest day of the 1997 summer.

Table WT-4. Maximum and minimum water temperatures on August 6, 1997 (warmest day of the year for water temperatures) at three stations on Trout Creek.

Station	Min. Temp (C)	Max. Temp (C)	Difference
Trout Creek below Crater Cr.	7.5	10.1	2.6
Trout Creek below TC Flats	11.1	17.8	6.7
Trout Creek above Hemlock Lk	17.6	20.8	3.2

The large diurnal temperature fluctuations in the Trout Creek Flats are due to the fact that channels in this area are wide, shallow, and unprotected by a forest canopy. They are easily heated by daytime insolation, and lose heat at night to an open sky. The smaller fluctuation in water temperatures in the reach above the Flats results from a combination of factors: relatively constant temperature of the source waters; channel configurations that offer less stream surface area to absorb solar radiation and emit heat; and increased canopy cover reducing heat losses at night.

The relatively small diurnal swing in temperatures seen in the reach below Trout Creek Flats and above Hemlock Lake may be a result of a number of factors. Importantly, this reach has more water than any upstream reaches, so water temperatures are less prone to large diurnal temperature swings. But in addition, this reach has significantly different channel geometries than those found in the Flats, it has greater canopy protection, and the dark basalt bedrock and boulders through this reach may be largely responsible for continuing to deliver heat to the stream during the evening and night hours after absorbing heat throughout the day. Because this analysis is based on a relatively limited data set, additional analysis of these conditions is merited once more temperature data becomes available.

## Temperature Conditions in the Wind River

Water temperatures at the baseline monitoring station on the Wind River (located downstream of the mouth of Trapper Creek) have exceeded state standards for water temperature on at least 15 of the 22 years of monitoring. Although maximum temperatures on the Wind River do not reach the levels found on Trout Creek, the temperature standard has been exceeded for as many as 50 days in a single year (1992) at this station.

The maximum temperature reached in the last decade at this station was 21°C, which occurred in 1992. Average maximum yearly temperature during the decade was just 17.4°C. The baseline monitoring station on the Wind River is located approximately 20 miles upstream from the mouth of the River, just downstream of the mouth of Trapper Creek. Water temperatures on the Wind River change over the course of the 31-mile long river in response to heating or cooling of the mainstem, and from heating or cooling effects of tributaries that enter the Wind along its course.

The headwaters of the Wind River originate in McClellan Meadows and from a large number of springs and seeps in the gently sloping ground that forms a saddle between the Wind River watershed and the Lewis River watershed to the north. The large open expanse of McClellan Meadows is probably what allows water temperatures to increase even at the uppermost levels of the watershed. Although limited monitoring has been done on the Wind River above its confluence with Pete's Gulch, the temperature standard was exceeded in one of three years of monitoring at that site, which is just 2.5 miles from its source at McClellan Meadows (Table WT-5).

Table WT-5. Maximum water temperature and number of days temperatures have exceeded 16°C at the monitoring station on the Wind River above Pete’s Gulch.

Monitoring Year	Maximum Water Temperature (°C)	Number of Days Temperature Exceeds 16°C
1998	16.5	19
1999	14.9	0
2000	14.9	0

From headwaters to mouth, the Wind River measures over 30 miles in length. From the uppermost monitoring station (Wind River above Pete’s Gulch) to the lowermost monitoring station (Wind River near the mouth of the Wind River) there is a general increase in maximum water temperatures. But over two years of monitoring, the total increase in temperature in this length of channel averaged just 1.7°C. Figure WT-6 illustrates how water temperatures change along the course of the Wind River. The figure reflects data from both the 1999 and 2000 monitoring years.

The uppermost reach shown in Figure WT-6 is the reach beginning on the Wind River above Pete’s Gulch, and ending on the Wind River above Paradise Creek. In both years of monitoring, water temperatures increased in this reach. The increase ranged from 0.4°C in 1999 to 2.2°C in 2000. Potential sources of this increase include inputs from tributaries including Pete’s Gulch, Oldman Creek, and Youngman Creek, and warming occurring in the mainstem itself. From limited monitoring of Pete’s Gulch, it appears that this stream runs cooler than the Wind River, so is probably not the source of the heating. No data is available from Youngman or Oldman Creek.

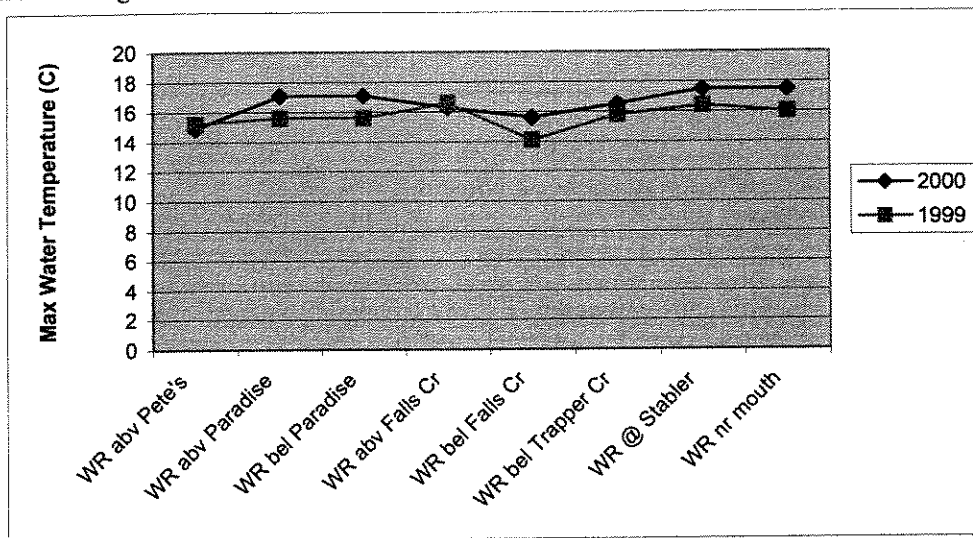


Figure WT-6. Maximum water temperatures at monitoring stations along the Wind River (WR), years 1999 and 2000. Data are arranged in a downstream direction from left to right.

Moving downstream, the second reach brackets the mouth of Paradise Creek. Through this reach, there is no change in temperature in either year of monitoring, even though Paradise Creek enters the Wind River here, and generally is 1-2°C cooler than the Wind River.

The next reach extends from below the mouth of Paradise Creek to just upstream of the mouth of Falls Creek. This includes the reach that has been referred to as the “mining reach”. Through this reach, the Wind River is broad and shallow, and in many cases braided. There are no significant tributaries entering

the river in this reach. Water temperatures increased through the reach in 1999, but decreased in 2000. Preliminary results from 2001 monitoring suggest that temperatures slightly increase through the reach. Temperature trends in this reach are clearly not consistent from year-to-year, and the reasons for that variability appear quite complex. Although there is substantial opportunity for heating in the broad shallow channels of this reach, there are also opportunities for cooling of the river from hyporheic inputs and from flow in shaded side channels. Further confounding the picture for these two years, substantial instream and riparian restoration work was being conducted on this reach of the Wind River during the summers of 1999 and 2000. Although one of the long-term objectives of this work was to reduce stream temperatures, it is not known how the actual implementation of the work may have temporarily affected water temperatures due to short-term changes in flow pathways.

One plausible explanation for the difference in temperature trends over the past three years in this reach is that as the active channels in this reach shift from year-to-year, side channels can become more or less significant in terms of the proportion of summer flow they carry. When more of the summer flow happens to occur in shaded side channels, this reach may be more apt to show a decrease in temperature, and conversely on years when more of the flow is out in the open exposed channels, the reach may show increases. Continued temperature monitoring and further analysis may help clarify which processes are dominant in this reach.

The next reach downstream is the reach that brackets the mouth of Falls Creek. In both years of monitoring, water temperatures in the Wind River have decreased in this reach. The change in temperature was 2.5°C in 1999 and 0.7°C in 2000 (Table WT-6). Falls Creek, which averaged 2.2°C cooler than the Wind River in these two years, is clearly responsible for helping maintain or cool temperatures in the Wind River.

Table WT-6. Maximum water temperatures on the Wind River above and below Falls Creek, and on Falls Creek near the mouth during the summers of 1999 and 2000.

Monitoring Year	Wind River above Falls Creek	Falls Creek	Wind River below Falls Creek	Change in Temperature in the Wind River
1999	16.6°C	13.5°C	14.1°C	-2.5°C
2000	16.3°C	15.1°C	15.6°C	-0.7°C

Continuing downstream, the next reach extends from below Falls Creek to below Trapper Creek. The Wind River through this reach flows largely through bedrock walls until it meets Dry Creek. Water temperatures increased in this reach in both years of monitoring. The increases ranged from 1.7°C in 1999, to 0.6°C in 2000. In this reach, major tributaries entering the Wind River include Ninemile Creek, Dry Creek, and Trapper Creek. Maximum summer temperatures on Trapper Creek near the mouth of Trapper approximate those in the Wind River, so Trapper is not seen as a source of either warming or cooling to the Wind River. Little is known about the temperature of Dry Creek or Ninemile Creek where they enter the Wind River, but both of these streams are known to flow subterranean for some portion of their length, suggesting that temperatures may be cooled in those reaches.

The next reach downstream is the reach that begins just below the mouth of Trapper Creek, and continues down to the town of Stabler (upstream of the confluence with Trout Creek). The majority of this reach is below the National Forest boundary. The upper portions of this reach are alluvial, with many segments having significant exposure to solar radiation. Nevertheless, water temperatures through the reach increase by just 0.6°C and 1.2°C in 1999 and 2000 respectively. Although additional temperature increases might be predicted to occur in this reach due to insolation, there may be offsetting cooling occurring through hyporheic inputs. In addition, there are a number of small tributaries that enter the Wind River through this reach that may provide cool water. The largest of these are Cold Creek and Hollis Creek.

The lowermost reach shown in Figure WT-6 begins on the Wind River at Stabler and extends all the way to near the mouth of the river (below the confluence with the Little Wind River). This is by far the longest reach, and yet temperatures through this reach actually decreased by 0.4°C in 1999 and showed no change

in 2000. This reach is characterized by a bedrock and boulder controlled channel, which for the most part lies at the bottom of a deep canyon. There are three major tributaries, and a number of minor tributaries entering the Wind in this reach. Panther Creek, the largest of the tributaries, had maximum temperatures of 2.5°C and 1.3°C less than the Wind River at Stabler during the two years of monitoring. Trout Creek had temperatures higher than those in the Wind River, at 1.8°C higher in 1999 and 2.5°C higher in 2000. Bear Creek had temperatures closer to those measured in the Wind River, but was still cooler than the Wind River at Stabler by 0.8°C and 1.7°C in 1999 and 2000 respectively.

Overall, the temperature pattern in the Wind River is significantly different from that in Trout Creek. In Trout Creek, temperatures in the headwaters are quite low throughout the summer, and are increased dramatically in a downstream direction. In contrast, the Wind River begins with relatively high temperatures even in headwater reaches—apparently a natural condition. Temperatures increases in the Wind River are much more modest, and are largely offset by inputs of cool water from some of the larger tributaries including Falls Creek and Panther Creek.

## WATER USES

### Introduction

Because stream water temperature is inversely related to stream discharge (Brown 1972), variations in streamflow levels play an important role in the heating or cooling of streams. Although streams go through annual, seasonal, diurnal, and event-based fluctuations in discharge based on climatic or meteorological conditions, their discharge can also be affected by water withdrawals for human uses. Depending on the proximity and relationship of groundwater to surface channels, withdrawals of groundwater can also influence water quality in streams, by limiting recharge of streams, or increasing water losses through streambeds.

This analysis is intended to characterize water withdrawals in the Wind River watershed with respect to the location of the withdrawals, the amount and timing of the withdrawals, and the potential impact of the withdrawals on low flow discharge of the source streams. Much of this analysis is included in the Water Quality Restoration Plan summarized elsewhere in this Watershed Analysis, but the entire water withdrawal analysis is included here because it may have uses beyond those of analyzing water temperature implications.

### Analysis Methods

In the state of Washington, any diversion or use of surface water, and any use of groundwater in excess of 5,000 gallons per day requires a water right, which is issued by the State Department of Ecology. The Department tracks those water rights through the Water Rights Application Tracking system (WRAT's) database. Actual water withdrawals at any given time from streams in the Wind River watershed are not known, but information from the WRAT's database can be used as an indicator of the amounts of water that may be withdrawn in the watershed under reported water withdrawals.

The use of data from the WRAT's database to estimate water withdrawals in the Wind River watershed has limitations. Three of the more important limitations are: 1) Although the water rights are shown on the database, there is no way of knowing the seasonal fluctuations in use, or how much water is being used at any given time; 2) Water rights *claims* represent nearly half of the total number of entries on the WRAT's database, yet there is no water quantity reported in association with those claims, so it is impossible to know how much water is being used by them. (Based on conversations with Department of Ecology personnel, we assumed that claims for domestic uses would be in the neighborhood of 5-10 gallons per minute for surface water claims, and 5,000 gallons per day for groundwater claims (S.Carrol, personal communication, April 6, 2001. Although this may be a reasonable estimate for most domestic uses, there are some claimants who cite irrigation and stock watering in addition to domestic uses. Water withdrawals

for irrigation in particular could be substantially higher than the estimated quantities for domestic uses, but for this analysis we have no way of estimating the quantity used under those claims; 3) Water rights records are identified in part by a legal description, but it is often not specific enough to determine which watershed or subwatershed the withdrawal is in.

## Amount and Types of Withdrawals

As of April, 2001, there were 224 water rights applications, permits, certificates, and claims registered with the State of Washington for waters in the Wind River watershed. Actual water right *certificates* make up 101 of the total, while 8 are *applications* for water rights, 2 are temporary *permits* to use water while the water right application is being processed, and 103 are *claims* of water rights. The *claims* consist of water rights that have been claimed by individuals or organizations on the basis of historical uses of water. These *claims* will not become actual water rights until the claimant has gone to court to show evidence that in fact water has been used at that site since prior to 1917 for surface water and 1945 for groundwater (S.Carrol, pers. comm. 2001).

Based on the water quantities recorded in the WRAT's database, and the estimates applied to the claims as described above, Table WU-1 shows the quantity of water that is potentially being drawn from various points in the Wind River watershed under existing water rights certificates, permits, claims, and applications.

Table WU-1. Water quantities in existing water rights certificates, permits, claims, and applications in the Wind River watershed.

Status/Type of Water Right	No. of entries in WRAT's	Surface Water Appropriations (cubic ft/second)	Groundwater Appropriations (gallons/minute)
Certificates	101	256.9	4758
Permits	2	.01	450
Claims	103	10.928 (estimated)	140 (estimated)
Applications	8	4.004	380.2
(Totals)	224	271.8	5728.2

In total, there are 271.8 cubic feet per second (cfs) of surface water allocated to the existing water rights certificates, permits, claims and applications. However, not all of the uses of this water are consumptive. The largest uses of surface water listed in WRAT's are for fish propagation, non-consumptive uses associated with the Carson Fish Hatchery and Shipherd Falls fish ladder. Water rights intended solely for fish propagation account for 217 cfs (80%) of the total surface water uses identified and quantified in the WRAT's.

Considering just consumptive uses, the amount of water potentially withdrawn from surface waters in the watershed is 54.9 cfs. Irrigation and frost protection are the largest uses of both surface and groundwater in the Wind River watershed, representing 87% of the consumptive uses of surface waters, and 82% of the consumptive uses of groundwater (Figures WU-1 and WU-2). The balance of the surface and groundwater uses are a mix of domestic uses, irrigation, stock watering, mining and commercial. Because many of the water rights list several uses for the water under the same water right (e.g. domestic, irrigation, and stock watering), an accurate accounting of the quantity of water used for each of these use categories is not possible. For simplicity, this analysis assumes that the first use listed on the water right is the primary use for that water, and the entire quantity of water appropriated under each right, claim, permit or application is reported under that primary use.

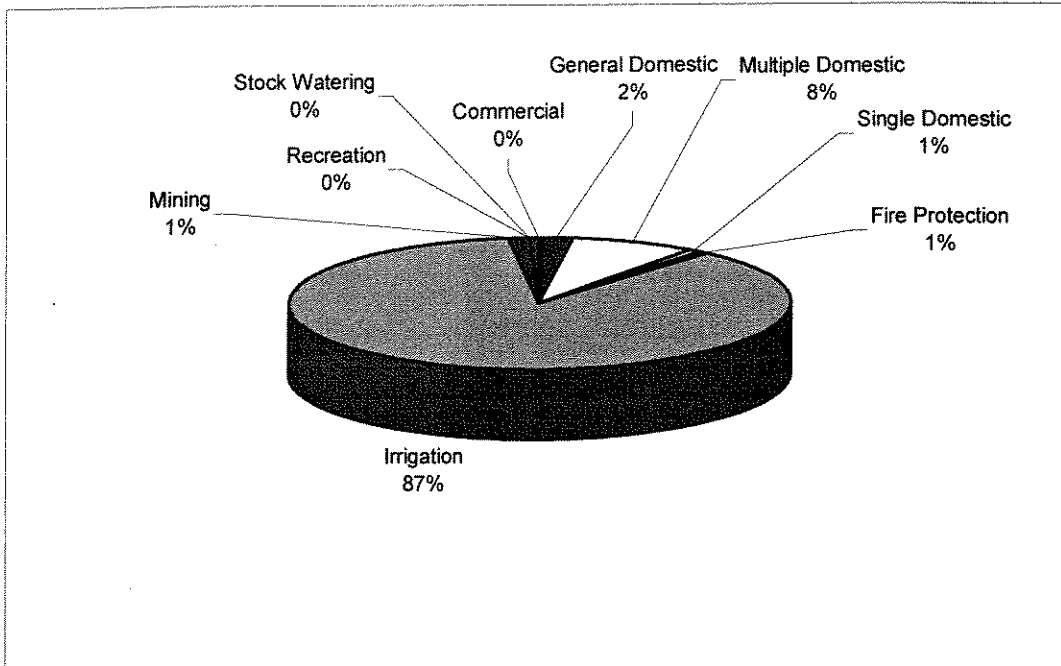


Figure WU-1. Consumptive uses of surface water in the Wind River watershed.

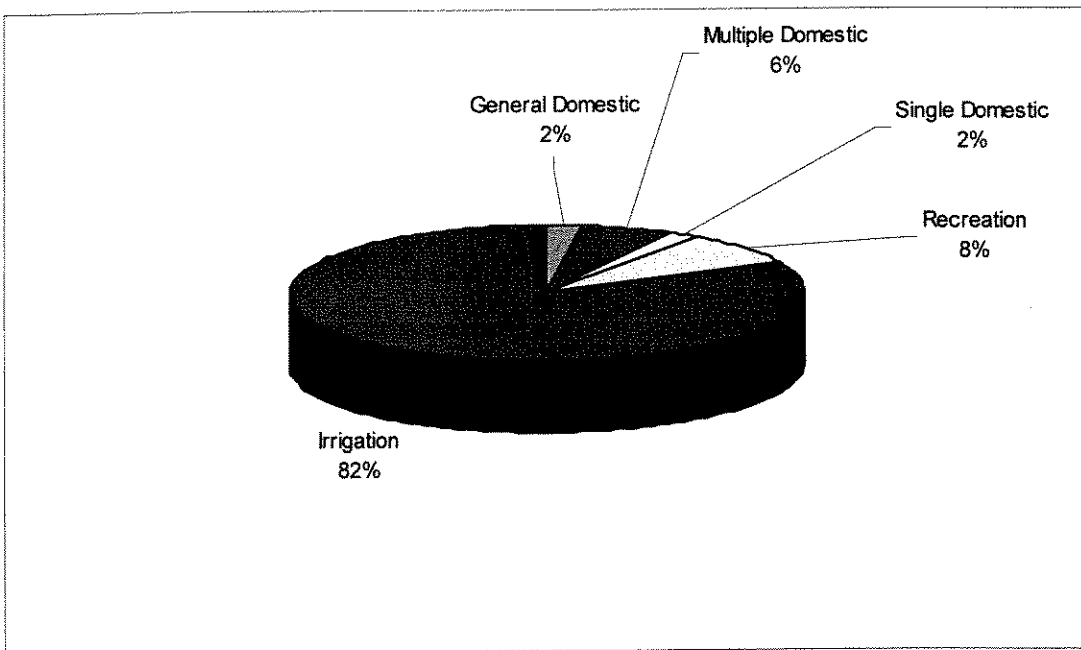


Figure WU-2. Groundwater uses in the Wind River watershed. (Uses totaling less than 1% are not shown)

A large share of the irrigation uses shown in these two figures are associated with the Wind River Nursery, which is no longer in operation, and no longer withdrawing irrigation water. Without including the irrigation and frost watering uses associated with the Wind River Nursery, the irrigation component shrinks to about 31% of the surface water (consumptive) uses, and just 8% of the groundwater uses across the watershed. Although the Forest Service plans to retain some of the water rights from the now defunct nursery, it will also be transferring some of the rights to Skamania County along with the nursery lands. It is unclear whether or how much water will continue to be used at the Nursery site.

Based on the types of uses shown above for the water withdrawals, it is likely that withdrawals are occurring year round in the watershed. If there is a time of year that withdrawals would be at their maximum levels, it is likely to be the late summer months when streams are naturally at their minimum flow levels.

## Location of Withdrawals

A majority of the water rights certificates, permits, claims and applications listed on the WRAT's database lie in the Lower Trout Creek, Lower and Middle Wind River, and Lower Panther Creek subwatersheds. While most of the withdrawal points lie downstream of National Forest boundaries, the largest consumptive uses of water are those associated with the Wind River Nursery, located on National Forest lands in the Lower Trout Creek subwatershed. Table WU-2 quantifies the surface and groundwater uses in the Wind River by subwatershed.

Table WU-2. Surface and groundwater uses by subwatershed.

Subwatershed Name	Estimated Surface Water Uses (cfs)	Estimated Consumptive Surface Water Uses (cfs)	Estimated Groundwater Uses (gpm)
Upper Wind R	0.51	0.51	0
Falls Creek	0	0	0
Dry Creek	0.126	0.126	0
Middle Wind R	101.049	3.809	468.7
Trout Creek	30.542	23.542	4277
Panther Creek	4.388	0.388	47
Bear Creek	2.032	2.032	53.5
Lower Wind R	133.292	12.952	885.5
(Entire Watershed)	271.939	43.359	5731.7

## Effects of Water Withdrawals on Low Flow Stream Discharge

To assess the potential for the withdrawals to impact water temperatures in streams draining these subwatersheds, low flow stream discharge values were developed from data collected at the Wind River streamflow gauge and other gauges in the watershed. Table WW3 shows the results of this analysis. The table shows two values for low flows in streams in the watershed. The first value is the average discharge for the month of September, over the period of 1935 through 1977 (period of record of the stream gauge). The second value represents the lowest flow measured on the Wind River (and estimated for the tributaries) over the period of record of the gauge. It must be noted that during 1992, a draught year in western Washington, discharges on Trout Creek were measured at less than one half the lowest flow shown in Table WU-3. The point is that the lowest flows measured during the 1935-1977 period of gauge operation do not necessarily define the lowest discharges that will be seen on these streams.

Table WU-3. Estimated low flow discharge and water withdrawals by subwatershed.

Subwatershed	Mean Monthly Discharge* (Sept 1935-1977) (cfs)	Minimum Recorded Discharge* (1935-1977) (cfs)	Estimated Consumptive Water Uses for Surface Waters (cfs)	Proportion of Mean Lowflow Stream Discharge Appropriated to Water Uses (%)	Proportion of Minimum Lowflow Stream Discharge Appropriated to Water Uses (%)
Upper Wind R	32.8	17.6	0.51	2	3
Falls Creek	22.7	12.2	0	0	0
Dry Creek	28.4	15.2	0.126	<1	1
Middle Wind R	28.1	15.1	3.809	14	25
Trout Creek	23.4	12.6	23.542	101	187
Panther Creek	43.2	23.2	0.388	1	2
Bear Creek	15.5	8.3	2.032	13	24
Lower Wind R	28.4	15.2	12.952	46	85
(Entire Watershed)	234.5	126.0	43.359	18	34

\* Tributary discharges estimated based on their proportional drainage area within the watershed, except for Trout Creek, which is known to account for approximately 10% of the flow of the entire Wind River during low flow conditions (based on gauge data).

From Table WU-3, it is evident that water withdrawals (if they occur in the amounts reported in the WRATs database) represent less than 5% of the lowest flows on record in the Upper Wind, Falls Creek, Dry Creek and Panther Creek subwatersheds. However, there is a much greater potential for water withdrawals to affect water temperatures in the Lower and Middle Wind River, Bear Creek, and Trout Creek subwatersheds, where withdrawals can represent 24% (in Bear Creek) to 187% (in Trout Creek) of the low flow discharge of those streams. Even during an "average" year, nearly half of the flow of the lower Wind River, and over 100% of the flow of Trout Creek could apparently be withdrawn from those streams during low flow conditions (except that the Forest Service water right on Trout Creek stipulates that a minimum of 8cfs are to be left in the stream after irrigation withdrawals).

## Discussion

Based on this analysis, the primary areas of concern within the Wind River watershed in terms of the effects of water withdrawals on water temperatures are clearly in the Trout Creek, Lower Wind, Middle Wind, and Bear Creek subwatersheds. Water withdrawals occurring in the Lower and Middle Wind River subwatersheds are in large part occurring on private lands below the National Forest boundary, and do not influence conditions on National Forest lands. However, the bulk of the water appropriations occurring in Bear Creek and Trout Creek occur on the National Forest portions of those subwatersheds—particularly associated with two facilities: 1) the City of Carson's municipal water supply intake on Bear Creek; and 2) the water uses associated with the Wind River Nursery and Work Center.

In **Bear Creek**, the municipal water supply intake for the City of Carson is located approximately one mile upstream of the National Forest boundary. The water right certificate for this appropriation dates back to 1951, and allows for the withdrawal of 2 cfs from Bear Creek. From the analysis above, it appears that this could represent as much as 24% of the Bear Creek discharge during low flow conditions. However, Mt Adams Ranger District records indicate that summer flows in Bear Creek are often less than 5 cfs, and have at times been measured at less than 1 cfs above the city intake. Clearly the extraction of the full 2 cfs from Bear Creek could at times significantly reduce the volume of flow in the channel, and possibly affect water temperatures there.

To date, most of the temperature monitoring that has been done in Bear Creek has occurred just upstream of the diversion, at the Forest Service baseline water quality monitoring station. Water temperatures there

exceed the state standard in general about one out of every two years, though rarely exceed by more than 1°C. In 1999, the Underwood Conservation District began operating a temperature monitoring station about one mile downstream of the city intake, at the National Forest boundary. With only one year of monitoring data available, it appears that water temperatures in Bear Creek increase in this one mile reach. The maximum recorded temperature at the Forest Service baseline station in 1999 was 15.6°C, while at the downstream station reached 16.8°C. No discharge measurements were taken on Bear Creek in 1999, and the role of the water diversion on the temperature increase is unknown at this time.

The situation in **Trout Creek** is somewhat more complex than in Bear Creek because there are a number of water rights associated with the Wind River Nursery and Work Center (some of which are not currently being used), there is the dam and Hemlock Lake, created by the dam, and there are additional water withdrawals occurring on private lands downstream of the nursery complex.

As part of the nursery decommissioning and transfer of nursery lands from the Forest Service to Skamania County, the existing water rights are also changing status. The Forest Service is retaining some of the water rights associated with the nursery, the lake, and the work center, but is conveying some of the water rights to the County along with the lands. Table WU-4 summarizes the existing water rights, the purpose of the rights, and the projected status of the rights. Although decisions have not been finalized regarding the final disposition of all of the water rights, this table displays the situation as of the writing of this document.

Water rights associated with the nursery that are not conveyed to the County will be retained and used by the Forest Service to serve the remaining Forest Service facilities at the Wind River Work Center, and possibly used to irrigate a small portion of the nursery that was retained by the Forest Service. Those rights not conveyed to the County and not used will either be put into a water trust, or will be forfeited due to non-use. Water rights conveyed to the County will presumably be used to provide water for the new uses of the former nursery.

Table WU-4. Water rights in Trout Creek associated with the Wind River Nursery

Purpose	Source	Quantity	Ownership	Projected Use
Water Storage	Reservoir	120 acre ft/yr	FS	Pending fate of Hemlock Dam
Power	Surface Water	7 cfs	FS	Not used in many years, probably no longer a valid water right
Irrigation, Frost Protection	Surface Water	14.5 cfs	Being conveyed to Skamania County	Unknown
Irrigation, Frost Protection	Surface Water	8.25 cfs	FS splitting with Ska. Co.	FS portion may be used to irrigate a small area in the nursery fields retained. Skamania County portion is unknown
Irrigation, Multiple Domestic	Surface Water	0.5 cfs	FS	Old withdrawal site, may no longer be a valid water right
Irrigation, Frost Protection, Multiple Domestic	Groundwater	200 gpm	FS	To water trust?
Irrigation, Frost Protection, Multiple Domestic	Groundwater	3990 gpm	FS	To water trust?

Although currently not being used, the water rights associated with the nursery are clearly sufficient in quantity to significantly change the discharge in Trout Creek during low flow periods according to Table WU-3. But as was the case with Bear Creek, District records of actual discharge levels on Trout Creek show late summer discharges of even less than those predicted in Table WU-3. Discharge levels on Trout Creek have been measured at less than 10 cfs above the water intake, and as low as 5 cfs above the intake during very dry years (e.g. 1992). While water rights for the nursery allow for some 22.75 cfs to be withdrawn from Trout Creek, the water right was conditioned with an instream flow requirement of 8 cfs. That is, water withdrawals could not occur if they caused discharge in Trout Creek to fall below 8 cfs.

In terms of water temperatures, Trout Creek stands out as the stream that exceeds the state standard more frequently, reaches higher temperatures, and maintains higher temperatures longer than any other stream in the watershed. Since monitoring began in 1977, Trout Creek has exceeded the state standard for temperature every year but one, and has reached temperatures as high as 25°C above the dam (and lake), and above the water intakes. In fact, much of the heating of Trout Creek occurs in the upper watershed, well upstream of the nursery complex. Water temperatures have been measured in a number of locations throughout these upper reaches of Trout Creek, and temperature exceedances there have been well documented (see Water Temperature section of this report). But limited monitoring has been done below the intake structures to allow assessment of the effects of the withdrawals on water discharge or temperature. With just one year of monitoring results at two stations below the nursery intake, water temperatures actually decreased in the reach immediately below the intake. However, the monitoring of this reach occurred in the summer of 2000, after the nursery had been decommissioned, so little (if any) water was withdrawn from Trout Creek during that summer.

## **Recommendations**

- 1) Continue measuring temperatures at two locations in Bear Creek, and consider adding upstream stations.
- 2) Measure discharge at both stations on Bear Creek during low flow conditions
- 3) Characterize canopy cover, shade, and channel morphology in the intervening reach of Bear Creek to facilitate modeling of temperature increases.
- 4) Install additional temperature probes on Trout Creek below the dam and above the confluence with Martha Creek.
- 5) Measure discharge at monitoring stations and characterize canopy cover, shade, and channel morphology to facilitate modeling of water temperatures in Trout Creek.

# **WATERSHED RESTORATION— UPLANDS**

## **Road Decommissions Completed Since the Initial Wind Watershed Analysis**

Since 1995, the Forest Service has decommissioned some 80 miles of road in the Wind River watershed (Figure WR-1). This represents approximately 19% of the Forest Service roads that existed in the watershed in 1995, or 14% of the total road network (Figure WR-2). Approximately 498 miles of road remain in the watershed, with 343 of those road miles (69%) under Forest Service administration.

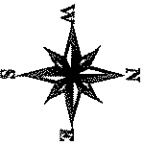
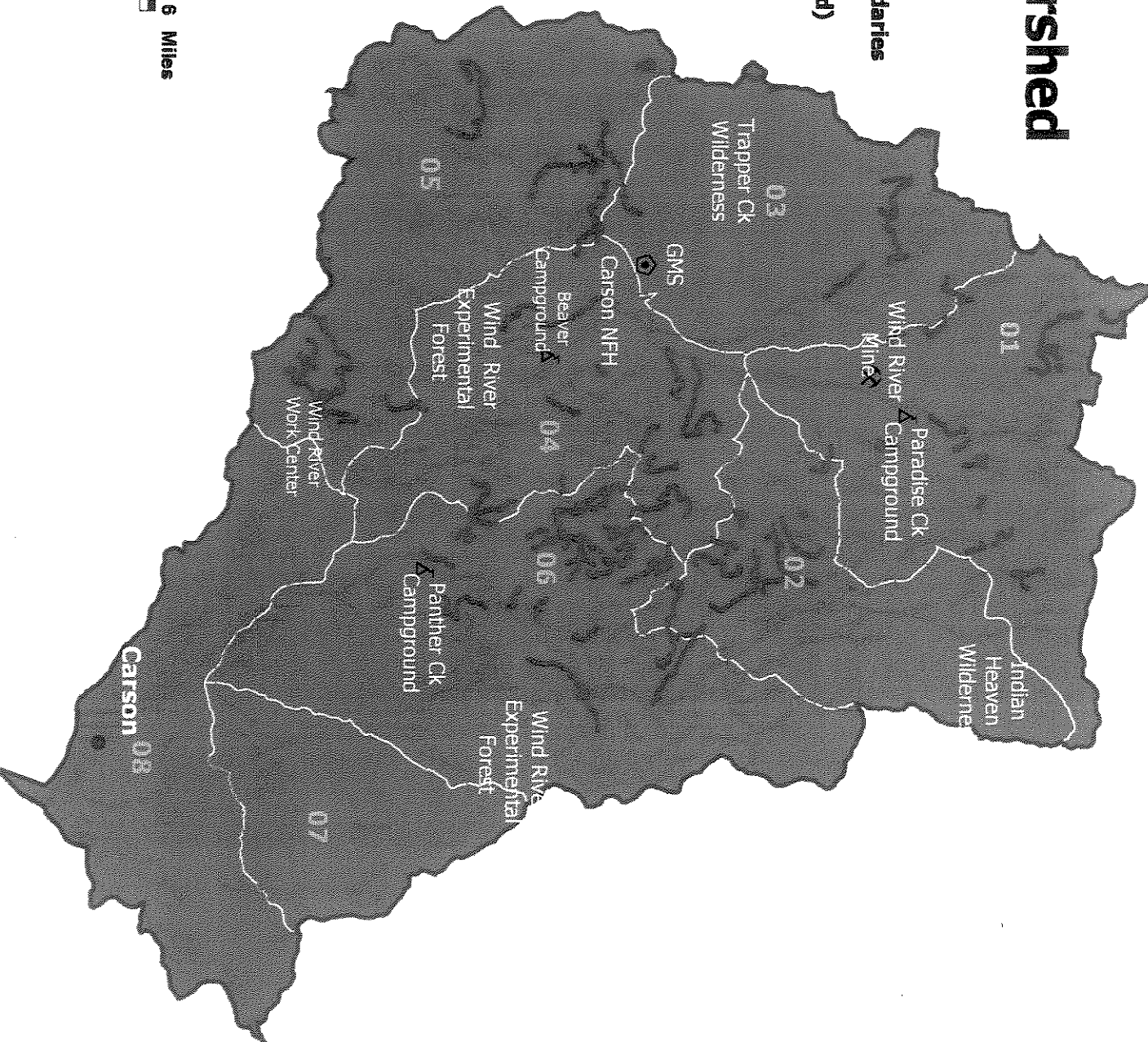
# Wind River Watershed

 Decommissioned Roads

 Watershed and Subwatershed Boundaries

## Subwatershed Boundaries (6th Field)

- 01 - Upper Wind River
- 02 - Falls Creek
- 03 - Dry Creek
- 04 - Middle Wind River
- 05 - Trout Creek
- 06 - Panther Creek
- 07 - Bear Creek
- 08 - Lower Wind River



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Figure WR-1. Decommissioned roads in the Wind River watershed.

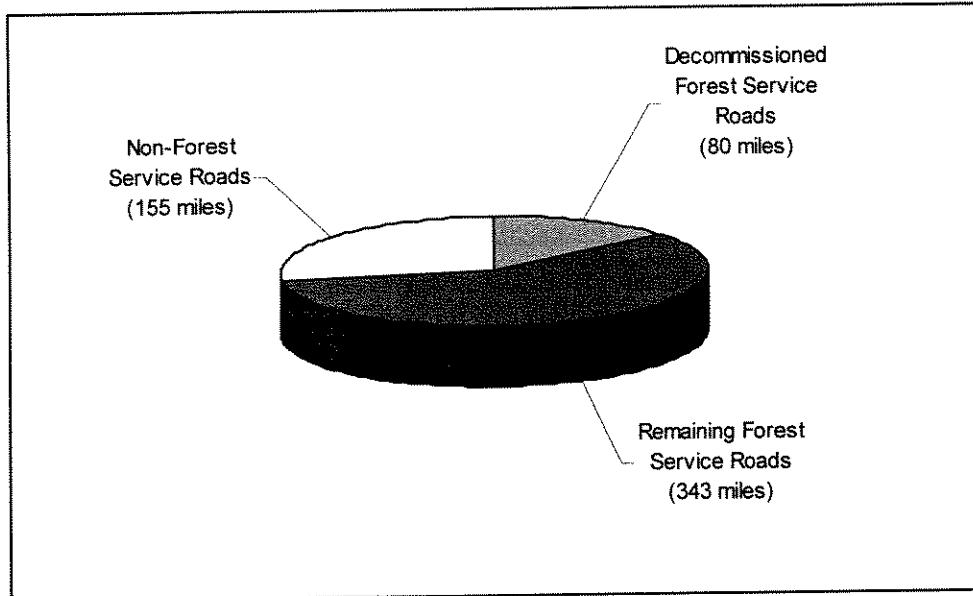


Figure WR-2. Current road system in the Wind River watershed.

Decommissioning efforts over the past five years have focused on reducing road miles in subwatersheds with the highest density of roads. Subwatersheds with road densities in excess of 3.0 miles per square mile were prioritized for road reduction due to the potential impacts of roads on water quality, peak streamflows, and possibly low flows. Overall, road density in the Wind River watershed has been reduced from 2.6 miles to 2.2 miles per square mile over the past five-years. Figure WR-3 shows how road densities have changed in each subwatershed as a result of decommissioning efforts.

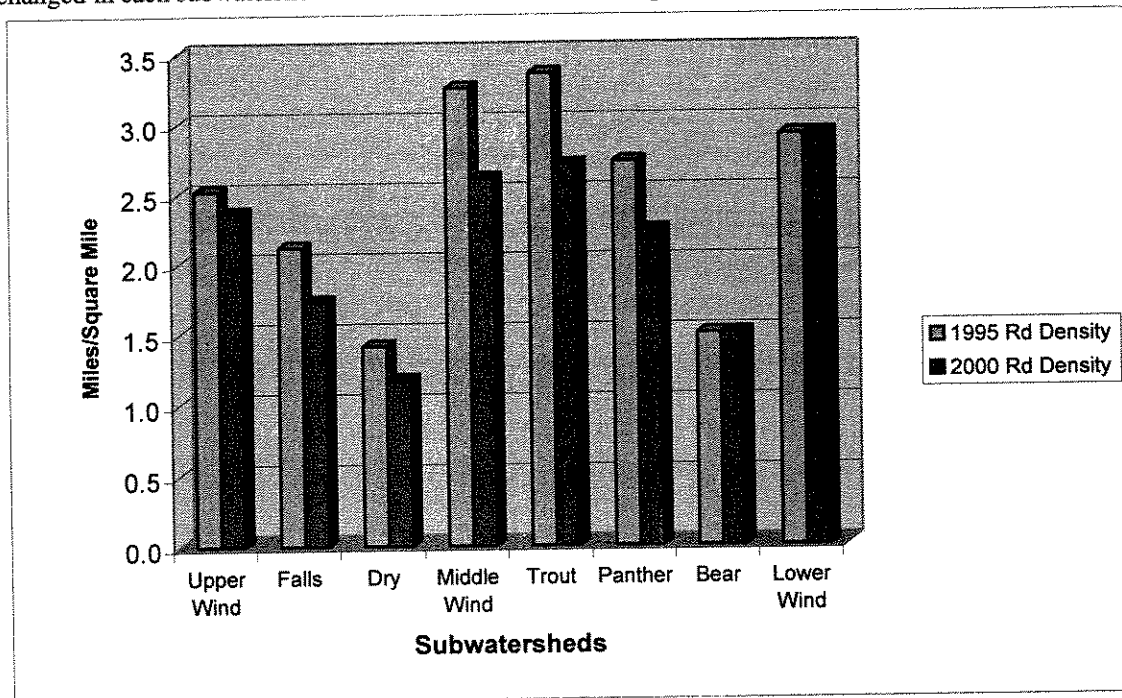


Figure WR-3. Road density reductions in the Wind River watershed (1995-2000).

Currently, road density levels in all eight 6<sup>th</sup> field subwatersheds are below three miles per square mile. Subwatersheds with the greatest decrease in road density are the Trout Creek and Middle Wind subwatersheds, where densities have decreased by 0.7 miles per square mile (mi/mi<sup>2</sup>). In the Trout Creek

subwatershed, road density fell from 3.4 mi/mi<sup>2</sup> to 2.7 mi/mi<sup>2</sup> as a result of the decommissioning of approximately 22 miles of road. In the Middle Wind River subwatershed, road density was reduced from 3.3 to 2.6 mi/mi<sup>2</sup> after decommissioning 17 miles of road.

There have been no decommissions in the past five years in either the Bear Creek or Lower Wind subwatersheds. In Bear Creek, no decommissions have been proposed because road density there is already quite low on the National Forest portion of the subwatershed. In contrast, road density in the Lower Wind River subwatershed is currently higher than in any other subwatershed in the Wind River drainage. However, much of this subwatershed is comprised of private or state lands; the Forest Service manages just under 10% of the roads in the subwatershed. Many of the roads in this subwatershed are probably associated with the development in the area of the town of Carson, which lies in large part in the Lower Wind River subwatershed.

Because roads can act to impede surface water infiltration, intercept subsurface flows, and provide a direct surface linkage for routing water into stream channels, the road network can substantially increase the natural drainage density of a watershed. Figure WR-4 shows how the "natural" (pre-road system) drainage density in each subwatershed was increased by roads as of 1995, and how the drainage density increases of 1995 have been *decreased* as a result of road decommissions occurring between 1995 and 2000. The drainage density increases were calculated assuming that 57% of the length of each road in the subwatershed was contributing surface water to the stream network during runoff conditions (following Wemple 1995). Although the 57% value is an extremely rough estimate that averages differences relating to surface slope, soils, geology, natural drainage density, storm/runoff conditions and other factors, it is used here as the best available information.

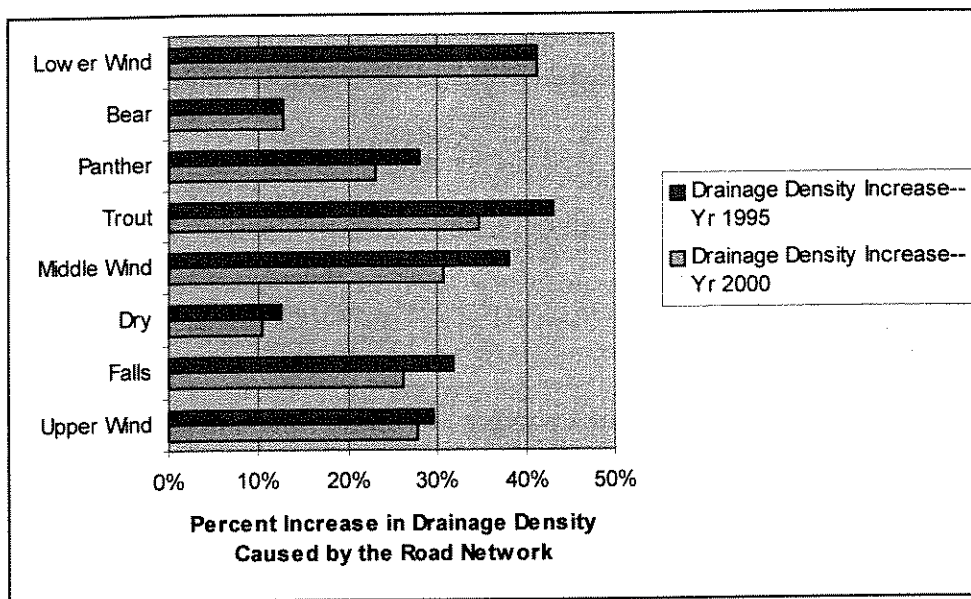


Figure WR-4. Estimated increase in natural drainage density caused by roads, and how the increased drainage density has changed from 1995 to 2000.

As of 1995, the natural stream drainage network in the Trout Creek subwatershed had been expanded by over 40% by the road system (Figure WR-4). As the surface channel network is increased, the efficiency at which water is routed from hillslopes into stream channels is increased. With nearly half again as many surface channels as the watershed would have naturally, it is not hard to imagine that streamflows in the Trout Creek drainage have been influenced by the road network. Moreover, the character of the tributary streams that receive this excess surface water is likely to have been changed as a result of having more water delivered to the channel during runoff conditions. Road decommissioning in Trout Creek has not eliminated the problem of increased drainage network density, but has reduced the estimated increases in

drainage density from 43% to 35%. Similar, though smaller reductions have occurred in other subwatersheds where decommissioning has taken place.

Because stream crossings represent the location where roads can most directly impact water quality and runoff processes, roads with a large number of stream crossings or a high frequency of crossings are often the roads that cause the greatest risk to aquatic resources. In selecting roads for decommissioning, the District has targeted roads in subwatersheds where road densities are high, but has also focused efforts on those roads that have the greatest existing or potential effects to the aquatic system.

Figure WR-5 compares the percent reduction in road miles that has resulted from decommissioning to the percent reduction in road crossings that has occurred as a result of removing those roads. The intent of this comparison is to help assess the degree to which the selection of road decommission candidates has focused on the roads considered to be the greatest hazard to aquatic values.

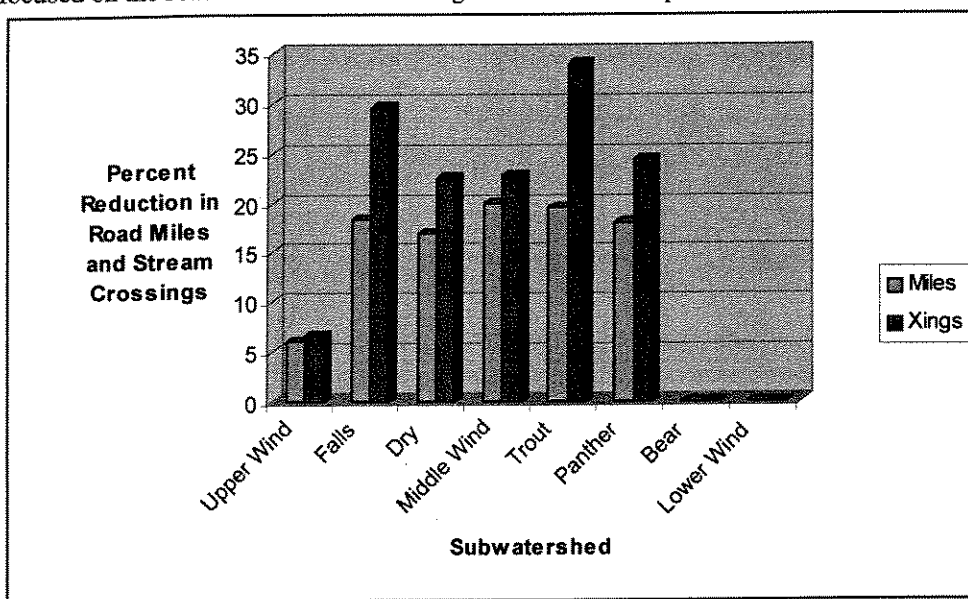


Figure WR-5. Comparison of the percent reduction in road miles vs. the percent reduction in stream crossings that have resulted from the past five years of road decommissions in the Wind River watershed.

Figure WR-5 illustrates that in every subwatershed, there has been a greater reduction in road crossings than in road miles. This is important because it suggests that road decommissions completed-to-date in the Wind River watershed have yielded a relatively large return in terms of aquatic resource protection for the number of miles of road decommissioned.

## Monitoring of Road Decommissions

### Introduction

Monitoring was conducted during the summer of 1999 to evaluate decommission projects implemented in the Wind River watershed in 1996, 1997, and 1998. The emphasis of the monitoring was on assessing the effectiveness of road decommissioning efforts, and the degree to which they were implemented as planned. The monitoring was brought about by a need to determine whether road decommissioning projects were meeting hydrologic objectives as originally intended, and to identify what improvements could be made to either the design or implementation of these projects.

## Monitoring Results

- 1) Road closure structures, which typically consist of a four-foot high berm backed up by a four-foot deep trench, were in place on each decommissioned road system monitored. In all cases, these structures met contract specifications and were highly effective at preventing vehicular access to decommissioned roads.
- 2) Scarification of the road surface, which was most commonly done with an excavator, met contract specifications for depth of excavation and aerial coverage of treatment. The scarification appeared highly effective at reducing overland water flow and promoting water infiltration on the road surface.
- 3) Waterbar spacing varied considerably depending on local site conditions, but averaged 370 feet across all roads surveyed. The number of waterbars counted during the survey exceeded the minimum number called for in the contracts. When constructed all the way across the road surface to the cutslope, the waterbars were highly effective at routing surface water out of the inside road ditch. However, when not constructed to the cutslope, they tended to be ineffective, and contributed to failure of downslope waterbars by allowing too much water to accumulate in the ditch. In addition, where waterbars were lacking from critical locations (such as immediately upslope of culvert removals), excessive scour and erosion was present.
- 4) Cross-drains were installed according to contract specifications, and were highly effective at routing water across the road surface. Cross-drains are typically constructed at locations where there has been no culvert, but where water drainage across the road surface appears likely (i.e. due to an upslope swale, depression, or seeps). Approximately 56% of the surveyed cross-drains had some evidence of fluvial scour on the bottom of the channels, indicating that they were functioning as intended in terms of routing surface water across the roadbed from sources above the road.
- 5) Road fills were scheduled to be pulled back from the outside edge of the road prism at locations that showed signs of instability during pre-project field reviews. Surveyors found that all fill pullbacks were done in accordance with contract specifications, and that treated sites all appeared stable at the time of the survey.
- 6) 96% of the culverts scheduled for removal as part of the decommissioning were actually removed. Of those that were not, two were left in place as a result of problems encountered during excavation, the other three were apparently left in inadvertently, and were not noticed during contract inspection.
- 7) 54% of the culvert removal sites exhibited signs of fluvial erosion in the form of vertical erosional surfaces along the channel edge. In most cases, these erosional surfaces were discontinuous in any given crossing, appearing as a result of some localized scour around an instream obstruction, or from channels beginning to regain some sinuosity in the crossing. However, in some cases it appeared that the erosion occurred because the excavation was not deep enough or wide enough, and the stream had either incised vertically through remnant fill material, or had cut laterally into the excavated banks during higher flows.
- 8) Overall, 63% of the culvert removals were found to be highly effective, 28% were given effectiveness ratings of "moderate", and 9% were given "low" effectiveness scores.
- 9) Success of erosion control seeding was variable across the roads surveyed, with average coverage at the time of the monitoring ranging from 20% to 70%. Monitoring results suggest that the type of seed mix used, and rock content of the road surface are two factors that contribute to the success (or lack thereof) of the seeding. In addition, it is suspected that site conditions, timing and rate of seed application, and possibly seed lots also affected grass cover percentages.

- 10) Two grass seed mixes stood out as being most effective at providing ground cover. The Mountain Brome, Colonial Bentgrass, and Orchard Grass mix had the highest rate of cover at an average of 80% on the roads visited. This mix is considered to be non-native and non-invasive. More recently, the Forest has developed its own supply of locally collected native grasses, including Blue Wildrye and Slender Wheatgrass. This mix was also highly effective, providing cover that averaged 75%. This mix is preferable to use because the seed stocks are generated from plants found in the watershed.
- 11) Grass coverage at culvert removal sites was slightly lower on average than on the roadbed, in spite of heavier seed application rates used at the culvert sites. The grass coverage at culvert removal sites (which averaged 49%) is probably due to seeds raveling or being washed down the slope after seeding.
- 12) Live (planted) hardwood seedlings were evident at all perennial stream crossings, and at most of the ephemeral and intermittent stream crossings at the time of the survey. In addition, because of the common occurrence of alder in roadside ditches and on cut and fill slopes, natural seeding of alders was found to be substantial on many of the decommissioned roads.

## **Evaluation of Decommissioning Effectiveness**

With some exceptions, results of the monitoring indicate that road decommissions are being implemented as planned, and are effective at meeting established hydrologic objectives. This section describes how well the objectives of road decommissioning efforts have been met in decommissions undertaken in the past five years.

### **Objective 1: Reduce overland water flows on road surfaces and concentration of water in roadside ditches.**

#### Reduce overland flows:

Overland water flows were not measured directly during this monitoring effort, but we infer from the data collected that this objective was met. All road surfaces were scarified, providing increased infiltration capability on the road surface. The data suggest that the scarification completed with an excavator does an excellent job of discouraging overland water flows by not only decompacting the road surface, but also by leaving a hummocky terrain across the road surface. Water that does not immediately infiltrate the ground is captured in the depressions instead of being allowed to run off. In addition, the vegetation established on the scarified road surface is expected over time, to encourage water infiltration by protecting the soil surface from direct raindrop impact, and maintaining a more pervious soil structure at ground surface and below.

#### Reduce concentration of water in inside ditches:

Although scarification of the road surface allowed for increased infiltration and decreased the amount of water being delivered to the roadside ditch, some ditches still carry water from cutslope seeps, from upslope drainage areas, and from adjacent road surfaces. Waterbars constructed across the road surface to the cutslope were effective at reducing this ditch flow, by routing the water across the road surface and outletting to the slope below the road. Effectiveness of the waterbars at relieving ditch flow was evident from the surface erosion found along the base of many of the waterbars. Where waterbars were incorrectly constructed or were absent, this objective was not fully met. These situations typically resulted in some form of erosional feature downslope of the absent or poorly constructed waterbar, in addition to not meeting the objective of dispersing and eliminating ditch flow.

### **Objective 2: Reduce surface erosion and potential for catastrophic fill failure.**

#### Reduce surface erosion from road surface:

Scarification of the road surface and subsequent grass seeding appeared to be highly effective at getting vegetation re-established on the road surfaces. This was evident in that road surfaces averaged over 50% grass cover based on ocular estimates. The seed mix containing chewings fescue, creeping red fescue, highland bentgrass, and perennial rye showed the best cover. Although these are not all native species, they were available in the quantities needed, and are considered non-invasive.

In addition, we infer from the depth of ripping that deep root penetration has been facilitated. The number of roads with volunteer alder seeding in on the road surface is evidence that natural processes are occurring that will further improve the road beds as growing sites, and will improve hydrologic function of the decommissioned road surface. With increased water infiltration, reduced overland water flows, and increased vegetative cover, surface erosion potential is presumed to be reduced.

Minimize surface erosion from culvert excavations:

Surface erosion from culvert excavation sites was not measured directly, but was evaluated by visual observations of grass cover, the presence or absence of rills, soil pedestals, and other indications of erosion. From the results of this type of evaluation, we find that surface erosion from these sites was variable. Sites with the best vegetative cover and least likelihood of contributing surface erosion were those with lower slope gradients, and channel excavations that had not been undercut by the stream. Alternatively, crossings that failed to meet slope requirements, and those crossings that had substantial fluvial erosion at the base on the excavation may continue experiencing surface erosion until those overly steepened slopes have revegetated.

Reduce the risk of catastrophic fill failure:

With five exceptions, all of the culverts were removed from roads monitored during this effort. Removal of culverts from decommissioned roads eliminates the potential for fill failure associated with culvert plugging. In addition, by removing fill material from directly over the channel, the magnitude of any subsequent failure (should it occur) is expected to be significantly smaller. Fill piles left next to removed culvert sites were found to be stable in that no failures were identified from those piles during the monitoring survey. However, surveyors found that the piles that appeared most stable were those that were centered over the inside ditch and cutslope as opposed to over the centerline of the road. In addition, piles that were spread further down the length of the road as opposed to being piled higher adjacent to the crossings better fit the natural topography.

**Objective 3: Provide for stable channel configuration following removal of culverts.**

Provide adequate capacity for channels to function at a range of flows.

Monitoring results indicate that nearly nine in ten culvert removal sites provided the specified channel bottom width. Yet half of the culvert removal sites had evidence of fluvial scour—either lateral cutting or channel incision—along the toe of the excavated slope, and nearly three quarters of the perennial stream crossings had evidence of this fluvial scour along some portion of the crossing. Some degree of scour along these channel margins is to be expected simply because a channel is being re-created in an old channel bed that's been loaded with fill material for several decades. The new channel needs to establish its form, to re-armour itself, and to develop bank stability from vegetative growth on the channel banks.

We believe that most of the crossings are exhibiting minor scour that is within the range of acceptable and expected. However, we also find that some crossings—particularly those that have not met the specification for bottom width—are overly constrained by the excavation slopes. This problem can be resolved through planning and contract administration.

Minimize potential for channel incision following removal of culverts.

A quantitative assessment of channel incision was not done as part of this monitoring effort. Because we had not established fixed reference points and channel cross sections and profiles at culvert removal sites, we were unable to quantitatively assess the degree to which these culvert removal sites aggraded, degraded, or widened. However, evidence of fluvial erosion was noted for waterbars and cross-drains, and was measured on all stream-crossing culverts. Vertical erosional surfaces at the edge of the streams were used as an indicator that the stream had done some adjusting—either through vertical incision, lateral shifts, or

bank cutting because of an overly narrow channel construction. Although we did not attempt to discriminate between these processes, we presume that some of each had occurred. Future monitoring needs to focus on establishing post-project cross sections and profiles of culvert removal sites (prior to the first winter following the decommissioning), to allow quantification of channel changes following culvert removals.

#### **Objective 4: Protect restoration work accomplished on decommissioned roads.**

All of the treated roads were closed with a berm and ditch combination to prevent damage from subsequent vehicular travel. The berm and ditch combination were highly effective at protecting restoration work in all cases, as there was no evidence of vehicular traffic on any of the decommissioned roads surveyed.

### **Design and Implementation Recommendations for Future Decommissioning**

Recommendations from the report are summarized here along with some additional, more general recommendations included to help improve future decommissioning projects.

#### **Road Closure Structures:**

- Continue using the berm and ditch approach to blocking decommissioned roads.
- Encourage revegetation of the berm so that over time it fits in with the surroundings.
- Avoid using non-native materials to create the berm or to pile on the berm, as the intent is for the decommissioned road to blend in with the rest of the landscape over time.

#### **Scarification:**

- Continue requiring use of the excavator for ripping to facilitate and encourage infiltration of surface water onsite.
- Throw slash across ripped road surface to provide additional protection of the ripped surface from rainfall, and to provide organic matter, shade, and possibly seed material.

#### **Waterbars and Cross-drains:**

- Ensure that waterbars are constructed at the specified height all the way to the cutslope.
- Wherever possible, locate waterbars such that outlets drain to flat or gently sloped surfaces to prevent downcutting at the outlet.
- When outlets must be placed over steeper slopes, decrease waterbar spacing to reduce the amount of water handled by any one waterbar.
- Consider armoring the outlets of waterbars that must be discharged to steep slopes.
- Continue to place waterbars at relatively close spacing to handle unforeseen ditch water from springs, seeps, and upslope swales.
- Ensure that waterbars are placed upslope of every culvert removal to prevent ditch water from flowing over newly excavated slopes at culvert removals.
- Evaluate the need for additional waterbars upslope of ditch relief culverts to limit the amount of water flowing through those excavations.
- Ensure that waterbars and cross-drains are drained to stable areas.

#### **Fill Pullbacks:**

- In areas of known historic instability, consider pulling back the outer edge of fill even where cracking of the fill is not evident. Implementing this recommendation may reduce the potential for failures such as that seen on the 5400-305 road. The recommendation is made in acknowledgement that pre-project field reviews are imperfect, and may not identify all potentially unstable portions of fill due to vegetative or other debris obscuring cracks in the fill. Moreover, it is possible that by encouraging water infiltration into the roadbed, that marginally stable fills may become overly weighted by the increased water content, and subsequently could fail.

## **Culvert Removals:**

- Enforce contract language that requires removal of all fill and bedding material down to the level of the natural streambed at culvert removal sites. Because this elevation can be difficult to identify, it may require the hydrologist and COR to be onsite during culvert excavations.
- Enforce contract requirements that specify minimum bottom widths for channels at culvert excavations. Channel bottoms must be wide enough to provide adequate room for the stream at different flow stages, to allow for channel sinuosity, and to allow for rock and/or woody debris placement and deposition in the excavated channel.
- Work with equipment operators and COR's to establish common understanding of the need to provide this capacity in excavations.
- Use rock to help protect and stabilize the reconstructed channels—particularly where stream bottom widths are constrained by natural topography.
- Maintain specified slopes on culvert excavations from top of the excavation to the toe to prevent erosion of lower slope and to provide a suitable slope for revegetation.
- Reduce slopes of excavations where possible to provide better sites for revegetation and slope stabilization.
- Enforce contract requirements for minimum fill setbacks.
- Require that fill piles be placed against cutslopes and outsloped to better mimic the natural terrain.
- Place roadside slash over excavated slopes after treatment to provide additional cover and to discourage large animal traffic over the revegetating slope.
- Apply straw mulch to excavated slopes at all stream crossings.

## **Ground Cover and Vegetation**

- To provide better substrate for revegetation, aggregate removal or reduction should be considered on roads with deep rock surfacing.
- A perennial mix of local native (e.g. Blue Wildrye, Slender Wheatgrass) and/or non-native, non-invasive seed (e.g. Mountain Brome, Colonial Bentgrass, Orchard Grass) is recommended to increase the chances for a sustained growth of grass on the scarified road surfaces.
- Placement of straw mulch or native brush and roadside slash over the decommissioned road may increase seed germination and survival by providing shade and moisture retention.
- Placement of roadside slash on excavated slopes at culvert removal sites may have the added benefit of impeding or discouraging animal traffic across these newly excavated slopes, and in that way may improve success of erosion control measures there.
- Subsequent monitoring should include examination of some of the roads where mulch was used either in addition to, or in place of grass seed.

## **General**

- Consider leaving a narrow unscarified trail along the road surface to facilitate subsequent use by forest visitors including hikers, hunters, and forest product gatherers. Because of the effectiveness of the scarification by excavator, the roads are quite difficult to navigate by foot after decommissioning. Leaving this unscarified swath would allow for meeting essentially the entire hydrologic objective, and at the same time meeting some other forest user's objectives.
- Post cheap, informative signs at entrances to road decommissions to let forest users know why the roads are being decommissioned.
- Future monitoring: evaluate the benefits of using straw mulch along with/ or as a substitute for grass seed.
- Future monitoring: establish cross section and longitudinal profiles at culvert removal sites to measure changes in channel form and profile following culvert removals. Initial surveys should be conducted immediately after the channel excavation takes place.
- Future monitoring: because of the amount of information taken at culvert sites during this monitoring effort, along with the time required to walk the roads, and the limited time available for this project, the number of roads monitored for this project is small. Subsequent monitoring efforts may want to reduce the amount of data collected to allow more road miles to be surveyed.

# Recommendations for Upland Restoration

The following recommendations are based on findings from the Roads Analysis described previously in this Watershed Analysis. These recommendations are made in light of current and foreseen uses of the roads, and the estimated environmental effects of the roads to aquatic resources. *The first step needed prior to finalizing restoration decisions, and prior to implementing any action on these roads is to conduct a field review of the selected roads. In addition, current GIS road coverages should be updated to reflect current road status for all existing and decommissioned roads in the watershed.*

1) Field review the following roads for maintenance needs, and prioritize for upgrading or maintenance to protect aquatic resources:

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
30-102	7	1.75	Upper Wind	B
30-136	10	0.94	Upper Wind	B
3053-030	23	2.58	Upper Wind	B
3053-030*	22	0.24	Upper Wind	B
3059	36	0.70	Lower Wind	A
3062	37	3.38	Middle Wind	J
31	55	2.60	Lower Wind	A
31-106	60	1.72	Upper Wind	B
31-106*	57	0.22	Upper Wind	B
31-107	65	0.59	Upper Wind	B
33	77	6.46	Trout	M
33*	81	0.53	Trout	I
33-408*	85	1.22	Trout	M
33-409	86	0.86	Trout	M
42	101	7.80	Trout	H
43	112	9.06	Trout	N
4303	128	3.28	Trout	I
4303-413	132	2.66	Trout	I
4303-414	134	1.63	Trout	N
4303-430	135	0.63	Middle Wind	J
4306	137	3.13	Trout	I
4309	139	2.23	Trout	N
4309-415	141	1.91	Trout	M
54	148	9.15	Trout	I

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
60	177	13.13	Middle Wind	G
60-300	196	3.31	Panther	L
6048	213	3.28	Falls	C
6057-048	233	0.86	Panther	L
6060-059	241	1.99	Middle Wind	J
65	276	17.65	Upper Wind	W
6511	300	0.3	Panther	L
6513	302	1.56	Panther	Q
67	310	1.2	Upper Wind	B
67	309	2.86	Falls	C
6701	340	3.18	Upper Wind	B
6701	339	0.86	Falls	P
6707	353	0.88	Falls	C
6707-127	355	1.65	Falls	C
67-121	319	2.06	Upper Wind	B
67-122	321	1.09	Falls	C
67-123	322	0.80	Falls	C
67-124	327	3.24	Upper Wind	B
67-125	330	1.67	Upper Wind	B
6801	375	2.48	Panther	R
6801	388	2.31	Panther	R
6801-069	386	3.5	Panther	L
6801-601	390	0.37	Panther	L

2) Field review the following single purpose roads and evaluate for stormproofing or decommission:

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
6707	352	0.7	Upper Wind	V
30-678	20	0.23	Upper Wind	B
31-106*	59	0.43	Upper Wind	B
3055-145	31	0.51	Upper Wind	B
3056	34	1.52	Upper Wind	B
60-078	191	0.61	Middle Wind	J
60-088	193	0.75	Middle Wind	J
60-089	194	0.54	Middle Wind	J
33*	75	0.26	Trout	M

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
33-407	82	0.57	Trout	M
6048-021	215	1.14	Panther	L
6801-026	382	0.61	Panther	L
50-608	146	0.36	Panther	L
6057-024	231	0.68	Panther	L
65-030	286	3.47	Panther	L
6513	301	1.44	Panther	Q
6801	376	2.66	Panther	L
6801-071	389	0.39	Panther	R

3) Field review and decommission the following non-essential roads—high priority:

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
30-101	4	1.50	Upper Wind	B
30-102*	6	0.13	Upper Wind	B
30-138	13	0.15	Upper Wind	B
67-121*	315	0.2	Upper Wind	B
60-064	189	0.41	Falls	C
6063-039	246	0.41	Middle Wind	J

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
42-420	107	0.28	Trout	H
60-788	206	0.43	Panther	L
65-606	297	0.33	Panther	L
6801-025	381	1.12	Panther	L
6801-605	391	0.17	Panther	L

4) Field review and decommission the following non-essential roads—moderate priority:

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
30*	3	0.73	Upper Wind	V
30-102*	5	0.11	Upper Wind	B
3056*	33	0.32	Upper Wind	B
3062-610	41	0.27	Upper Wind	V
30-650	19	0.23	Upper Wind	V
31*	53	0.1	Upper Wind	B
31*	54	0.52	Upper Wind	B
31-107	64	0.33	Upper Wind	B
31-107*	62	0.12	Upper Wind	B
6701-601*	344	0.21	Upper Wind	B
6701-604	346	0.71	Upper Wind	B
6701-605	347	0.09	Upper Wind	B
6701-605*	348	0.44	Upper Wind	B
6701-606	349	0.19	Upper Wind	B
6701-609	350	0.18	Upper Wind	B
67-121*	312	0.08	Upper Wind	B
67-121*	313	0.1	Upper Wind	B
67-121*	314	0.12	Upper Wind	B
67-121*	316	0.2	Upper Wind	B
67-121*	317	0.24	Upper Wind	B
67-124*	326	0.3	Upper Wind	B
67-124*	324	0.14	Upper Wind	B
67-124*	325	0.14	Upper Wind	B
60-064*	187	0.15	Falls	C
60-064*	190	0.46	Falls	C
60-305	198	0.21	Falls	C
6052*	218	0.15	Falls	C
6052*	219	0.39	Falls	C
60-792	208	0.43	Falls	C
65-066	289	0.60	Falls	C
67-143	332	0.39	Falls	C
67-600	335	0.19	Falls	C
30*	520	0.5	Middle Wind	J
30*	523	0.5	Middle Wind	J
30-601	15	0.24	Middle Wind	J
30-601*	508	0.7	Middle Wind	J
30-602*	17	0.76	Middle Wind	J

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
3080*	48	0.6	Middle Wind	J
54-610	159	0.33	Middle Wind	J
54-610*	160	0.73	Middle Wind	J
54-610*	158	0.16	Middle Wind	J
54-632	161	0.12	Middle Wind	J
60*	176	0.42	Middle Wind	G
60-094	195	0.34	Middle Wind	J
6052*	221	0.70	Middle Wind	G
60-680	202	0.36	Middle Wind	G
33-408*	84	0.3	Trout	M
33-408*	83	0.2	Trout	M
33-410	87	0.22	Trout	M
37-423*	95	0.18	Trout	H
37-604	99	0.11	Trout	H
43*	518	0.1	Trout	N
50-610	147	0.19	Panther	L
6057-048*	232	0.23	Panther	L
6057-079	236	0.5	Panther	L
60-786	204	0.29	Panther	L
60-788*	205	0.13	Panther	L
60-790	207	0.13	Panther	L
60-798	212	0.43	Panther	L
60-798*	419	0.26	Panther	L
62*	248	0.19	Panther	K
65*	505	0.4	Panther	Q
65-030*	284	0.12	Panther	L
65-030*	285	0.16	Panther	L
65-070*	524	0.4	Panther	Q
6801-028	385	0.59	Panther	L
60-798*	418	0.12	Bear	O
6808*	399	0.24	Bear	X
6808-012	409	0.33	Bear	O
6808-015	411	0.27	Bear	O
30*	1	0.14	Lower Wind	A
3107*	70	0.28	Lower Wind	A
6808*	401	0.3	Lower Wind	Z

5) Field review and decommission the following non-essential roads—low priority:

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
60-064*	188	0.20	Falls	C
60-309	199	0.38	Falls	C
60-311	200	0.06	Falls	C
60-320	201	0.27	Falls	P
6052*	216	0.12	Falls	C
6052*	217	0.14	Falls	C
60-795	209	0.15	Falls	C
60-796	210	0.23	Falls	P
60-797	211	0.27	Falls	P
65*	275	0.15	Falls	C
65-065	288	0.83	Falls	C
65-166	293	0.87	Falls	P
65-706	298	0.18	Falls	C
30-607	18	0.58	Dry	F
58-221*	167	0.30	Dry	E
58-222	169	0.21	Dry	F
58-223	170	0.08	Dry	E
58-606	173	0.28	Dry	D
64*	512	0.1	Dry	F
64*	513	0.2	Dry	F
64*	250	0.32	Dry	F
6401-218	266	0.24	Dry	F
6401-235	270	0.17	Dry	F
6401-243	272	0.61	Dry	F
64-201	255	0.67	Dry	F
64-201*	254	0.11	Dry	F
64-605	261	0.2	Dry	F
64-611*	262	0.28	Dry	F
30*	519	0.5	Middle Wind	J
30*	521	0.3	Middle Wind	J
30-602*	507	0.8	Middle Wind	J

FS Road Number	Road Seg No.*	Seg Length (miles)	6th Field Subwshed	7th Field
60*	174	0.11	Middle Wind	G
60*	175	0.18	Middle Wind	G
60-032	184	0.61	Middle Wind	G
6060-042	240	0.78	Middle Wind	J
4101	100	0.29	Trout	N
42-422	109	0.44	Trout	H
4303-600	136	0.21	Trout	I
4309-600	145	0.20	Trout	N
43-462	122	0.58	Trout	N
43-630*	517	0.2	Trout	N
43-635	125	0.32	Trout	N
54-431	155	0.48	Trout	N
65-604	294	0.29	Panther	Q
68*	502	0.5	Bear	T
6808*	404	0.54	Bear	X
6808*	395	0.13	Bear	X
6808*	396	0.14	Bear	X
6808*	397	0.23	Bear	X
6808*	398	0.23	Bear	X
6808*	402	0.32	Bear	X
6808-016	412	0.68	Bear	O
68-602	371	0.61	Bear	X
68-611*	372	0.07	Bear	X
(none)	526	0.3	Lower Wind	U
31-106*	58	0.23	Lower Wind	A
31-169	68	0.19	Lower Wind	A
6401-238	271	0.23	Lower Wind	A
6808*	400	0.28	Lower Wind	Y
6808*	403	0.43	Lower Wind	Z
6808-013	410	0.18	Lower Wind	Y

# FISHERIES

## Introduction

Timber harvest, road building, and other land use activities within the watershed have reduced the quality and quantity of fish habitat in the Wind River watershed. In 1992, the American Fisheries Society rated summer and winter steelhead at a moderate and high risk of extinction respectively, and they listed the Wind River sea-run cutthroat trout as extinct (Nehlsen, 1991). In 1997 Washington Department of Fish & Wildlife (WDFW) rated the Wind River summer run steelhead as critical. Wind River steelhead was listed as threatened under the Endangered Species Act (ESA) on May 18th, 1998. Due to the status of this stock, the Wind River summer steelhead has the highest priority for restoration in the State of Washington's Lower Columbia Steelhead Conservation Initiative. The following fisheries analysis builds on past assessments and assesses the current status of fish stocks, water quality and habitat. Management recommendations for preservation, restoration and monitoring within this report are based on this analysis. In addition, new data and analysis tools such as the Ecosystem Diagnosis and Treatment model (EDT) will be used to evaluate salmonid productivity. The EDT model is ongoing at this time and will be added as an addendum upon its completion.

## Fish Status

Cooperative efforts within the watershed since the 1995 watershed analysis have measurably increased our knowledge of fish distribution and life history. Pat Connolly and Ian Jezorek of the USGS and Dan Rawding and Charlie Cochran of Washington Department of Fish and Wildlife have made substantial progress toward understanding the biology of the watershed. Their efforts are reflected in the following narrative.

Fish assemblages in the Wind River can generally be divided into the area above and below Shipherd falls. The falls is a set of four plunges that drop a total of 43 feet in less than ¼ mile. Prior to construction of a fish ladder in 1956, only steelhead were capable of ascending these falls. Below the falls the following salmonids are present: spring and fall chinook, coho salmon, winter and summer steelhead, and coastal cutthroat trout. It is likely that chum salmon historically used this area but are believed to be extirpated. Other fish present include: largescale and bridgelip suckers, pacific and brook lamprey, three spine stickleback, sculpins, white sturgeon, resided shiners, peamouth, and northern pike minnow.

The number of fish species that consistently occur above Shipherd Falls in the Wind watershed is limited to five species, of which three are endemic (steelhead trout, shorthead sculpin, and mountain whitefish) and two are introduced (brook trout and spring chinook salmon). Steelhead are the only fish species that largely occurs throughout the portion of the watershed that is accessible to anadromous fish. No anadromous fish except unmarked steelhead are allowed above Hemlock Dam on Trout Creek. Shorthead sculpin is found in most areas except upstream of the canyon area of Trout Creek, which has numerous small falls that are potential barriers to this sculpin's upstream distribution. Mountain whitefish, brook trout, and spring chinook occur in limited areas of the watershed, and wider occurrence is probably limited by habitat requirements and preferences. Fish surveys and smolt trap catches suggest that natural reproduction by spring chinook occurs but has been very limited to date. There have been recent observations of other fish species above Shipherd Falls, including sockeye salmon, coho salmon, lamprey (1 or more species), and brown trout. These species could simply be strays or if they maintain self-sustaining populations, they are at a very low level.

*Steelhead; Onchorychus mykiss (Threatened, Lower Columbia ESU, 3/98)*

Natural spawning of summer and winter steelhead in the Wind River occurs primarily in upper main-stem reaches, but spawning also occurs in Trout Creek and Panther Creek and in the lower reaches of nearly every major tributary [REDACTED]. Until recently, Trout Creek accounted for a large amount of total spawning, but the annual adult return to Trout Creek has declined from over 450 (range: 162-464) in the

1980's to less than 30 and as low as 8 in 1990's. Forty-five percent of all redds observed in Wind River Watershed were found in Trout Creek between 1985 to 1989 (WDFW & USFS Redd survey and adult trap data, 1985-2000.1989, Wind River Sub-basin Salmon and Steelhead Plan). Prior to construction of a ladder over Shipherd Falls, steelhead were the only anadromous salmonid known to pass the falls successfully.

Size of historical spawning populations is not well documented, but historic run size has been estimated at 2,500 fish (Bryant 1951). The current escapement goal for wild summer steelhead is 1,000 adults, but the last time this goal was met was probably in 1970's. In 1999, WDFW initiated a mark-recapture study for wild summer and winter steelhead. Preliminary estimates indicate that less than 200 wild summer steelhead returned in 1999.

Based on redd and snorkel surveys, the abundance of wild summer steelhead population has declined since the late 1980s [REDACTED]. The data from these surveys serve as an index of population strength and change rather than estimates of population numbers because redd surveys cover a small portion of the basin and snorkel surveys have typically occurred before the entire run entered the basin. At the present time, a population estimate is unavailable for adult wild winter steelhead. Surveys in the mid-1980s and late 1990s found juvenile steelhead in all major tributaries accessible to returning adult steelhead, including Paradise, Dry, Trapper, Trout, and Panther creeks. A resurvey of streams in the late 1990s found that juvenile steelhead was present in all streams surveyed in the mid-1980s [REDACTED]. However, the densities and biomass of juvenile steelhead in the late 1990s were less than or similar, but never exceeded those from the mid-1980s.

# Steelhead (*Oncorhynchus mykiss*)

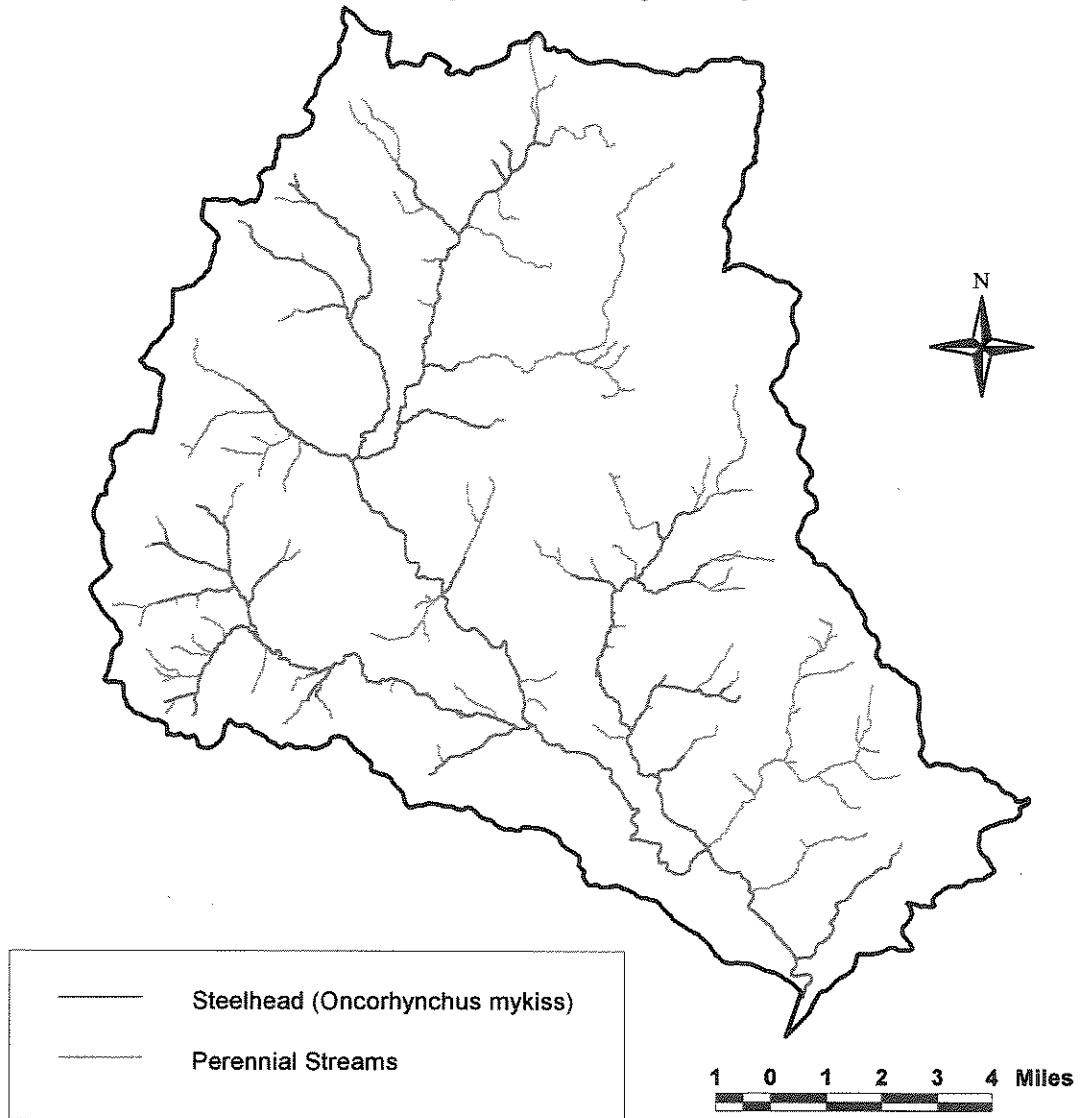


Figure F-1. Steelhead distribution in the Wind River watershed.

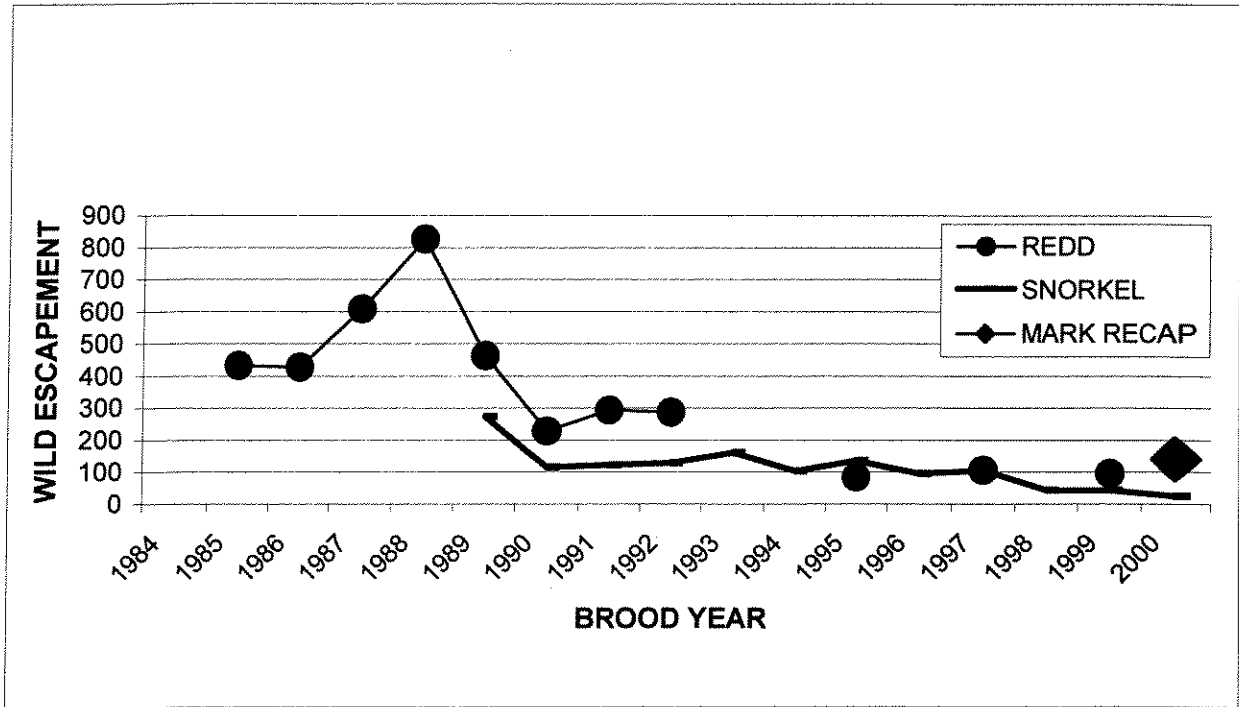


Figure F-2. Adult steelhead abundance derived from redd, snorkel and mark and recapture surveys for the Wind River, Skamania County Washington.

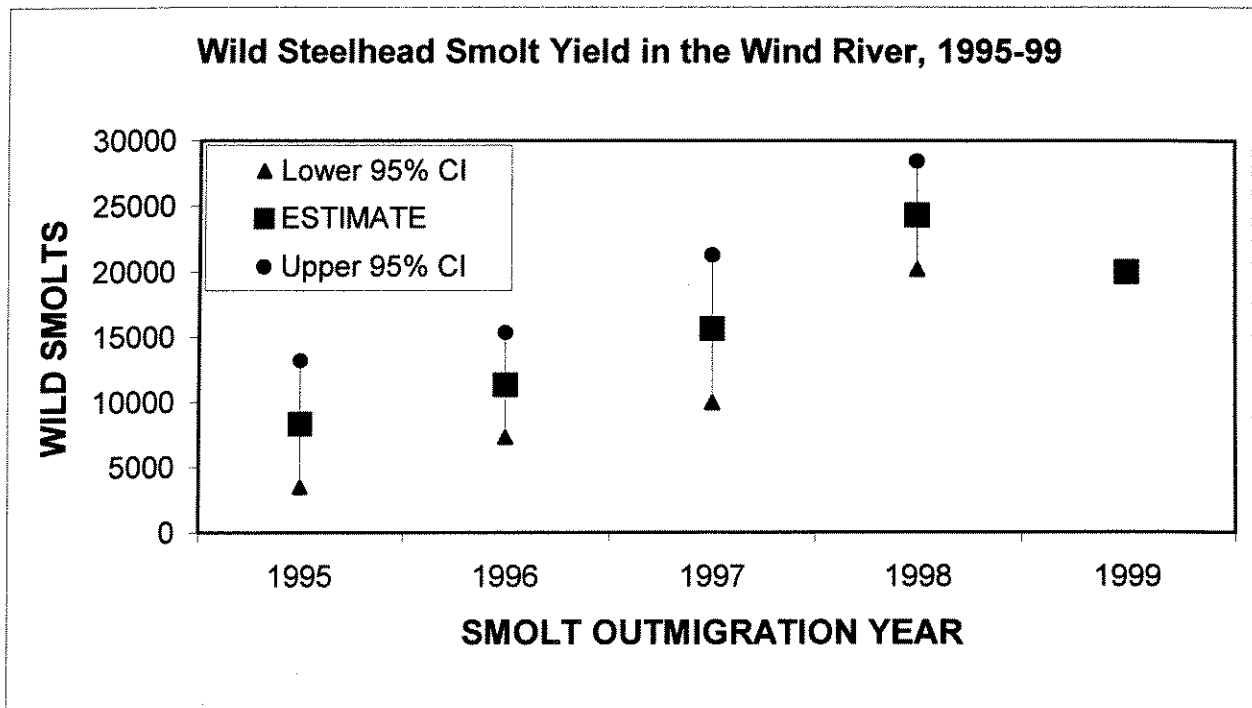


Figure F-3. 1995-1999 Wild steelhead smolt yield in the Wind River, Skamania County Washington.

There is concern about the ecological and genetic risks posed by the anadromous hatchery programs (NMFS 1996). Carson National Fish Hatchery was constructed on river mile 19 of the Wind River in 1938 to mitigate for the construction of Bonneville Dam and currently produces 1.8 million spring chinook smolts. A fish ladder at Shipherd Falls was constructed to allow salmon access to the hatchery at river mile 18.

Skamania Stock summer steelhead have been released in the Wind River watershed above Shipherd Falls most years since 1960. Releases of smolts were suspended in the early 1980s when WDG began managing the Wind River intensively for wild summer steelhead. Releases of adipose-clipped smolts were re-instated in the mid-1980s. The river has been managed under catch-and-release regulations for wild steelhead since that time. Angling closures and size-restrictions have been established to decrease angler take of juvenile steelhead and smolts. Hatchery releases of catchable rainbow trout were discontinued in 1994 and releases of hatchery steelhead were discontinued in 1997 because of concerns about negative ecological and genetic interactions with wild steelhead. An adult trap has been operated at river mile 2 on Trout Creek since 1993, and hatchery fish have been excluded from this tributary to preserve and maintain the genetic diversity of the wild stock. Recent genetic analyses by WDFW indicate genetic differences between hatchery and wild steelhead have been maintained. Due to the lack of reproductive success of hatchery Skamania stock in the wild, the exclusion of hatchery fish in Trout Creek, and the results of genetic analyses, WDFW believes that wild fish primarily sustains wild production in the watershed.

**Chinook salmon; Oncorhynchus tshawytscha(Threatened, Lower Columbia ESU, 3/99)**

Natural spawning of spring chinook in the upper Wind River did not occur until passage facilities were built at Shipherd Falls in 1956. After passage was provided, a spring chinook run was established at the Carson National Fish Hatchery (CNFH), and natural spawning began in habitats above and below the hatchery. Most juvenile chinook have been found in the main-stem Wind River above the hatchery but occasionally in tributaries including Compass, Crater, Planting, Trout, and Trapper creeks. In two years of smolt trapping below one of primary spawning areas (above the CNFH) only four unclipped chinook smolts have been observed, which equates to approximately 16 naturally produced smolts. WDFW believes the majority of naturally spawning fish are hatchery strays, and that this population is not a self-sustaining. Currently, spring chinook salmon in the Wind River are managed for hatchery production.

## Spring Chinook (*Oncorhynchus tshawytscha*)



Figure F-4. Distribution of spring chinook in the Wind River system.

Natural spawning of tule fall chinook in the Wind River occurs in the main-stem below Shipherd Falls. Spawning also may occur in the Little Wind River, but surveys have not been completed for this tributary. Completion of Bonneville Dam inundated the primary habitat in the lower Wind River. Naturally produced fry are likely composed of naturally produced adults and hatchery strays.

observed each year in the lower Wind River smolt trap indicating that fall chinook are successfully spawning. Tule fall chinook in the Columbia Basin has primarily been managed for hatchery production.

### Fall chinook (*Oncorhynchus tshawytscha*)

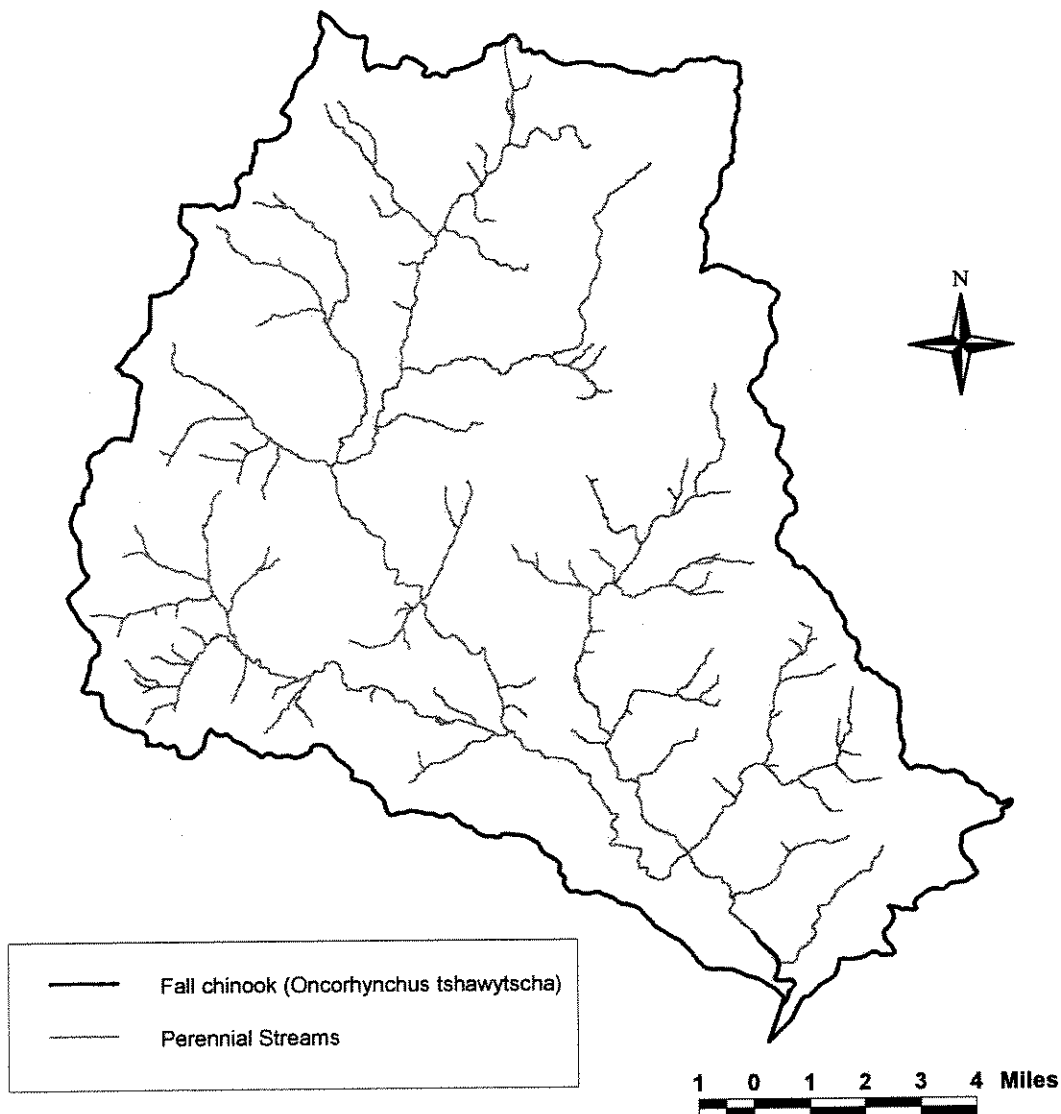


Figure F-5. Distribution of fall chinook in the Wind River system.

Bight fall chinook salmon originated from the Columbia River above McNary Dam. These fish have been reared at Bonneville and Little White Salmon hatcheries to mitigate for chinook salmon lost due to the

construction and operation of mainstem Columbia River dams. Strays brights from these facilities have been observed in the Wind River and natural production of bright fall chinook occurs in the Wind River. Bright fall chinook salmon tend to spawn later than tule fall chinook and the abundance of bright fall chinook salmon has been enumerated since 1988 in the lower Wind River .

*Bull Trout; Salvelinus confluentus (Threatened, 1998)* – The status of bull trout in the Wind River is unknown. Bull trout have been observed in the lower river below Shipherd Falls and managers believe that it is likely that these fish are part of an adfluvial population, which uses the Bonneville Pool. WDFW has initiated a bull trout-sampling project in the Columbia Gorge Province to more accurately determine the distribution of bull trout in the Wind River and other Washington tributaries. Until this project is completed, there is insufficient information to determine distribution, assess population status, or develop a recovery plan for these fish.

*Coastal cutthroat trout; Oncorhynchus clarki clarki (ESA candidate)* – Coastal cutthroat trout occur in the watershed, but the historic and recent distribution and status of this species are unknown. Historical distribution may have been limited to below Shipherd Falls, with the Little Wind River likely providing suitable habitat. Reports of cutthroat trout occurring above Shipherd Falls do exist, but they appear to be after hatchery cutthroat had been released into the watershed above Shipherd Falls. Hatchery cutthroat releases occurred at least as early as the 1930s, but were discontinued at least three decades ago. Personnel from USGS-CRRL have not observed any cutthroat trout during their extensive recent (1996-99) surveys in first and second order tributaries accessible to anadromous fish throughout the watershed above Shipherd Falls. WDFW personnel have observed three coastal cutthroat in five years of smolt out migration monitoring at the lower Wind River trap located below Shipherd Falls. Because of the limited information and the lack of sampling that specifically targeted cutthroat trout, the status of coastal cutthroat trout in the watershed is unknown, but, if present, the population number appears to be very low, the distribution appears to be very limited, and the sea-run form may be extirpated.

*Coho; Oncorhynchus kisutch (ESA candidate, Lower Columbia ESU, 7/95)*

The primary spawning grounds for coho were inundated by the Bonneville dam pool in 1938 yet a small spawning population of coho persists in the Wind River. WDFW believes that upstream adult coho distribution was limited to the area below Shipherd Falls. Although hatchery coho are not released in the basin, a few hatchery coho were observed at the Shipherd Falls adult trap in the fall of 1999 during the first year of adult trapping. Smolt trapping in the lower Wind River during the last five years has produced few wild coho smolts. This indicates that current natural production for coho is low and hatchery strays are a likely a source of any natural production.

## Coho (*Oncorhynchus kisutch*)

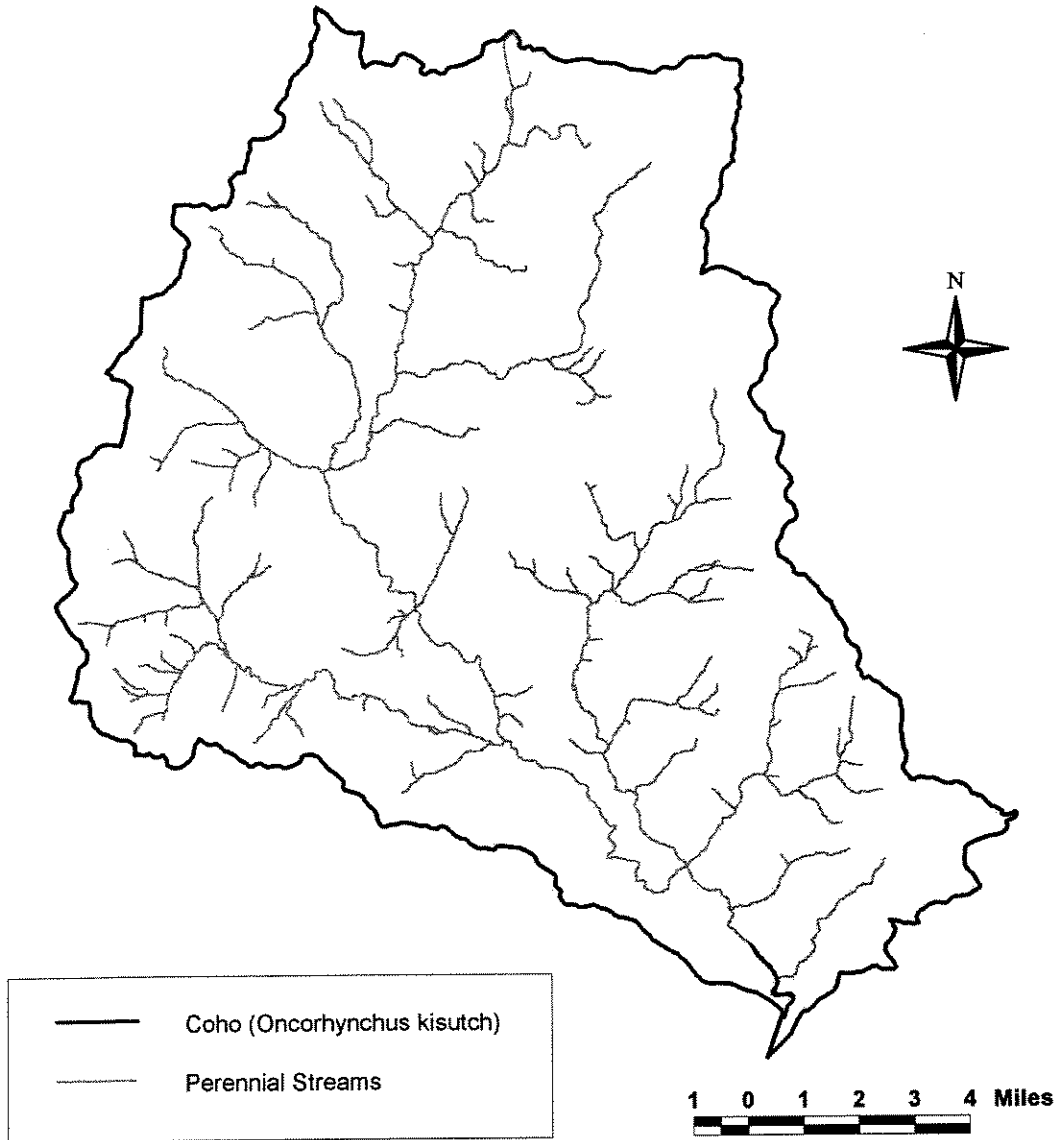


Figure F-6. Distribution of coho in the Wind River system.

*Resident Rainbow; Oncorhynchus mykiss and Brook Trout; Salvelinus fontinalis*

Resident rainbow trout are native to the Wind River drainage and occur sympatrically with steelhead within the anadromous zone. They are also present above the anadromous zone. Hatchery rainbow trout have been stocked in the Wind River watershed. Initially, hatchery trout were stocked throughout to provide local anglers recreational opportunities. The Hemlock Lake program was terminated in the early 1990's

due to concerns about declining steelhead in Trout Creek. When juvenile steelhead/rainbow trout were collected for genetic analysis in the 1990's, there was no evidence of hatchery rainbow trout introgression in these collections. The status of rainbow trout is unknown at this time.

Brook trout are non-indigenous to the Wind River watershed. Hatchery releases have been discontinued but naturally reproducing populations have been established within the Wind River. Brook trout densities are highest in upper Trout Creek and Tyee Springs (Connolly et al. 2001). In these areas they are likely to compete with native rainbow/steelhead populations. The status of brook trout populations is unknown at this time.

*(Pacific Lamprey; lampetra tridentatus – YIN Species of Concern)*

Pacific lamprey have been observed in the Wind River subbasin above and below Shipherd Falls. The status of these fish is unknown. Pacific lamprey were historically and are currently important to the Yakama Indian Nation.

## **Historic Land Management and Influences on Steelhead and Aquatic Habitat**

Most populations of salmonids that historically occupied the Wind River watershed are considered depressed (WDF et al. 1993). Shipherd Falls, which is 4.3 miles upstream from the historic mouth of the Wind River, was a natural barrier to all anadromous fish except steelhead (Bryant 1949), summer steelhead were dominant and numerous above this barrier. USFWS (1951) estimated the summer steelhead run size was 3,250 with an escapement of 2,500 spawning adults. The current number of wild summer steelhead spawning in the Wind River has been reduced to approximately 200 adults in recent years (Rawding 1997). In addition, a fall race of chinook that dominated the lower reach of the Wind River is depressed and composed of a substantial number of stray hatchery fish (WDF et al 1993).

Anadromous fish losses have been attributed to adverse ocean conditions, the construction of Bonneville Dam, timber harvest, and rural development of the upper watershed (WDFW et al. 1990). These activities in the upper watershed have severely impacted riparian areas and stream channels in several key steelhead sub watersheds. Poor upland, riparian, channel conditions cumulatively produce maximum water temperatures exceeding 24°C (75°F), risk of increased peak flows and increased sedimentation (USDA 1996).

# Rainbow trout (*Oncorhynchus mykiss*)

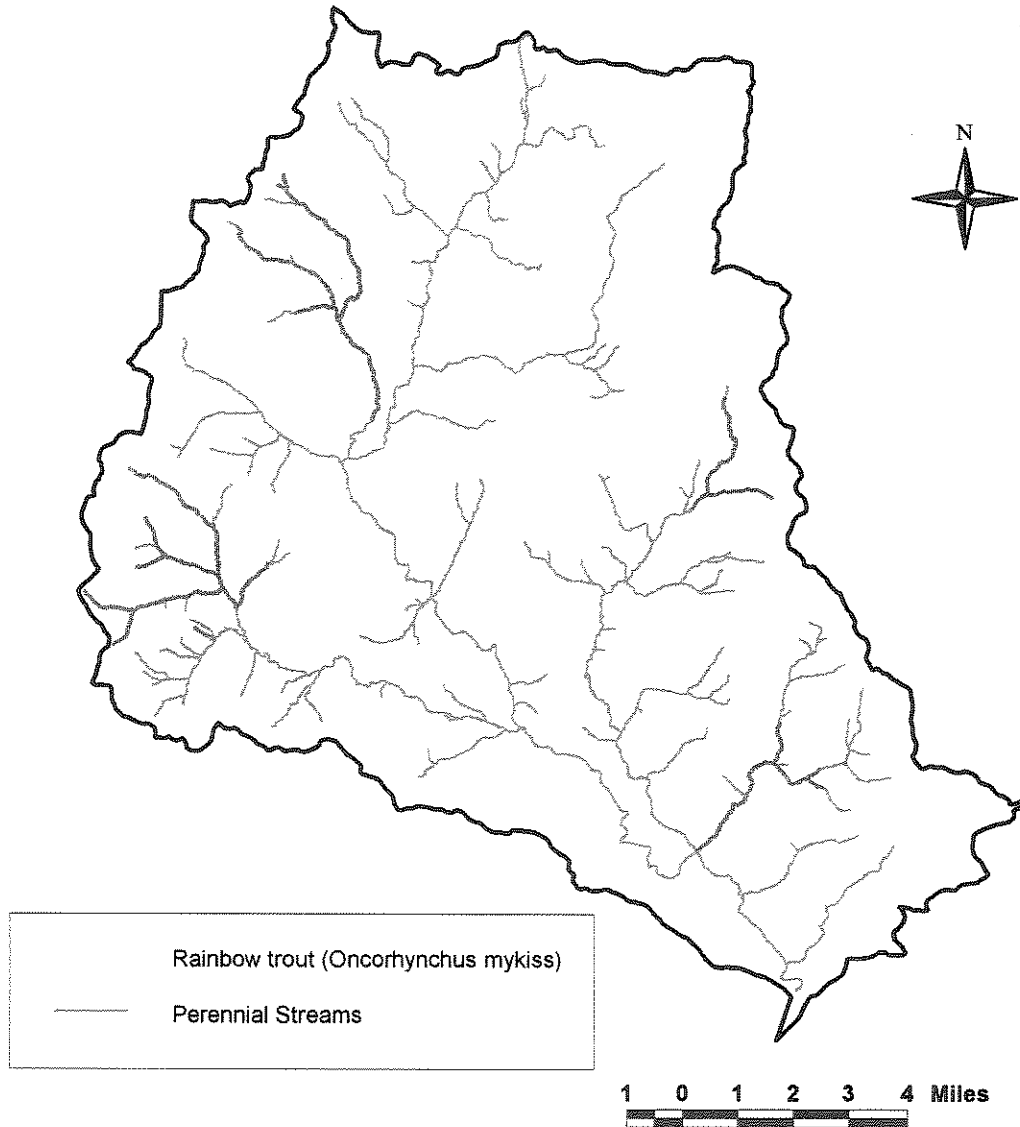
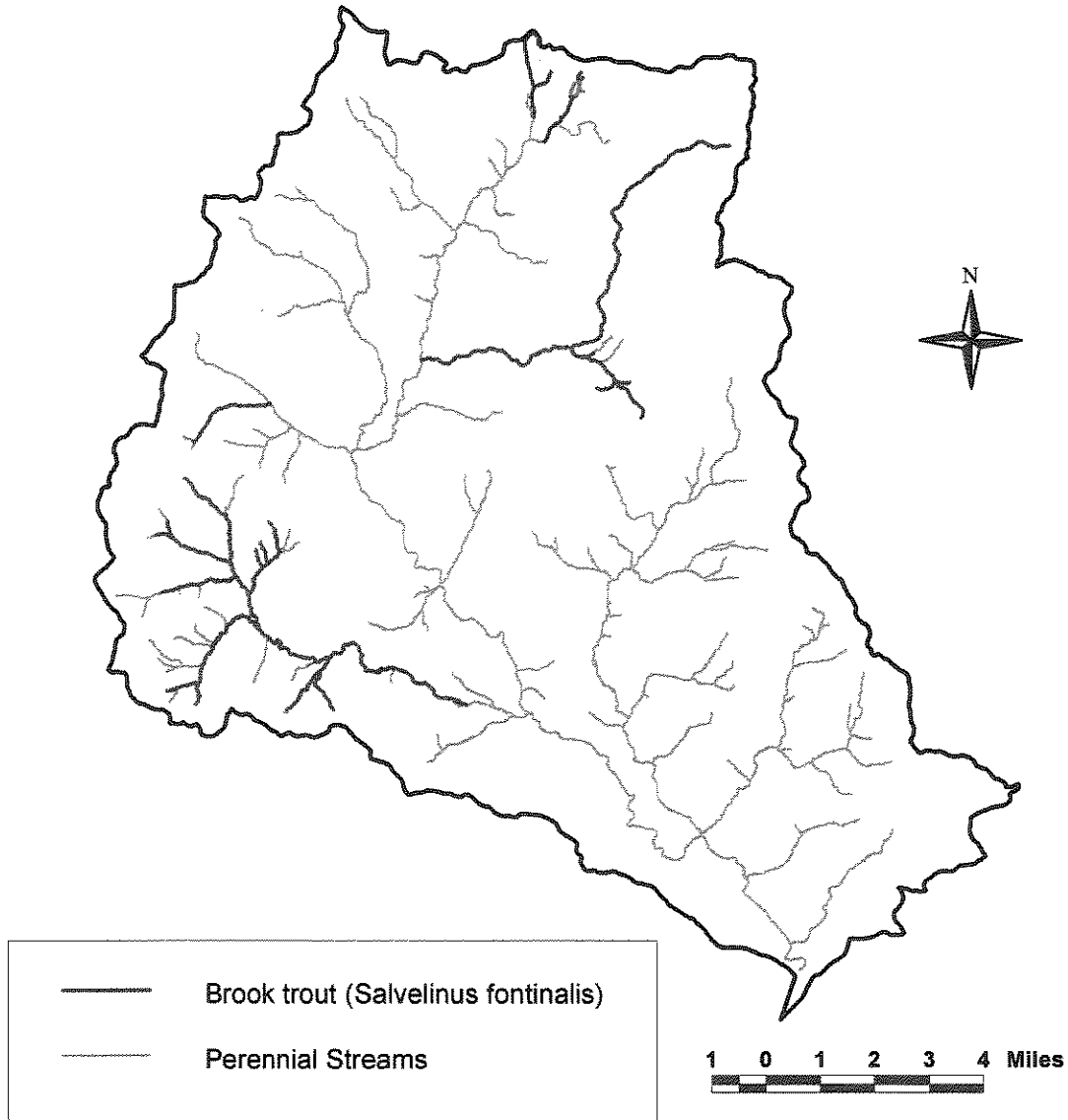


Figure F-7. Distribution of rainbow trout in the Wind River system.

## Brook trout (*Salvelinus fontinalis*)



**Figure F-8. Distribution of brook trout in the Wind River system.**

The predominant land management activity within the Wind River watershed has been timber harvest. Timber harvest within the basin began in the late 1800's. "Splash dams" were constructed on the main stem Wind River and tributaries to stockpile and transport logs down stream to the mills along the Columbia River. Riparian areas were targeted due to the large quantities of old growth timber and access to the stream.



Figure F-9. 1944 aerial photo of Dry Creek and the upper Wind River (river mile 20-25), Skamania County, WA. Logging in the early part of the century focused on the main stem Wind River and major tributaries due to historic logging methods (splash dams and railroad logging) and the old growth timber along the streams.

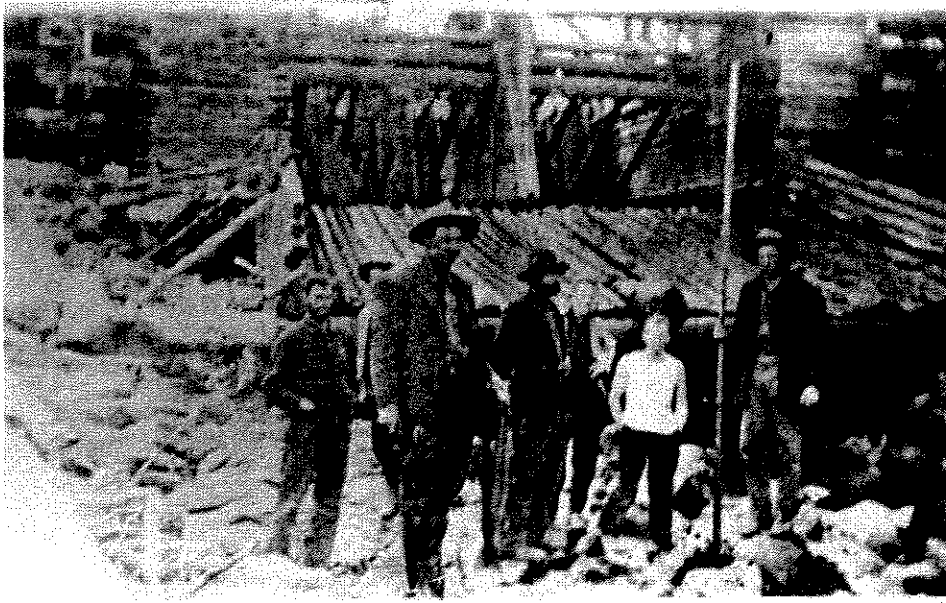


Figure F-10. 1902 Photo of the Trout Creek splash dam under construction, Skamania County, Washington. The man in foreground is holding a large fish presumably a steelhead caught at the base of the dam.

Although logging was the primary commercial resource within the watershed, steelhead trout have culturally been an integral part of the Wind River. Early managers recognized the importance of the fishery and built fish ladders around at least one of the splash dams. On February 29, 1916 Columbia Forest Supervisor, Anson Cohoon wrote to the District Ranger at Stabler Washington; *"Dear Mr. Cline, Please advise if you settled with Mr. Page, as instructed, for the meals furnished employees of the Wind River Lumber Co. while they were working on the fish ladder at the Trout Creek dam..."*. The Trout Creek

splash dam was taken out and replaced with a concrete dam in 1935 to supply electricity to the Ranger Station. A concrete fish ladder was constructed in 1936 and is still functional to this day. The ladder is one of the first concrete fish ladders built in the Pacific Northwest predating the ladder on Bonneville dam. There was not enough water through the summer months to generate electricity and the facility was converted to irrigate the Wind River Tree Nursery. The Wind River Nursery closed in 1997, and the reservoir has been maintained as a recreational facility

## Aquatic Habitat Status

Unlike many basins in the Northwest anadromous fish have access to over 95% of the historic spawning and rearing habitat. Minor blockages occur near the upper extent of steelhead use in the Wind River in Tyee springs, Youngman creek, and Oldman creek. These blockages total approximately less than two miles of 2<sup>nd</sup> order habitat. The single largest loss of habitat occurred with the flooding of the lower Wind River after the construction of Bonneville Dam. The dam inundated the primary spawning area for fall chinook, coho winter steelhead and chum salmon.

The USFS manages 89% land within the Wind River watershed. The Northwest Forest Plan (ROD) categorizes the Wind River Basin as a Tier 1, Key Watershed that provides critical habitat for anadromous salmonids. Federal management will largely determine the quality of habitat in the Wind River watershed. Some areas in the Trapper Creek wilderness are relatively undisturbed and contain excellent habitat. However, most habitats in the watershed is degraded compared to historic conditions. Habitat problems in the watershed are mainly related to past timber harvesting practices and rural development. This is evidenced by maximum water temperatures exceeding 24° C (75° F), increased peak flows, increased sedimentation, lack of large woody debris, increased width to depth ratios, and lack of riparian vegetation (USDA 1996). Throughout the watershed there continues to be a need to restore riparian vegetation, reduce sediment delivery to streams, enhance channel complexity and ensure continuous recruitment of large woody debris into the system. The Washington Department of Ecology has designated stream segments of the Wind River watershed water quality impaired. The 303(d) list identifies segments that do not meet the standards of the federal Clean Water Act. DOE is presently conducting a TMDL for water temperature in this watershed.

Stream surveys, sub-basin assessments and watershed analysis were used to evaluate limiting factors in the Wind River. Fish habitat and water quality have been negatively impacted by past riparian timber harvest, stream clean-outs, road building and regeneration harvest within the rain-on-snow zone. Alluvial reaches within the main-stem Wind River and tributaries, which contain the majority of steelhead spawning habitat, have been significantly impacted. Many of these reaches were disturbed over 80 years ago, yet habitat and water quality have not recovered and in some cases are getting worse.

Stream channels within the Wind River were classified with the Rosgen system, which incorporates channel slope, meander width ratio, channel entrenchment, sinuosity, and width to depth ratios. Channels were typed out as A, B, C, or E (USDA 1996). Low gradient meandering stream channels (generally Rosgen C, D and E channels) contain substrate and water velocities that are preferred by salmonids for spawning and early rearing. In addition, coho and chinook salmon prefer these channels for rearing to the smolt stage. Rosgen A and B channels have moderate to low sinuosity, moderate to low width to depth ratios, moderate to high gradients and high to moderate entrenchment. "A" and "B" channels are dominant in this watershed and provide excellent steelhead rearing habitat but contain limited spawning habitat. Rawding (1999a) summarized the movements of steelhead in Wind River from the available data. In general, adult steelhead holdover in the canyon areas of "B" channels, move into "C" channels or suitable spawning habitat in "B" channels for spring spawning. After emergence, fry seek out margin habitat of these channels for early rearing most fish are likely to over-winter near their natal areas. At age 1 in the late spring and early summer parr migrate into "B" channels and remain there until they smolt at age two or three. Redd survey data indicate that the "C" channels in the Trout Creek flats, Panther Creek, Middle Wind, and Upper Wind have provided the highest spawning densities for steelhead. In contrast the "B" channels in the Lower Wind, Lower Panther Creek, and Lower Trout Creek have produced up to 75% of the smolts in the Wind River (Rawding 1999b).

The majority of the main stem Wind River and Major tributaries have been logged. Rosgen B channel types within the Wind River are recovering at a more rapid pace and need less maintenance or rehabilitation than the low gradient alluvial C channels. The B channels are more confined/entrenched and are inherently more stable which allows riparian vegetation to recover at a more rapid rate than the more volatile alluvial C channels. Large woody debris complexity is still severely lacking within most of the B channels of the Wind River due to stream clean-outs and streamside logging.

Alluvial C channels need good riparian vegetation and adequate LWD to maintain lateral channel stability. Riparian areas and habitat within C channels have not recovered due to the lack mature conifers and root structure to maintain bank stability and the lack of in-stream wood needed for velocity modification that protects young riparian stands from floods. The result has been an acceleration of lateral channel migration that has severely degraded water quality and fish habitat.

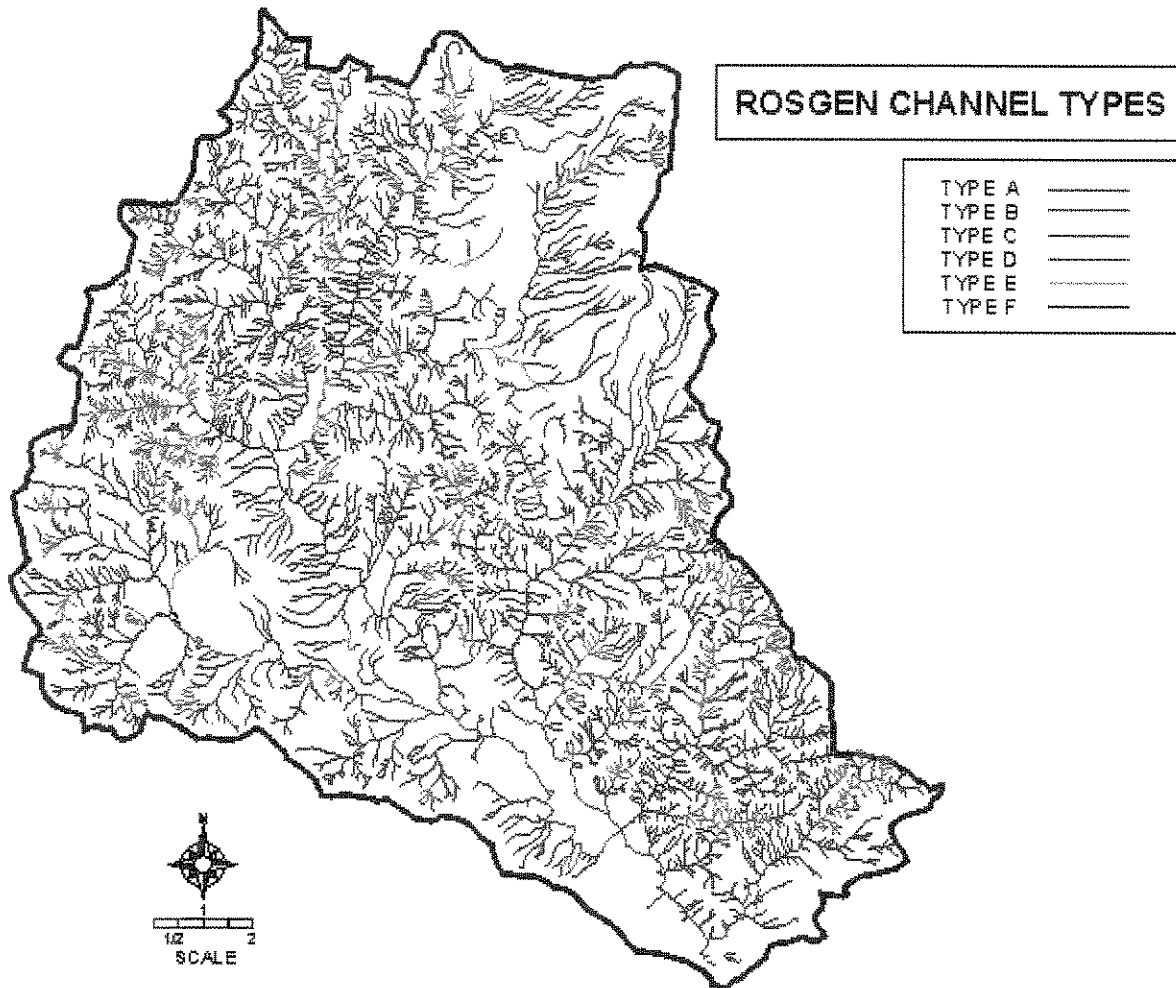


Figure F-11. Rosgen channel types throughout the Wind River.

Stream survey data and aerial photo analysis depict the problems found in the mining reach of the Wind River. Figures F-12 through F-15 show the existing channel conditions relative to the up-stream old growth reach. Large woody debris (>12" in diameter, >50' in length) within undisturbed reaches averaged 130 pieces per river mile in "C" channels of the Wind River watershed. Within the Mining reach average LWD was 73 pieces per river mile (Figure F-13). Riparian areas within the Mining reach are dominated with deciduous species such as alder, which help fix nitrogen within riparian soils and is an early successional species important to aquatic ecosystems. Alder typically reaches climax and dies after 30

years. Perpetual stands of alder typically exist within the belt width of alluvial channels (inner riparian zone). The dominance of alder outside of the historic belt width within this reach 70 years after being logged indicates that channel disturbance is outside the range of natural recovery. Analysis of belt widths provides additional evidence of accelerated disturbance and poor channel stability. Belt width is the width in which a stream contains its meanders. Belt widths in the up-stream section of the Mining reach are dominated with old growth timber. Belt widths within this reach averaged 60 meters compared to an average belt width of 145 meters in the logged reach just down-stream (Figure F-14). Bank full width to depth ratios also provides evidence of poor channel stability and habitat conditions. Bank full width to depth ratios within the old growth Mining reach averaged 18. Down-stream in the logged reach bank full width to depth ratios averaged 62 (Figure F-15).

### Wind River Riparian Seral Composition

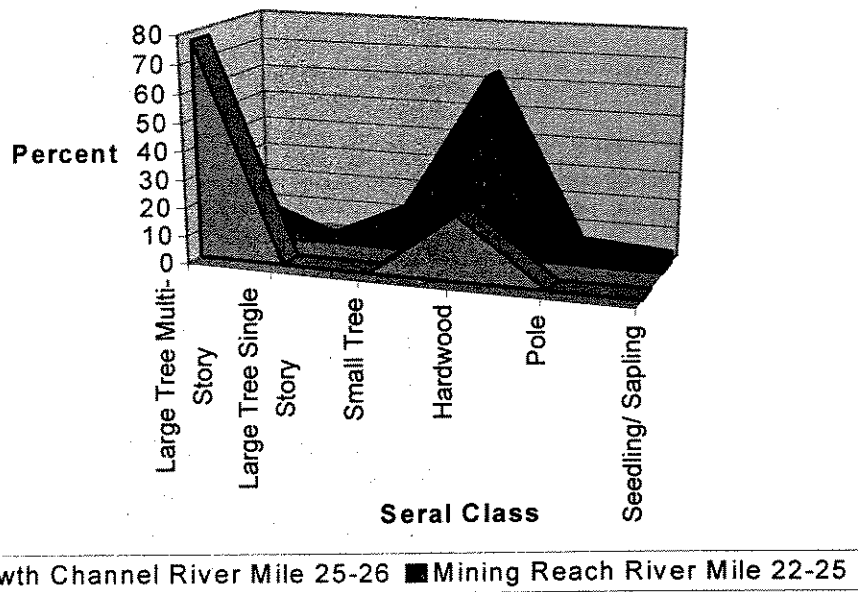


Figure F-12. Percent composition of riparian stands\* by seral class for the Wind River, River Mile 22-26, Skamania County Washington.

\* Riparian stands are delineated by the Aquatic Conservation Strategy standards; 360' from bank full channel. Seral class definitions: Large tree = 48"-32" in diameter, Small tree = 32"-9" in diameter, Hardwood = alder, maple, cottonwood, Pole = 9"-5" in diameter, Seedling/Sapling = <5" in diameter, Large tree multi-storied is a mix of large and small class/ old growth.

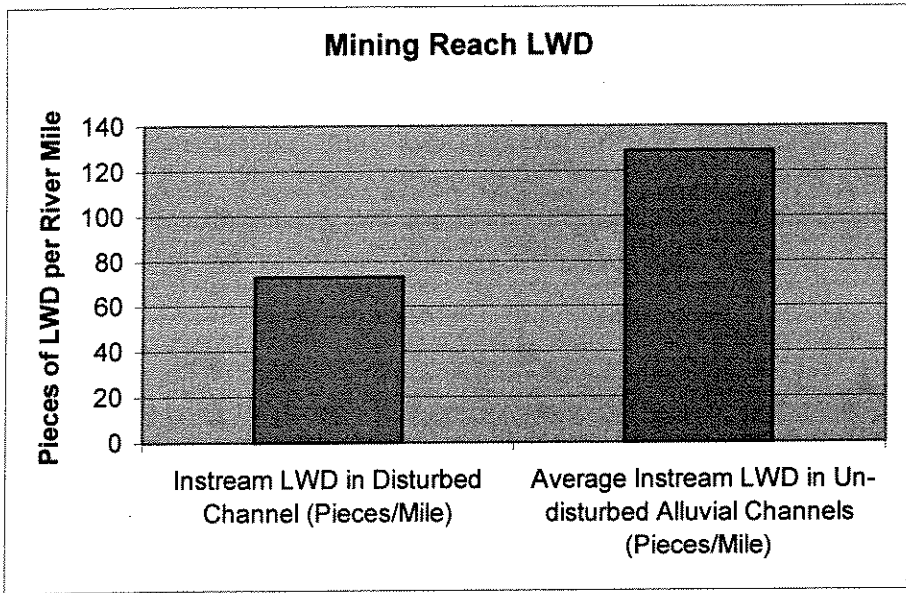


Figure F-13. Comparison of existing LWD observed in the Mining Reach and average LWD per river mile observed in 13 alluvial reaches of stream within Wind River, Skamania County Washington. LWD is defined as pieces >12" in diameter and >50' in length.

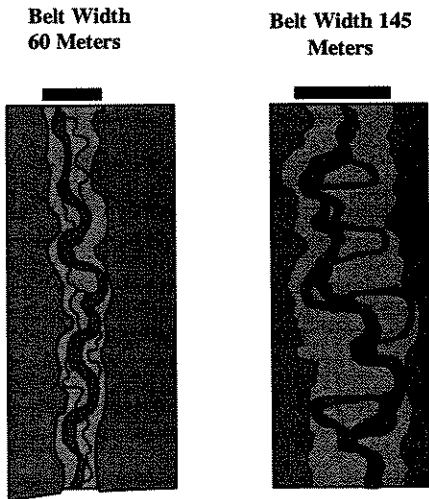
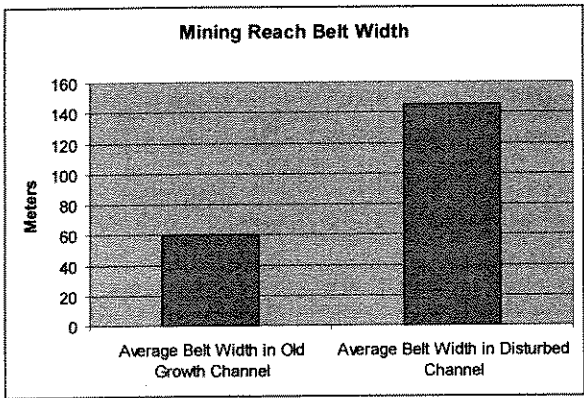


Figure F-14. Comparison of belt widths in old growth and disturbed channels for the Mining Reach of the Wind River, Skamania County WA.

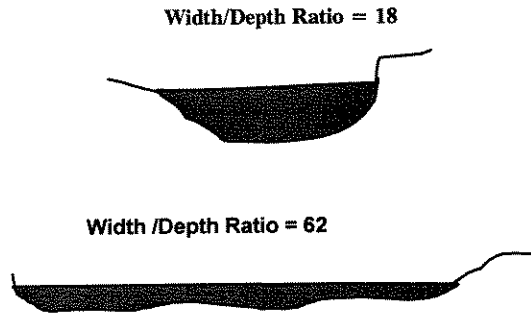
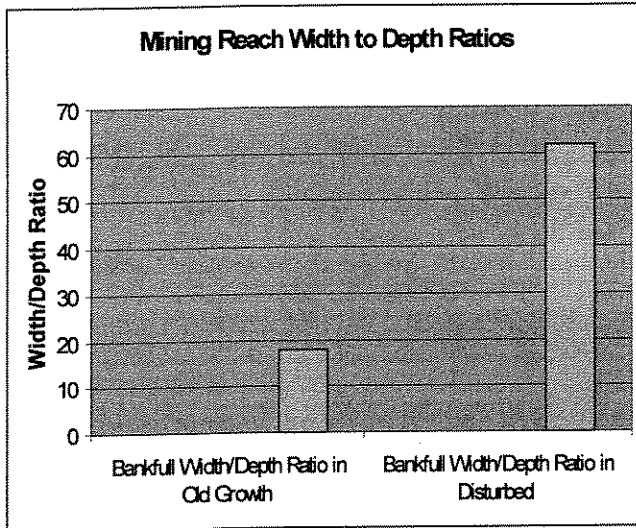


Figure F-15. Comparison of the average width to depth ratios in old growth and disturbed channels for the Mining Reach of the Wind River, Skamania County WA.

From the late 1800's to 1940 logging within the watershed was concentrated on the riparian areas of larger streams and valley bottoms. After World War II with technological advances in equipment, logging of the upper watershed within the rain on snow zone began in earnest. By the late 1970's wet winters and clear-cut logging within the upper watershed appears to have increased the magnitude of peak flow discharge.

The removal of mature streamside / instream LWD and clear-cut logging in the rain on snow zone was a one two punch for the riparian areas and stream channels. As streams began to recover from streamside logging peak flows increased which continually set the clock back by wiping out the young stands of riparian vegetation. From a biological stand point the discharge regime has dictated the evolution and influences all life histories of the Wind River steelhead. If the timing or magnitude of discharge is altered migration and spawning could also be negatively affected (Figure F-17). In addition, the removal of stream shade and the deterioration of channels has increased maximum water temperatures within the watershed. Figure F-17 graphically depicts that during warm water years altered maximum water temperatures pose a high risk of negatively affecting all life stages; immigration, spawning/emergence, rearing and emigration.

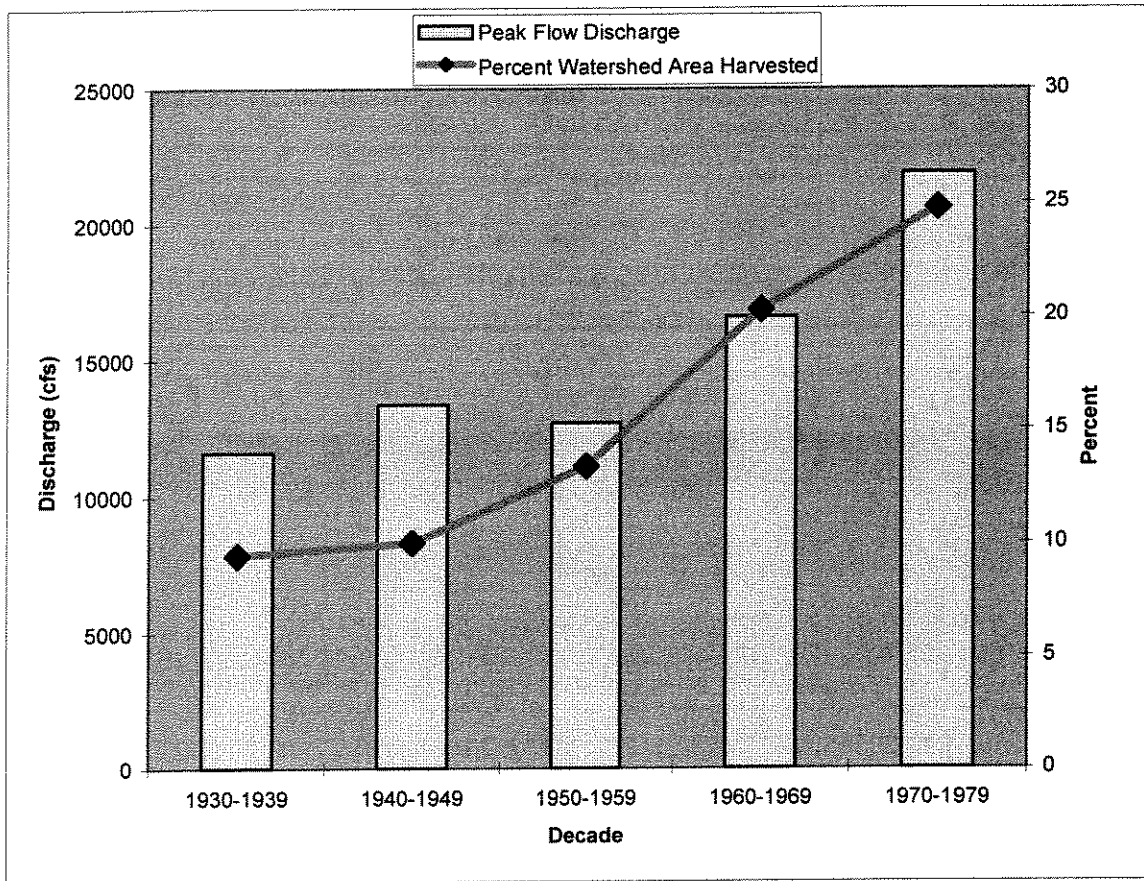


Figure F-16. Average peak flow discharge vs. the percentage of watershed area harvested by decade for the Wind River Watershed, Skamania County Washington.

## WATERSHED RESTORATION— INSTREAM AND RIPARIAN

In 1992, the Wind River watershed was assessed and the US Forest Service (USFS), US Fish and Wildlife Service (USFWS) and Underwood Conservation District (UCD) initiated cooperative habitat restoration projects in 1994. The Wind River Restoration Team (WRRT) was formed in 1994 in response to the decline of steelhead within the Wind River basin. The team includes technical specialists from the UCD, USFWS, WDFW, USGS, Washington Trout (WT) and the Yakama Nation (YN). Acknowledging that watershed-scale restoration can only be successful if all stakeholders are involved, the UCD, in cooperation with Skamania County and the WRRT, facilitated the development of the Wind River Watershed Council (WRWC) in 1997. The group is comprised of representatives of landowners, businesses, logging companies, government agencies, conservation groups, schools, and others. The mission of WRWC is “a partnership which encourages the use of land management practices which sustain and improve water quality, fish habitat, and other natural resources, while contributing to long-term economic and community sustainability within the Wind River watershed.” The WRWC meets monthly in Carson, WA. Meetings provide a clearinghouse for local input and knowledge as well as serve as a forum to ensure coordination of all watershed restoration activities. Through this process, restoration activities will be more effective at addressing the concerns of landowners, land managers, and resource users.

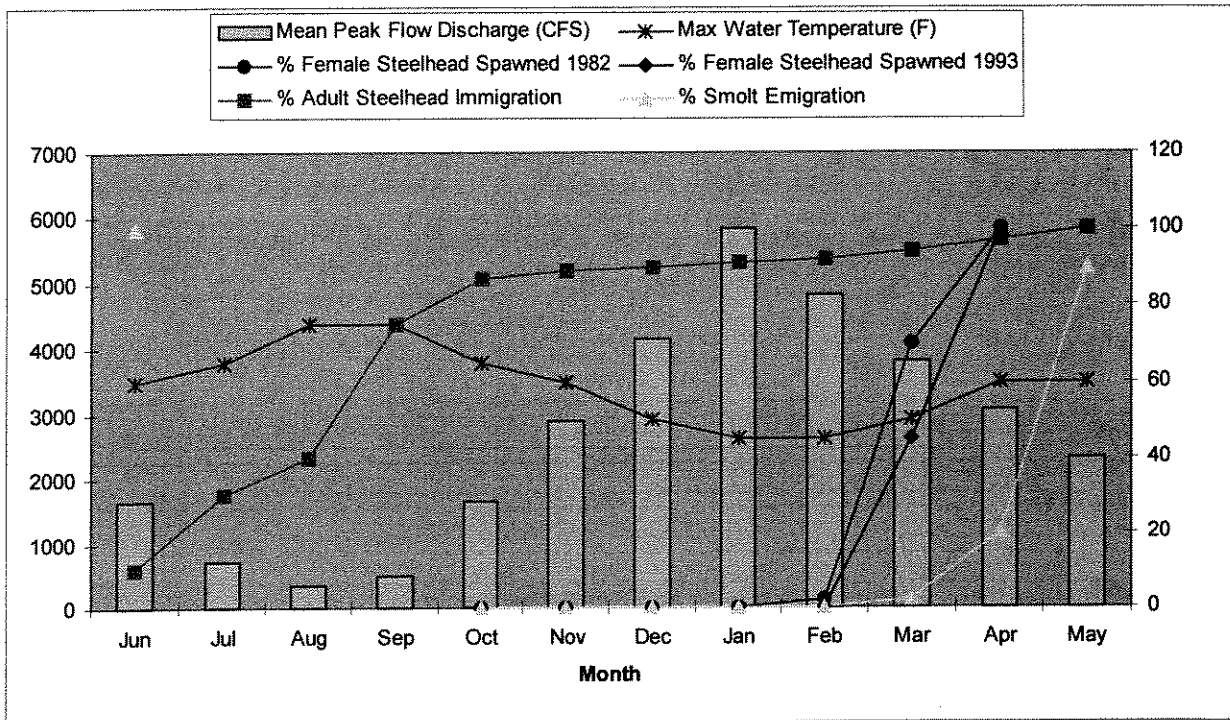


Figure F-17. Mean peak flow discharge (CFS), maximum water temperature, percentage of wild female steelhead spawned (1982 & 1993), percentage of adult wild steelhead immigration and percentage of smolt emigration by month for the Wind River, Skamania County, Washington.

The WRWC is supported by the Technical Advisory Committee (TAC), which is made up of members of the WRRT plus specialists in forestry, geomorphology, and education. The WRWC and TAC work collectively to solicit projects and to prioritize these activities for funding. Top priority projects are submitted to various state and federal funding sources, including the Lower Columbia Fish Recovery Board, with which we have a close working relationship.

Several environmental education programs in local schools are tied closely with the Wind River watershed project and receive technical assistance from the UCD, USFS, USFWS and WDFW. Stevenson High School classes conduct water quality monitoring, channel monitoring, and bio-assessment of the Wind River at select sites throughout the basin. Wind River Middle School classes conduct monitoring of restoration projects. Outreach projects include distributing brochures to basin landowners, installing signs along roads indicating watershed boundaries, and advertising the project in the local media.

The USFS completed a watershed analysis for the Wind River in 1996, which identified stream reaches that posed a high risk to the long-term survival of steelhead (USDA 1996). The analysis identified the Trout Creek watershed as the top priority for steelhead conservation due to the historic productivity and potential for recovery. In 1996 and 1997, the US Forest Service, US Fish and Wildlife Service and Underwood Conservation District expanded rehabilitation of the Trout Creek sub-watershed. In 1998 Bonneville Power Administration (BPA) Fish and Wildlife Restoration funds were received to accelerate restoration and monitoring within the watershed. These efforts have resulted in the development of bio-technical methods to improve steelhead habitat by stabilizing stream banks, improving channel complexity, reconnecting flood plains, and rehabilitating riparian areas (Bair 1997). In addition the USFS and USFWS cooperatively addressed adult fish passage problems at Hemlock Dam identified by Orsborn et al. (1987). These problems were partially corrected in 1996 by increasing adult attraction flow at the ladder entrance and eliminating false attraction flow from the Wind River Nursery irrigation bypass. Lethal maximum water temperatures, juvenile passage and recreation impacts at this facility remain unresolved. However Washington State University (WSU) was contracted to evaluate the facility and develop management recommendations. A proposal to remove the dam was made by WSU engineers in 1999.

The restoration projects completed to date are products of stream surveys (1987-1998), a sub-basin assessment (1992) and watershed analysis (1996) conducted by the USDA Forest Service (USFS). Projects on private lands are products of stream surveys conducted by Underwood Conservation District and US Fish & Wildlife Service. *The goals of these projects are to accelerate the recovery of water quality and fish habitat in which wild Wind River steelhead evolved.* These goals will be achieved by utilizing a holistic, community-based watershed restoration approaches on both public and private lands. Restoration efforts address known degraded streams, riparian areas, and hill-slopes. An adaptive management strategy has permitted partners to build upon past successes in restoring degraded water quality and habitat within the Wind River sub-basin. On-going collection and analysis of biological, physical habitat, and water quality data will fill information gaps on private and public lands. This information is necessary to assess watershed processes and success of past restoration efforts and to identify future restoration needs. Coordination and education of land owners, the community, and other stakeholders is an important part of achieving restoration goals and preserving wild steelhead within the watershed.

The goals of restoration efforts in the Wind River have been to accelerate the recovery of riparian, in-stream habitat and water quality in which the steelhead evolved. The objectives to accomplish these goals are: reduce road densities, reforest, and rehabilitate riparian areas, flood plains, and stream channels. The US Forest Service, US Fish and Wildlife Service, Bonneville Power Administration and Underwood Conservation District have made significant progress in restoring hydraulic processes and rehabilitation of critical habitat. Since 1992, approximately 100 miles of road have been stabilized or “storm-proofed”, 35 miles have been decommissioned, 120 acres of flood plain have been reclaimed, 300 riparian acres have been planted and 3,000 pieces of LWD have been placed back in 8 river miles of stream. In addition, the USFWS and UCD have initiated restoration on private lands with the implementation of two “demonstration” projects. One is a reforestation project along Martha Cr. near Stabler, and the other is a riparian and channel rehabilitation project on the Wind River. Funding was recently secured to conduct additional projects in the privately owned portion of the watershed. These activities will assist landowners with riparian and channel restoration, slope stabilization and erosion control.

Figure F-18 summarizes the proportion of restoration funding contributed by agencies involved in restoration efforts in the Wind River watershed. Figure F-19 depicts the percentage of funds expended by subwatershed within the Wind River.

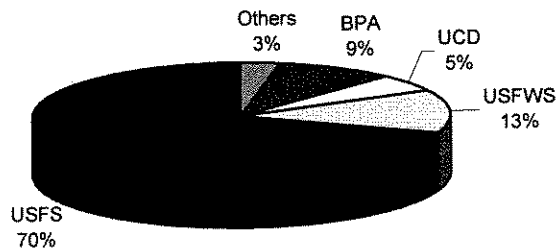


Figure F-18. The percentage of restoration funds contributed by cooperator (1991-1999), Wind River, Skamania County Washington.

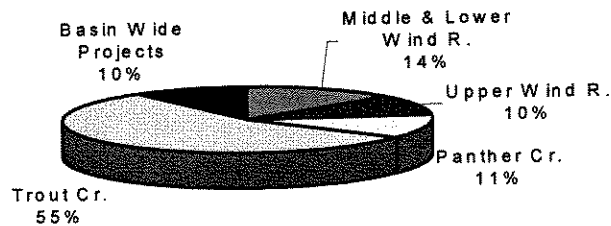


Figure F-19. The percentage of restoration funds expended by project area (1991-1999), Wind River, Skamania County Washington.

Habitat and water quality have made substantial improvements as a result of restoration efforts within the watershed. Monitoring in Trout and Layout Creek where the majority of restoration work has occurred since the 1995 Watershed Analysis have shown encouraging results. The Powers, 1998 Layout Creek Monitoring Report documented the following:

- Large woody debris (>12" in diameter) was increased 333%, from 36 to 120 pieces per mile.
- Bank stability was increased from 60% to 93%.
- Coarse and fine sediment input from eroding banks was decreased by 73%.
- Six hundred feet of relief/side channel habitat was reconnected to the flood plain.
- Subterranean flow was reduced by 80%.

Recent monitoring of the Mining Reach Restoration Project evaluated 700 meters of stream for physical changes after restoration. Preliminary results are as follows:

- Large woody debris (>12" in diameter) was increased 497%, from 76 to 378 pieces per mile.
- Increased bank stability by 58%.
- Increased bank full channel length by 48% by reconnecting flood plains and side channels.
- Increased bank full pool volume by 520% ( $429\text{m}^3 - 2234\text{m}^3$ ).

Biologically it is extremely hard to determine direct, indirect and cumulative effects associated with rehabilitation efforts due to the high variability of factors associated with both freshwater and marine environs. While there has been an increase in habitat usage and productivity in the last six years there is not enough data at this point to positively correlate those variables to restoration. The US Geological Survey, Biological Resources Division, Washington Department of Fish and Wildlife and the US Forest Service are working cooperatively to evaluate the effects of past and future restoration.

## Fisheries Summary


A fisheries risk factor analysis was conducted during the 1995 Wind River Watershed Analysis to prioritize watersheds and stream reaches for restoration. This exercise has been modified and repeated for the 2001 iteration. Table F-1 presents the 1995 risk factor analysis table. The 1995 aquatic impacts index prioritized sub-watersheds for restoration based on their potential to negatively impact aquatic organisms such as steelhead. Aquatic impacts index values were obtained by adding the number of "X's". The higher the index numbers the higher priority for restoration needs within that particular sub-watershed. The "Steelhead Biological Hot Spots" ranking is a quantitative and qualitative value based on past redd surveys, juvenile densities and potential quality of spawning and rearing habitat. Sub-watersheds that contained the hottest spots or higher biological productivity were used to further refine restoration priorities and focus funding on the areas that would have the greatest benefits.

Potential disease and competition denotes the presence of introduced, naturally producing non-native species such as brook trout or chinook. High risk of increased peak flows identifies sub-watersheds that

contain high road densities and/or high probability of rain on snow due to relatively high percentages of early seral vegetation within the basin. High risk of sedimentation impacts identifies sub-watersheds, which contain streams with unstable channels and banks and high sediment routing capabilities from roads. High risk of increased water temperature identifies sub-watersheds that have poor perennial riparian canopy cover, southern aspects and known temperature problems. "Extremely poor habitat conditions" identifies sub-watersheds that have streams with extremely poor riparian vegetation, LWD, and width/depth ratios. The "migration Barriers" column identifies sub-watersheds that possess subterranean flows, dams, or culverts that are migration barriers or impediments to fish.

**Table F-1. 1995 Wind River risk factor analysis and watershed ranking for restoration prioritization, Skamania County, Washington**

Aquatic Impacts Index	Sub-Watershed	Biological "Hot Spots" Ranked	Potential Disease and Competition	Risk of Hybridization	High Fishing Pressure	High Risk of Increased Peakflows	High Risk of Sediment Impacts	High Risk of Increased Maximum Water Temperature	Extremely Poor Habitat Conditions (Riparian Veg. LWD, Pools, WVD)	Migration Barriers (Subterranean Flows, Dams or Culverts)
8	Lower Trout	4	X	X	X	X	X	X	X	X
7	Layout	2	X	X	X	X	X	X	X	X
7	Upper Trout	3	X	X	X	X	X	X	X	X
7	Compass/Crater	5	X	X	X	X	X	X	X	X
6	Middle Wind	1	X	X	X	X	X	X	X	X
6	Headwaters Wind		X	X	X	X	X	X	X	X
5	Lower Falls		X	X	X	X	X	X	X	X
4	Pete's		X	X	X	X	X	X	X	X
4	Lower Panther	8	X	X	X	X	X	X	X	X
4	Upper Wind	7	X	X	X	X	X	X	X	X
4	Lower Wind	11	X	X	X	X	X	X	X	X
3	Nine-mile		X	X	X	X	X	X	X	X
3	Paradise	9	X	X	X	X	X	X	X	X
3	Trapper	6	X	X	X	X	X	X	X	X
3	Dry		X	X	X	X	X	X	X	X
3	Upper Panther		X	X	X	X	X	X	X	X
3	Eight-mile		X	X	X	X	X	X	X	X
3	Lower Bear		X	X	X	X	X	X	X	X
2	Mouse		X	X	X	X	X	X	X	X
1	Upper Falls		X	X	X	X	X	X	X	X
1	NF Bear		X	X	X	X	X	X	X	X
1	Cedar	12	X	X	X	X	X	X	X	X
1	Little Wind	10	X	X	X	X	X	X	X	X
1	EF Bear		X	X	X	X	X	X	X	X
1	Brush		X	X	X	X	X	X	X	X
0	Big Hollow		X	X	X	X	X	X	X	X

**KEY**  
 = Sub watershed Negatively Impacting Aquatic Resources

After sub-watersheds were prioritized stream survey data was evaluated to identify limiting factors and projects to rehabilitate habitat and water quality (1995 Wind River Watershed Analysis III-4-38). For the 2001 reiteration of the Wind River Watershed Analysis each attribute (i.e.; Risk of Increased Sedimentation, Risk of Increased Peak Flow, etc) were assigned numeric values (1, 0, -1) instead of "X's" for higher resolution. The "Extremely Poor Habitat Conditions" attribute in the 1995 analysis was expanded to represent each of the habitat elements i.e.; width to depth ratios, LWD, etc. The rest of the process was similar to the previous edition, which added the scores for attributes within each sub-watershed row and multiplied by the ranking of historic steelhead production. The highest negative values are associated with the watersheds that pose the greatest risk to limiting steelhead production and are priority for restoration. Risk factor analysis was performed for both 6<sup>th</sup> and 7<sup>th</sup> field watersheds to reflect the new watershed delineation and provide a reference for comparison of the old analysis.

The highest priority 6<sup>th</sup> field watersheds are: Trout Creek, Upper and Middle Wind River watersheds. The highest priority 7<sup>th</sup> field watersheds are: Lower Trout, Layout, Upper Trout, Middle Wind, Upper Wind and Compass/Crater sub-watersheds.

The results of the "higher resolution" 2001 version differ slightly from the 1995 analysis. Lower Trout remains the highest priority due to Hemlock dam, however Layout Creek dropped from the second highest priority to the fifth highest priority due in large part to the 1996-1997 restoration efforts. Upper Trout has shifted to the second highest priority due to the extremely poor condition of the upper reach.

Stream reaches were ranked similarly with numeric values (1, 0, -1) assigned and based on habitat conditions, which could negatively impact aquatic resources. These values were multiplied by the 7<sup>th</sup> field watershed restoration priority factor that was derived from the Aquatic Impacts Index.

**Table F-2. Wind River sixth field risk factor analysis and watershed ranking for restoration prioritization, Skamania County, Washington.**

6th field sub-watershed steelhead risk factor analysis and restoration prioritization for public lands, Wind River, Skamania County, Washington												
Aquatic Impacts Index	6th Field Sub-Watershed	Steelhead Spawning (Potential Production)	Potential for Disease and Competition	Potential for Poaching	Risk of Increased Peak Flows	Risk of Sedimentation Impacts	Risk of Maximum Water Temperature Impacts	Riparian Vegetation Conditions	LWD/Mile	Pool Quality	Wetted WD Ratios	Migration Barriers
-53	Trout	2	-1	-1	-1	-1	-1	-1	-1	0	-1	-1
-52	Upper Wind	3	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-51	Middle Wind	1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1
-10	Panther	4	-1	-1	-1	-1	-1	0	0	0	0	
-6	Lower Wind	6	-1	-1	-1	0	-1	-1	-1	0	0	
-4	Dry	5	0	-1	-1	-1	-1	0	-1	0	0	
-1	Falls	7	-1	-1	0	-1	-1	0	0	0	0	
-1	Bear	8	-1	0	-1	-1	-1	0	0	0	0	
Poor -1			Introduced Fish / Disease within watershed	Roads, Homes or Dispersed Camp Sites adjacent to Spawning or Holding Habitat	High Risk of Increased Peak Flows (Hydrology Assessment)	High Risk of Sedimentation Impacts (Hydrology Assessment)	Max. Water Temp >20 degrees. Poor Riparian Vegetation, Width/Depth Ratios and Watershed Aspect (degrees) 248-293 & 58-112	>25% EARLY SERAL	<75 pieces/mile	Pool Surface Area/ Volume >68	Width/ Depth >9	Dams, culverts or other human created barriers
Good 0			No known Introduced Fish / Disease within Watershed	Minimal Roads, Homes or Dispersed Camp Sites adjacent to Spawning or Holding Habitat	Moderate Risk of Increase Peak Flows	Moderate Risk of Sedimentation Impacts	Max. Water Temp 17-19 degrees, Good Riparian Vegetation, Width/Depth Ratios and Watershed Aspect (degrees) 234-315 & 46-68 & 112-134 & 226-248	10-24% EARLY SERAL	76-112 pieces/mile	Pool Surface Area/ Volume 59-68	Width/ Depth = 6-8	No known barriers
Excellent 1			Pristine	Pristine	Low Risk of Increased Peak Flows	Low Risk of Sedimentation Impacts	Max. Water Temp <17 degrees, Excellent Riparian Vegetation, Width/Depth Ratios and Watershed Aspect (degrees) 134-226 & 315-46	<10% EARLY SERAL	>112 pieces/mile	Pool Surface Area/ Volume <59	Width/ Depth <6	

**Table F-3. Wind River seventh field risk factor analysis and watershed ranking for restoration prioritization, Skamania County, Washington.**

Aquatic Impacts Index	Watershed ID	6th Field Sub-Watershed	7th Field Sub-Watershed	Steelhead Spawning	Potential for Disease and Competition	Potential for Poaching	Risk of Increased Peak Flows	Risk of Sedimentation Impacts	Risk of Maximum Water Temperature Impacts	Riparian Vegetation Conditions	LWD/Mile	Pool Quality	Wetted WD Ratios	Migration Barriers
-61	N	Trout	Lower Trout	4	-1	-1	-1	-1	-1	-1	-1	0	0	-1
-65	I	Trout	Upper Trout	3	-1	-1	-1	-1	-1	-1	-1	0	0	-1
-52	J	Middle Wind River	Middle Wind	1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1
-49	V	Upper Wind River	Upper Wind	7	-1	-1	-1	-1	-1	-1	-1	0	0	-1
-48	M	Trout	Layout	2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-45	H	Trout	Compass/Crater	5	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-2	T	Panther Creek	Lower Panther	8	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
-2	F	Dry	Dry	6	0	-1	-1	-1	-1	-1	-1	-1	-1	-1
-3	U	Lower Wind	Little Wind	10	0	-1	0	0	0	-1	-1	-1	-1	-1
-3	K	Panther Creek	Eight-mile		-1	0	-1	0	0	-1	-1	-1	-1	-1
-3	B	Upper Wind River	Headwaters Wind		-1	0	-1	-1	-1	0	0	-1	-1	-1
-4	A	Upper Wind River	Paradise		-1	-1	-1	0	0	0	-1	0	0	-1
-3	Z	Lower Wind	Lower Wind	11	-1	-1	0	-1	-1	-1	-1	-1	-1	-1
-2	G	Middle Wind River	Nine-mile		-1	0	-1	0	0	0	-1	0	0	-1
-2	W	Upper Wind River	Pete's Gulch		-1	0	-1	0	-1	-1	-1	0	0	-1
-2	C	Falls Creek	Lower Falls		-1	-1	0	-1	-1	-1	-1	-1	-1	-1
-2	P	Falls Creek	Upper Falls		-1	0	0	-1	-1	-1	-1	-1	-1	-1
-2	L	Panther Creek	Upper Panther		-1	0	-1	-1	-1	-1	-1	-1	-1	-1
-2	O	Bear Creek	Lower Bear		-1	0	0	0	0	0	0	-1	-1	-1
-2	S	Panther Creek	Cedar	12	0	-1	-1	0	0	-1	-1	-1	-1	-1
-2	R	Panther Creek	Mouse		0	0	0	-1	-1	-1	-1	-1	-1	-1
-2	D	Dry	Trapper	9	-1	-1	-1	0	0	0	0	0	0	0
-2	Y	Lower Wind	Brush		-1	0	0	0	0	0	0	0	0	0
-2	Q	Bear Creek	NF Bear		-1	0	-1	0	0	0	0	0	0	0
-2	X	Bear Creek	EF Bear		-1	0	0	-1	-1	-1	-1	-1	-1	-1
-2	E	Dry	Big Hollow		0	0	0	0	0	0	0	0	0	0
Poor -1					Introduced Fish / Disease within watershed	Roads, Homes or Dispersed Camp Sites adjacent to Spawning or Holding Habitat	High Risk of Increased Peak Flows (Hydrology Assessment)	High Risk of Sedimentation Impacts (Hydrology Assessment)	Max. Water Temp >20 degrees, Poor Riparian Vegetation, Width/Depth Ratios and Watershed Aspect (degrees) 248-293 & 58-112	>25% EARLY SERAL	<75 pieces/mile	Pool Surface Area/ Volume >68	Width/ Depth >9	Dams, culverts or other human created barriers
Good 0					No known Introduced Fish / Disease within Watershed	Minimal Roads, Homes or Dispersed Camp Sites adjacent to Spawning or Holding Habitat	Moderate Risk of Increase Peak Flows	Moderate Risk of Sedimentation Impacts	Max. Water Temp 17-19 degrees, Good Riparian Vegetation, Width/Depth Ratios and Watershed Aspect (degrees) 234-315 & 46-68 & 112-134 & 226-248	10-24% EARLY SERAL	76-112 pieces/mile	Pool Surface Area/ Volume 59-68	Width/ Depth = 6-8	No known barriers
Excellent 1							Low Risk of Increased Peak Flows	Low Risk of Sedimentation Impacts	Max. Water Temp <17 degrees, Excellent Riparian Vegetation, Width/Depth Ratios and Watershed Aspect (degrees) 134-226 & 315-46	<10% EARLY SERAL	>112 pieces/mile	Pool Surface Area/ Volume <59	Width/ Depth <6	

Table F-4. Stream reach ranking for the Wind River and tributaries, Skamania County, Washington.

Restoration Reach Rating	Restoration Watershed Priority Factor	Stream Name	Stream Reach	6th Field H2Oshed	7th Field H2Oshed	Pool Quality Rating	Low Flow W/D Ratio Rating	LWD Rating	Channel Stability Rating	Riparian Rating
135	27	E FK TROUT CK, rm 0.6-0.8, 09 92	3	Trout	Upper Trt					
108	27	E FK TROUT CK, rm 0.3-0.6, 09 92	2	Trout	Upper Trt	0	0	0	0	0
81	27	E FK TROUT CK, rm 0.3-0.3, 09 92	1	Trout	Upper Trt	0	0	0	0	0
72	18	FALLS CREEK, rm 2.9-0.0, 09 96	4	Falls	Lower File	0	0	0	0	0
60	20	PANTHER CK, rm 9.2-10.0, 09 94	7	Panther	Lower Prt	0	0	0	0	0
56	14	12 MILE CK, rm 0.0-0.5, 09 94	1	Panther	Upper Prt	0	0	0	0	0
54	18	FALLS CREEK, rm 1.6-2.9, 09 96	3	Falls	Lower File	-1	-1	-1	-1	-1
48	24	COMPASS CREEK, rm 1.7-2.1, 09 93	3	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
27	8	PARADISE CK, rm 1.0-2.3, 09 93	2	Upper Wnd	Paradise	0	0	0	0	0
27	27	E FK TROUT CK, rm 0.9-0.8, 09 92	4	Trout	Upper Trt	-1	-1	-1	-1	-1
26	26	SF PLANTING CK 09 92	2	Trout	Lower Trt	-1	-1	-1	-1	-1
24	24	CRATER CREEK, rm 1.6-1.8, 09 93	2	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
24	24	COMPASS CREEK, rm 1.1-1.7, 09 93	2	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
21	21	DRY CREEK, rm 3.4-3.8, 09 92	2	Dry	Dry Cr	0	0	0	0	0
20	20	PANTHER CK, rm 6.7-5.3, 09 94	3	Panther	Lower Prt	-1	-1	-1	-1	-1
20	20	PANTHER CK, rm 6.3-6.9, 09 94	4	Panther	Lower Prt	0	-1	-1	-1	-1
20	20	PANTHER CK, rm 7.7-9.2, 09 94	6	Panther	Lower Prt	0	0	-1	-1	-1
18	18	FALLS CREEK, rm 0.8-1.8, 09 96	2	Falls	Lower File	-1	-1	-1	-1	-1
16	16	UPPER WIND R, rm 27.9-28.6, 09 91	4	Upper Wnd	Hdwtra Wnd	-1	-1	-1	-1	-1
16	16	UPPER WIND R, rm 26.3-27.0, 09 91	2	Upper Wnd	Hdwtra Wnd	-1	-1	-1	-1	-1
16	16	UPPER WIND R, rm 27.4-28.4, 07 96	3	Upper Wnd	Hdwtra Wnd	0	0	0	0	0
14	14	10 MILE, rm 0.0-0.8, 09 94	1	Panther	Upper Prt	0	0	-1	-1	-1
10	10	PETES GULCH CK 8, rm 0.3-0.6, 09 96	2	Upper Wnd	Pete's	-1	-1	-1	-1	-1
6	2	TRAPPER	4	Trapper	Trapper	0	0	0	0	0
4	2	TRAPPER	6	Trapper	Trapper	0	0	0	0	0
2	1	RUSH CK, rm 0.6-1.7, 09 94	2	Rush	Rush	0	0	0	0	0
2	2	TRAPPER, rm 0.0-0.6, 09 94	1	Rush	Rush	0	0	0	0	0
2	2	TRAPPER	3	Trapper	Trapper	0	0	-1	-1	-1
2	2	TRAPPER	1	Trapper	Trapper	0	0	-1	-1	-1
0	4	MOUSE CK, rm 0.0-0.6, 09 94	1	Panther	Mouse	-1	0	0	0	0
0	2	TRAPPER	2	Trapper	Trapper	0	-1	-1	-1	-1
0	22	LAYOUT CK, rm 2.3-2.5, 09 91	3	Trout	Layout	-1	-1	-1	-1	-1
0	26	PLANTING CK, rm 0.4-0.9, 09 92	2	Trout	Lower Trt	0	0	0	0	0
0	26	*MIDDLE WIND, rm 16.9-20.4, 09 93	2	Middle Wnd	Mid Wnd	-1	-1	-1	-1	-1
0	26	TROUT CK, rm 2.8-4.8, 09 96	4	Trout	Lower Trt	0	-1	-1	-1	-1
0	24	CRATER CREEK, rm 1.1-1.5, 09 90	5	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
0	16	UPPER WIND R, rm 28.4-28.9, 07 96	4	Upper Wnd	Hdwtra Wnd	-1	0	0	0	0
-8	8	CEDAR CK, rm 1.3-2.5, 09 94	3	Panther	Cedar	-1	0	0	0	0
-10	10	PETES GULCH CK, rm 0.0-0.8, 09 96	1	Upper Wnd	Pete's	0	-1	-1	-1	-1
-10	10	PETES GULCH CK, rm 0.8-1.6, 09 96	2	Upper Wnd	Pete's	0	0	-1	-1	-1
-11	11	FALLS CREEK, rm 6.0-0.6, 09 96	5	Falls	Upper File	0	-1	-1	-1	-1
-13	13	8 MILE CK, rm 0.0-4.6, 09 94	1	8 Mile	8 Mile	0	-1	-1	-1	-1
-13	13	8 MILE CK, rm 0.8-1.3, 09 94	2	Panther	8 Mile	0	-1	-1	-1	-1
-15	15	OLDMAN CK, rm 0.0-1.1, 09 93	1	Upper Wnd	Hdwtra Wnd	0	-1	-1	-1	-1
-16	8	CEDAR CK, rm 0.4-1.3, 09 94	2	Panther	Cedar	-1	-1	0	-1	-1
-18	18	FALLS CREEK, rm 0.0-0.6, 09 96	1	Falls	Lower File	0	-1	-1	-1	-1
-18	9	PROVERBIAL CK, rm 0.0-1.5, 09 96	1	Upper Wnd	Paradise	0	0	-1	-1	-1
-20	20	PANTHER CK, rm 0.0-4.6, 09 94	1	Panther	Lower Prt	-1	-1	-1	-1	-1
-20	10	PETES GULCH CK 8, rm 0.0-0.5, 09 96	1	Upper Wnd	Pete's	0	0	-1	-1	-1
-21	21	DRY CREEK, rm 3.8-4.4, 09 92	3	Dry	Dry Cr	-1	-1	-1	-1	-1
-22	22	*LAYOUT CK, rm 0.0-1.9, 07 96	1	Trout	Layout	-1	-1	-1	-1	-1
-22	22	LAYOUT CK, rm 1.1-2.3, 09 91	2	Trout	Layout	-1	-1	-1	-1	-1
-22	11	FALLS CREEK, rm 9.5-11.4, 09 96	6	Falls	Upper File	-1	-1	-1	-1	-1
-23	23	*MIDDLE WIND, rm 22.0-24.4, 09 93	4	Upper Wnd	Upper Wnd	-1	0	-1	-1	-1
-24	24	CRATER CREEK, rm 1.5-1.8, 09 90	6	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
-24	24	CRATER CREEK, rm 0.8-1.1, 09 90	4	Trout	Crtr/Cmpa	-1	0	-1	-1	-1
-24	24	CRATER CREEK, rm 0.8-0.9, 09 90	3	Trout	Crtr/Cmpa	-1	0	-1	-1	-1
-25	25	*UPPER WIND R, rm 23.7-25.3, 09 91	1	Middle Wnd	Mid Wnd	0	-1	0	-1	-1
-26	26	TROUT CK, rm 2.4-2.8, 09 96	3	Trout	Lower Trt	-1	-1	-1	-1	-1
-26	26	SF PLANTING CK 09 92	1	Trout	Lower Trt	0	-1	-1	-1	-1
-26	26	PLANTING CK, rm 0.9-1.1, 09 92	3	Trout	Lower Trt	-1	-1	-1	-1	-1
-27	27	*TROUT CK, rm 5.4-4.7, 07 96	1	Trout	Upper Trt	-1	-1	0	0	0
-27	9	PROVERBIAL CK, rm 1.5-3.5, 09 95	2	Upper Wnd	Paradise	-1	0	-1	-1	-1
-27	9	PARADISE CK, rm 0.0-1.0, 09 93	1	Upper Wnd	Paradise	-1	-1	-1	-1	-1
-32	16	YOUNGMAN CK, rm 0.0-0.6, 09 93	1	Upper Wnd	Hdwtra Wnd	-1	0	-1	-1	-1
-32	18	UPPER WIND R, rm 28.6-29.0, 09 91	5	Upper Wnd	Hdwtra Wnd	-1	0	-1	-1	-1
-32	16	UPPER WIND R, rm 26.3-27.4, 07 96	2	Upper Wnd	Hdwtra Wnd	0	-1	-1	-1	-1
-32	16	UPPER WIND R, rm 28.9-29.7, 07 96	5	Upper Wnd	Hdwtra Wnd	0	-1	-1	-1	-1
-40	20	PANTHER CK, rm 6.2-7.7, 09 94	6	Panther	Lower Prt	-1	-1	-1	-1	-1
-40	20	PANTHER CK, rm 4.8-5.7, 09 94	2	Panther	Lower Prt	-1	-1	-1	-1	-1
-42	21	*DRY CREEK, rm 1.6-3.4, 09 92	1	Dry	Dry Cr	0	-1	-1	-1	-1
-44	22	LAYOUT CK, rm 1.9-2.5, 07 96	3	Trout	Layout	-1	-1	-1	-1	-1
-46	23	*MIDDLE WIND, rm 20.4-22.0, 09 93	3	Upper Wnd	Upper Wnd	-1	0	-1	-1	-1
-48	24	COMPASS CREEK, rm 1.5-2.4, 07 97	2	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
-48	16	UPPER WIND R, rm 27.0-27.9, 09 91	3	Upper Wnd	Hdwtra Wnd	-1	-1	-1	-1	-1
-48	16	YOUNGMAN CK, rm 0.9-1.7, 09 93	2	Upper Wnd	Hdwtra Wnd	-1	-1	-1	-1	-1
-48	16	OLDMAN CK, rm 1.6-2.1, 09 93	3	Upper Wnd	Hdwtra Wnd	-1	-1	-1	-1	-1
-50	26	*MIDDLE WIND, rm 16.7-18.9, 09 93	1	Middle Wnd	Mid Wnd	-1	0	-1	-1	-1
-52	26	TROUT CK, rm 1.8-2.4, 09 96	2	Trout	Lower Trt	0	0	-1	-1	-1
-52	26	PLANTING CK, rm 0.6-0.4, 09 92	1	Trout	Lower Trt	0	0	-1	-1	-1
-54	27	*TROUT CK, rm 6.8-8.7, 09 95	6	Trout	Upper Trt	0	0	-1	-1	-1
-54	27	*TROUT CK, rm 6.7-7.0, 07 96	2	Trout	Upper Trt	-1	-1	-1	-1	-1
-54	16	OLDMAN CK, rm 1.1-1.6, 09 93	2	Upper Wnd	Hdwtra Wnd	-1	0	-1	-1	-1
-56	22	*LAYOUT CK, rm 0.0-1.1, 09 91	1	Trout	Layout	0	-1	-1	-1	-1
-56	22	LAYOUT CK, rm 1.9-2.5, 07 96	2	Trout	Layout	0	-1	-1	-1	-1
-72	24	CRATER CREEK, rm 0.0-0.4, 09 90	1	Trout	Crtr/Cmpa	0	-1	-1	-1	-1
-72	24	COMPASS CREEK, rm 0.0-1.5, 07 97	1	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
-72	24	CRATER CREEK, rm 0.0-1.6, 07 96	1	Trout	Crtr/Cmpa	0	-1	-1	-1	-1
-78	26	PLANTING CK, rm 1.1-2.0, 09 92	4	Trout	Lower Trt	-1	0	-1	-1	-1
-78	26	TROUT CK, rm 8.7-9.4, 09 95	7	Trout	Lower Trt	-1	0	-1	-1	-1
-81	27	*TROUT CK, rm 7.9-9.4, 07 96	3	Trout	Upper Trt	0	-1	-1	-1	-1
-86	24	CRATER CREEK, rm 0.3-0.6, 09 89	2	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
-86	24	CRATER CREEK, rm 0.0-1.3, 09 93	1	Trout	Crtr/Cmpa	-1	-1	-1	-1	-1
-86	24	COMPASS CREEK, rm 0.0-3.1, 09 93	1	Trout	Crtr/Cmpa	0	-1	-1	-1	-1
-108	27	*TROUT CK, rm 4.6-4.8, 09 96	5	Trout	Upper Trt	0	-1	-1	-1	-1
-115	23	*UPPER WIND R, rm 22.0-23.3, 07 96	1	Upper Wnd	Upper Wnd	-1	-1	-1	-1	-1

Refuge ↑  
 ↓  
 Poor Habitat

\* = Project complete or ongoing

Key

Above median confidence interval for undisturbed reaches  
 Exist within the lower and median confidence intervals for undisturbed reaches  
 Below lower confidence interval for undisturbed reaches

The top 16 stream reaches in need of restoration are shown below in table F-5.

**Table F-5. Channel and Riparian Restoration project priorities, limiting factors and preliminary cost estimates for the Wind River watershed, Skamania County, Washington.**

Project Priority	6th Field Watershed	Stream Segment or Reach	River Miles	Pools	Limiting Factors					Migration Barriers	Cost Est.
					Width/Depth Ratio	LWD	Channel Stability/Bank Erosion	Riparian Vegetation Conditions	Flood Plain		
1	Trout	HEMLOCK DAM, rm 2.1	0.1		X					X	\$2,400,000
2	Trout	COMPASS CREEK, rm 0.0-1.1, 09 93	1.1	X	X	X	X	X			\$126,429
3	Trout	CRATER CREEK, rm 0.0-1.5, 09 93	1.5	X	X	X	X	X			\$172,403
4	Trout	TROUT CK, rm 8.7-9.4, 09 95	0.7		X	X	X	X	X		\$80,455
5	Trout	LAYOUT CK, rm 1.9-2.5, 07 98	0.6	X	X	X	X	X			\$68,961
7	Trout	N. FORK LAYOUT CK, rm 0.0-0.8	0.8	X	X	X	X	X			\$91,948
8	Trout	PLANTING CK, rm 0.0-1.5 09 92	1.5	X	X	X	X	X			\$172,403
9	Trout	SF PLANING CK 09 92	0.6	X	X	X	X	X			\$68,961
10	Trout	PLANTING CK, rm 1.1-2.0, 09 92	0.9	X	X	X	X	X			\$103,442
11	Trout	COMPASS CREEK, rm 1.5-2.4, 07 97	0.9	X	X	X	X				\$103,442
15	U Wind	PARADISE CK, rm 0.0-1.0, 09 93	1	X	X	X	X	X			\$114,935
12	U Wind	OLDMAN CK, rm 0.0-2.1, 09 93	2.1		X	X	X	X		X	\$241,364
13	U Wind	Wind R. rm 19.0-21.0	2			X			X		\$229,870
14	M Wind	Wind R. Private Land, rm 13.0-17.0	4	X	X	X	X	X			\$459,740
15	Panther	PANTHER CK, rm 6.9-7.7, 09 94	0.8	X	X	X	X	X			\$91,948
16	Panther	PANTHER CK, rm 4.6-5.7, 09 94	1.1	X	X	X	X	X			\$126,429
		<b>TOTALS</b>	19.7								\$4,652,726

The highest priority reaches of stream for channel and riparian restoration are: Trout Creek, river mile (rm) 2.1 (Hemlock Dam), Compass Creek rm 0-1.1, Crater Creek rm 0-1.5, Trout Creek rm 8.7- 9.4, Layout Creek N. S. Forks rm 1.9-2.5, Planting Creek rm 0-1.5, Paradise Creek rm 0-1.0, Oldman Creek rm 0-2.1, Wind River rm 19-21, Wind River rm 13-17, Panther Creek 4.6-7.7

## Recommendations for Instream Restoration

Trout Creek, Upper and Middle Wind River 6<sup>th</sup> field watersheds pose the greatest risk of negatively impacting water quality, fish habitat and steelhead production and are therefore the top priority for restoration.

Lower & Upper Trout Creek, Layout Creek, Compass/Crater Creek, Upper and Middle Wind River are the highest priority 7<sup>th</sup> field sub-watersheds for restoration.

For both 6<sup>th</sup> and 7<sup>th</sup> field watersheds, road density reduction projects designed to decrease the potential negative effects of road related sedimentation and peak flows are priority. Reducing road densities within riparian areas will also reduce the potential for poaching and harassment of juvenile and adult steelhead.

The following provides project recommendations by subwatershed.

**Trout Creek 6<sup>th</sup> Field Subwatershed**  
**Lower Trout Creek 7<sup>th</sup> Field Sub-watershed**

1. Modify or remove Hemlock Dam to allow unimpeded adult and juvenile migration and reduce maximum water temperatures.
2. Maintain existing adult fish trap or construct adult trap and weir if dam is removed.
2. Re-vegetate nursery fields to reduce peak flow impacts.
3. Increase LWD within Trout Creek; river mile 2.0-4.0

**Upper Trout, Layout, Compass/Crater Creek 7<sup>th</sup> Field Sub-watersheds**

1. Compass Creek rm 0-1.1, Crater Creek rm 0-1.5, Trout Creek rm 8.7- 9.4, Layout Creek N. S. Forks rm 1.9-2.5, Planting Creek rm 0-1.5, Pass Creek ~1.5-2.1 Stream Channel and Riparian Restoration; Objectives: decrease W/D, increase LWD, Pool quality and quantity, channel stability and off channel habitat.

**Upper Wind River 6<sup>th</sup> Field Subwatershed**  
**Paradise and Headwaters Wind River 7<sup>th</sup> Field Sub-watersheds**

1. Oldman and Youngman culvert removal/replacement
2. Paradise Creek rm 0-1.0, Oldman Creek rm 0-2.1 and Youngman stream channel stability and riparian restoration.

**Middle Wind River 6<sup>th</sup> Field Subwatershed**  
**Middle Wind River 7<sup>th</sup> Field Sub-watershed**

1. Wind River rm 19-21 (Falls – Dry Creek Reach), Wind River rm 13-17 (Private Idaho Reach) riparian and stream channel restoration.

**Panther Creek 6<sup>th</sup> Field Subwatershed**  
**Upper Panther Creek 7<sup>th</sup> Field Sub-watershed**

1. Panther Creek rm 4.5-7.5 pool and LWD enhancement.

**Dry Creek 6<sup>th</sup> Field Subwatershed**  
**Trapper Creek 7<sup>th</sup> Field Sub-watershed**

1. Trapper Creek Homes Riparian and Stream Management Plan.

## **Data Gaps**

**Level II Habitat Stream Surveys**

Martha, Nine-mile, Hollis, Bear and Lower Panther Creek, Lower Wind, Middle Wind, Little Wind River.

**Level III Geomorphology/Restoration surveys**

Falls-Dry Creek Reach

**Substrate Analysis**

Bear and Falls Creek

# RIPARIAN RESERVES

## Species and Habitats

### Introduction

This report documents the Wind River Riparian Reserve analysis, conducted as part of the second iteration of the Wind River Watershed Analysis. The Riparian Module, developed specifically for Watershed Analysis, was used as a guide only. Wind River is a Tier I Key Watershed on which numerous riparian restoration projects have occurred and on which more are planned. In addition, substantial silvicultural activities are planned in Late Successional Reserves such as Trout Creek and Dry Creek sub-watersheds. For these reasons, this riparian module endeavors to provide updated information on the riparian system to the Wind Watershed Analysis, and to make recommendations for further activities in the area.

The riparian ecosystem is the interface between riverine and terrestrial habitats. Its dimensions can be analyzed laterally, from floodplain to upland, and vertically, from subsurface to the canopy of riparian vegetation. With its location between the Cascades and Pacific Ocean, the Wind riparian system is highly productive, and likely the most important corridor in the watershed, used by diverse biota. Natural factors (disturbances) influencing both aquatic and terrestrial components of the riparian system are seasonal flows with periodic flooding, beavers and fire. Non-natural impacts to the riparian corridor of the Wind River are more pronounced: roading, logging, and recreation. Old-growth and old-growth characteristics occur only sporadically throughout the riparian system of the Wind River since it has been heavily impacted by logging. Some effects of human-caused impacts to riparian habitat, especially logging and road construction, have been previously documented (Wind River Watershed Analysis, First Iteration, 1996). This report further analyzes the habitat of the Wind watershed riparian system and the processes that affect it.

Much of the wildlife that occurs in the Wind River watershed is dependent upon the mosaic habitats of its riparian system. These habitats will be characterized in three ways: 1) specialized riparian habitats that occur in the Wind River watershed are defined (i.e., seeps and springs, splash zones, hardwoods, lentic systems and wetlands, and aquatic); 2) species of concern, especially species dependent upon old-growth forest, a habitat type that overlays all of the riparian habitats, are listed; and 3) natural processes affecting the heterogeneity of the riparian habitat are discussed. Stream morphology (also known as Rosgen stream channel types) along the Wind River is used to indicate both the potential for specialized riparian habitats and how the water interacts with the vegetation along certain stretches of the river.

## Habitats

### Forested Riparian Habitats

#### Hardwoods

Hardwoods (shrubs and trees) when they are part of a hardwood thicket or moist forest on the floodplain, provide food, cover and cool, shaded sites for a range of animals. Riparian hardwoods common in the watershed are alder, cascara, cottonwood, dogwood, elderberry, hazelnut, maple, and willow. Coarse woody debris is recruited and forest litter, leaf mold, and other debris are habitat attributes. Epiphytes, such as some rare lichens, become established on lush riparian hardwoods mixed with conifers (a "mixed forest"). As hardwoods lose their leaves, the gaps created allow sunlight to reach the forest floor. Periodic flooding and beaver or microclimate threatens species in this habitat. There are approximately 1590 acres of hardwoods in the riparian area of the Wind River.

## **Old-growth and Late-Successional Forests**

Older forests and trees provide the matrix for all the other special habitats indicated in this report. Riparian old-growth contributes stability and high nutrients to the aquatic system (e.g., diversity of insects, nitrogen-rich lichens from the canopy). The opposite is true, with a process called rheotaxis, where upstream migrating wildlife (e.g., salmon, elk, birds) bring evidence of the health of the watershed at the river's mouth, up to its headwaters. Some exemplary riparian old-growth stands still remain in the Wind River. Compass Creek, Government Mineral Springs, Martha Creek, Panther Creek, Paradise Creek, Pass Creek, and Trout Creek forests are known regionally for their high component of old-growth related species.

Riparian old-growth forests (including some late-successional forests) in the Wind River have been heavily logged in the 20<sup>th</sup> century. Logging practices were severely ground disturbing, leaving little of what would have been left after a natural disturbance such as fire and often removing the A1 soil horizon. These components are critical for certain species and, when they persist through generations, help the ecosystem to recover more quickly from disturbances. Characteristics that are important for biodiversity, that have been egregiously off-set by logging, are snags and woody debris, especially those that are well into decay; multiple layers of vegetation; the integrity and extent of the forest canopy; and the intact organic layers of soil.

## **Soil**

Soil organic matter, feeds fungi and is important for water absorption and retention. Certain plants when left as remnants between forest generations (e.g., ericaceous species, Douglas fir), help to maintain a mycorrhizal fungi complement that is critical in the development of a forest (Amaranthus et al. 1989). The forest floor and soil component are important for their physical and biological properties, but are often overlooked during management activities. Unwanted side effects of many management practices are increased soil density and decreased soil organic matter. Increased soil density, such as caused by compaction, is correlated to water storage, aeration, and other beneficial ecological qualities of particular importance to the highly productive and diverse riparian area. Compaction decreases soil structure and increases erosion (Childs et al. 1989). It is often removed during logging, road building, or other intensive management activity. When the flow of organic material is interrupted above ground, soil aggregation and forest productivity declines (Amaranthus et al. 1989).

## **Canopy**

Well-developed canopy layers in the riparian area maintain microclimate adds nutrients to the aquatic system and provides structure for habitat. Like soil organisms, canopy dwellers are frequently overlooked, but are becoming better understood in the Wind watershed with research done via the canopy crane. Rare lichens are found in the canopy over the Wind River. Arthropod species that are suspected in the watershed are 'canopy herbivores', 'coarse wood chewers', 'litter and soil dwelling species', 'understory and forest gap herbivores'. According to the SAT assessment, these arthropods' viability is provided by Riparian Reserves (Scientific Analysis Team, 1993).

## **Down Wood and Snags: Rationale for Desired Future Conditions (DFC) in Riparian Reserves**

Riparian areas are important habitats for wildlife and plant communities. Brown (1985) describes that 318 out of 414 wildlife species on the Westside of the Cascade Mountains use riparian or wetland plant communities as habitat. An additional 41 species are riparian or wetland obligates, which require these specialized habitats for all their life-history functions. Gregory et al. (1991) describes riparian communities as having approximately twice the number of species as upslope plant associations in the Oregon Cascades and the Sierra Nevada of California. Many bird species move through riparian corridors and wetlands during spring and fall migration as "fast-food" stops to refuel while many others breed or over winter there.

A DFC for Riparian Reserves at the watershed scale provides a wide range of ecosystem functions described under the Aquatic Conservation Strategy Objectives (ROD, page B-11) as well as terrestrial functions by connecting similar habitats on the landscape. The distribution and relative proportions of the various forest successional stages may begin to approximate the range of natural conditions prior to European-American settlement. As part of the DFC, maintaining or restoring habitat components like

snags, down wood, vertical canopy layering, canopy closure, and understory development shall provide habitat for a broad range of species and improve ecosystem function.

Under the Northwest Forest Plan, Riparian Reserves play a key role in providing long-term viability for a number of species listed in Appendix J2 (Holthausen et al. 1994). Within the Wind River Watershed, there are a number of botanical and wildlife Survey and Manage or Appendix J2 species known or suspected to occur within Riparian Reserves. For many of the species, we do not know the extent of their direct association with snags and down wood. Two Survey and Manage moss species, *Tetraphis geniculata* and *Buxbaumia viridis*, known to occur within the watershed, are rare and directly reliant on down wood for their habitat. Van Dyke's salamander is a Survey and Manage species known to use down wood in riparian areas as habitat (e.g. in stream debris jams). Many other local species, not on Survey and Manage or Appendix J2 lists, are reliant on snags and down wood in Riparian Reserves.

Another objective of Riparian Reserve management is connecting habitats for northern spotted owls (USDI 1993) contributing to their survival during dispersal. To meet this objective, Riparian Reserves shall be managed to provide quantities of down wood associated with robust populations of spotted owl prey species (small mammals) as well as maximize the extent to which we can provide habitat for other riparian-associated species, given the fact that Riparian Reserves have varying site potential. Data on down wood quantities are available through published, peer-reviewed research studies.

The Regional Ecosystem Office recommended that in LSR management, coarse woody debris objectives be based on research that shows optimum levels of habitat for late-successional forest-related species, and not simply based on quantitative values found in natural stands (Regional Ecosystem Office 1996). This recommendation transitions into a review of research findings about down wood levels.

#### **A Literature Review of Down Wood Resulting from Natural Disturbance**

There are a number of different measurements used to quantify down wood in scientific literature. Measures include biomass/acre, percent ground cover, number of fallen trees/acre, and volume/acre. The most common parameters appear to be biomass/acre and percent ground cover. While related, measurements of biomass and percent ground cover are not necessarily proportional. For instance Spies et al. (1988) measured down wood at 52 Mg/ha in young stands and 63 Mg/ha in old-growth stands in the Washington Cascades. However, these values converted to approximately 11.4% ground cover in young stands and 10.6% ground cover in old-growth stands. These data were taken in upslope areas.

Although there are some shortcomings and limitations to the percent ground cover parameter as described above, this parameter is one of the more commonly used parameters for comparison within the literature. For this reason, we shall express our Optimal Desired Future Conditions for down wood in Riparian Reserve in percent cover by a successional age class.

Minimum size criteria for down wood vary by study. Harmon et al. (1986) describe 4 inches as a minimum diameter for down wood because wood smaller than this decays substantially more rapidly. The Gifford Pinchot National Forest plant association guide uses size criteria for describing down wood of 3-6 inches in diameter, 6-12 inches in diameter, 12-20 inches in diameter, and >20 inches in diameter, and log lengths of >5 feet (Topik et al. 1986). For the development of the down wood DFCs, we shall adopt the most local measurements of 3 inches as a minimum diameter and 5 feet as a minimum length threshold for pieces of wood considered down wood.

Documentation on down wood levels in Douglas-fir forests within the Pacific Northwest suggests consistent trends between down wood levels and stand age under natural disturbances and is summarized below (Spies and Cline, 1988). Natural disturbances in the Pacific Northwest include disease or insect outbreak, fire, ice storm or windstorm events.

Table R-1. Down wood levels by stand age under natural disturbance.

Stand Age	Down Wood Levels under Natural Disturbance and Comments
30-80 years	<i>More</i> , greatest number of fallen trees of <i>all</i> sizes and often with wood carried over from the previous stand
80-200 years	<i>Least</i> , lowest number of fallen trees is at approximately 100 years where >50% of down wood comes from the previous stand and the remaining percent from the new stand
>200 years	<i>Most</i> , greatest number of <i>large</i> (>24 inches) fallen trees

Distribution of down wood by decay class also varies markedly by stand age. Maser et al. (1988) and Spies and Cline (1988) are fairly consistent with their findings. They inventoried proportions of biomass in decay classes. Much of the down wood in young (30-80 years) stands is remnant "carryover" wood from the previous stand while much of the wood in old-growth (>200 years) stands is recruited from within the existing stand.

Table R-2. Comparison between two research studies that inventoried the distribution of down wood by decay class and stand age under natural disturbance.

Stand Age	% Biomass of Down Wood in Decay Class 4 and 5	
	Spies and Cline 1988 (includes snags and down wood)	Maser et al. 1988 (down wood only)
30-80 years	59%	56%
80-200 years	37%	43%
>200 years	27%	34%

Little scientific literature focuses on and describes the amounts of down wood located specifically in riparian areas. However, amounts of debris, numbers and sizes of debris pieces generally increase with site moisture, as a result of higher site productivity, lower fire frequencies (which can consume some of the wood), and because of lower rates of decay resulting from excessively high moisture in the wood (Harmon et al. 1986, Maser et al. 1988). Spies and Franklin (1991) found that down wood levels on western Washington moist sites were 40% higher than on dry sites. Franklin et al. (1981) documented that the biomass of down wood in Douglas-fir forest old-growth plots in riparian areas were up to three times higher (259 tons/acre) than the average (85 tons/acre) taken for old-growth in a 2500-acre watershed. Franklin et al. (1981) attributed the large amounts of wood in riparian areas to down slope transfer as well as to moister site conditions. Spies and Cline (1988) found that down wood biomass in moist sites was three times higher than in dry sites of the Washington Cascades. These findings support the concept that we should expect greater amounts of down wood in Riparian Reserves than in upslope areas.

Table R-3. Summarized comparison of down wood levels within moist sites of old-growth stands.

	Quantity of Down Wood on Moist Sites within Old-Growth Stands (ranging 209 to >450 years) by Research Study				
	1	2	3	4	5
<b>Biomass of down wood on Moist Sites vs. Dry Sites</b>	3 times higher in riparian than drier upland	3 times or 300% higher on moist site Douglas-fir	40% higher on western WA moist sites	--	--
<b>% down wood ground cover</b>	23-29	--	24 avg (range 11-35)	15.3 avg	15-20
<b>Tons/acre</b>	259	--		--	--

1. Franklin et al. (1981)                      3. Spies and Franklin (1991)                      5. Carey and Johnson (1995)  
 2. Spies and Cline (1988)                      4. La Marr and Burgdorf (1999)

The following discussions pertain to the summarized data in Table R-3 above. Franklin et al. (1981) described down wood levels in riparian areas of old-growth Douglas-fir forests (approximately 350 or more years of age) as ranging up to 259 tons/acre. They document ground cover of 23-29% from mid-slope to

riparian stands in old growth forests. In the Wind River watershed, down wood data collected in late-successional riparian forest plots, average stand age 209 years based on GPNF GIS information, yielded an average of 15.3 percent ground cover of down wood 6 inches and greater in diameter (La Marr and Burgdorf, in progress). This mean value is based on 13, 1/10<sup>th</sup>-acre plots. Carey and Johnson (1995) found that 15-20% ground cover of well-distributed down wood is adequate for most small mammals they studied to reach their potential abundances. Carey and Johnson (1995) suggested that these greater amounts of down wood increased invertebrate populations, thus increasing populations of insectivorous small mammals.

### **Snags: Desired Future Condition (DFC) in Riparian Reserves**

Relatively little literature is available on snag levels specific to riparian areas. Maser et al. (1988) report snag densities in western Oregon and Washington in stands with natural disturbance as approximately 70 snags/acre in young stands (30-80 years), 50 snags/acre in mature stands (80-200 years), and 24 snags/acre in old-growth stands (>200 years). Cline et al. (1980) documented snag densities (>4 inches dbh) at approximately 207 snags/acre in young stands (30-80 years), down to 14 snags/acre in mature stands (80-200 years), and 8.3 snags/acre in Oregon Coast Range plots.

More locally, Topik et al. (1986) measured a range of snag densities in the Western Hemlock Plant Zone on the Gifford Pinchot National Forest as 16 snags/acre in young stands of natural origin (30-100 years old), 17.3 snags/acre in mature stands (100-200 years old), and 12 snags/acre in late seral stands (>200 years old) over all plant associations (including both mesic and dry plant associations). Snags measured by Topik et al. (1988) were at least 10 inches dbh and at least 10 feet tall. U.S. Fish and Wildlife Service and Gifford Pinchot National Forest (2001) measured mean snag densities of 25 snags/acre in Riparian Reserves in fire-regenerated stands (70-90 years) in the Trout Creek sub-watershed of Wind River watershed.

Since these values represent on-forest conditions, they were used to develop DFCs for Riparian Reserves. However, snag densities in Riparian Reserves would likely be different than snag densities in upland areas. To develop these DFC criteria, snag density averages as reported over all plant associations by seral stage in Table 6 of Topik et al. (1986) were weighted based on snag densities found in the seven wet and moist plant associations believed to dominate Riparian Reserves. These values were used in concert with mean snag densities found by U.S. Fish and Wildlife Service and Gifford Pinchot National Forest (2001) to create a range of mean desired future snag densities for previously unmanaged early seral and mid-seral riparian stands. Old-growth values are based primarily on data from Topik et al. (1986). These results are summarized as optimal DFCs in Table 1, with criteria on distribution by decay class based on Maser et al. (1988) characterized in Table 2.

Criteria are omitted for young stands (30-80 years) under a managed origin because these areas are currently highly impoverished of snags. Recent snag inventory on twelve 1/10 acre Riparian Reserve plots in approximately previously logged riparian stands (50-72 years) along the Wind River revealed an average of 5 snags/acre (>10 inches dbh and > 10 feet tall). The mean diameter at breast height for these snags was 13.5 inches. U.S. Fish and Wildlife Service and Gifford Pinchot National Forest (2001) found 7.5 snags/acre in Riparian Reserves of 35 to 50-year-old plantations in the Trout Creek sub-watershed. Because the number and size of snags in these stands are so much lower than those found in similarly aged stands of natural origin, no quantitative DFC was developed for young, previously managed stands.

Assuming most other riparian plantations have similar snag characteristics as those areas sampled in the Mining Reach of the Wind River, it will not be feasible in the short term to meet the snag number and diameter criteria identified as DFC for unmanaged stands of the same age. In general, these young, previously managed stands should be placed on a trajectory to move toward longer-term DFCs with an effort also made in the short-term. Snag creation or allowance for recruitment should be balanced with the potential need to increase amounts of down wood in these types of stands to meet DFCs for down wood described above. While it still may be desirable to create some snags in riparian areas of plantations, it may be most desirable to wait until average stand diameters are at least 14 inches dbh before actively creating snags in larger numbers that begin to approach the 20-25 snags/acre densities described here as DFCs in young (30-80 years) to mature (80-200 year), unmanaged stands.

The DFCs described above should be attained at the watershed scale. Not every acre within every Riparian Reserve is likely to meet these conditions. Some Riparian Reserves shall exceed these values. The values described here are based heavily on quantitative values for the seven moist and wet plant associations for the Western Hemlock plant zone of the GPNF. Riparian Reserves on drier sites or higher elevation riparian areas in the Pacific silver fir zone may not be capable of reaching these values. On the other hand, some of the more productive Riparian Reserves are undoubtedly capable of exceeding these values. Moist sites contain 20-100% more snags than dry sites.

## Aquatic Riparian Habitats

### Seeps and springs

Seeps and springs, common in the Wind drainage, are usually small, well-oxygenated "recharge" areas where cold water leaves the ground. Human activity can be threatening to species dependent on this habitat.

### Splash zones

Splash zones of lotic systems (cascades and waterfalls) are sites where water regularly splashes onto rocks, log jams, suspended logs, moss mats, etc. Recreation can be threatening to species dependent on this habitat.

### Lentic zones and wetlands

Lentic zones and wetlands are areas around still water and can be large as Black Creek Swamp, or small as some vernal pools and beaver ponds like those in Trout Creek and Dry Creek.

## Habitat Connectivity of Forested Riparian Reserves across the Watershed using the 70-11-40 Rule by Sub-watershed

**70-11-40 Rule for Riparian Reserves by Sub-watershed:** The objective of the Riparian Reserve (RR) system is to provide connectivity across the Matrix land allocation for species associated with late-successional forests. RRs serve to connect Matrix land allocation to LSRs. Mt. St. Helens wildlife biologist, Mitch Wainwright, uses a threshold of 70% within RRs to serve as an indicator when there may be broken habitat connections. Table R-4 shows habitat connectivity levels within RRs by sub-watershed.

Table R-4. Connectivity across RRs in forested cover averaging  $\geq 11$ " dbh and  $\geq 40\%$  canopy cover by sub-watershed. The recommended threshold is met when percent  $\geq 70\%$ . ***Bold and italicized*** sub-watersheds are below the recommended threshold.

Sub-watershed	11-40 Acres	Total Sub-watershed Acres in RR	Percent
Bear (07)	2477	2991	83
Dry (03)	3202	5520	76
<b><i>Falls (02)</i></b>	<b><i>2209</i></b>	<b><i>3484</i></b>	<b><i>63</i></b>
<b><i>Lower Wind (08)</i></b>	<b><i>2724</i></b>	<b><i>4289</i></b>	<b><i>64</i></b>
<b><i>Middle Wind (04)</i></b>	<b><i>2888</i></b>	<b><i>4400</i></b>	<b><i>66</i></b>
Panther (06)	4937	6983	70
<b><i>Trout (05)</i></b>	<b><i>3641</i></b>	<b><i>5959</i></b>	<b><i>61</i></b>
<b><i>Upper Wind (01)</i></b>	<b><i>3580</i></b>	<b><i>5237</i></b>	<b><i>68</i></b>

## Species

The following rare and uncommon wildlife, plant and fungal species have significant habitat in the Wind River riparian system. The information contained in Table R-5 was collected during field work, and

derived from two documents associated with the Northwest Forest Plan: Viability Assessments and Management Considerations for Species Associated with Late-Successional and Old-Growth Forest of the Pacific Northwest and the FEIS for Amendment to the Survey and Manage, Protection Buffer, and other Mitigation Measures Standards and Guidelines.

TABLE R-5. Summary of those species-of-concern whose viability may depend upon the quality of habitats within the Riparian Reserves of the Wind River.

SPECIES	LIFE-FORM	RARITY	FREQUENCY of OCCURENCE in RIPARIAN RES.	HABITAT COMPONENTS
<i>Buxbaumia viridis</i>	Moss	Rare	Often	Downed logs
<i>Cetraria cetrarioides</i>	Lichen	Uncommon	Often	Canopy
<i>Cinclus mexicanus</i>	Bird	Common ???	Always	Aquatic, mostly Rosgen A,B, and C channels
<i>Cryptomastix devia</i>	Snail	Uncommon	Often	Hardwoods, particularly big-leaf maple
<i>Cyphellostereum laeve</i>	Fungus	Rare	Often	Tied to moss
<i>Dermatocarpon luridum</i>	Lichen	Rare	Always	Aquatic
<i>Galerina atkinsoniana</i>	Fungus	Rare	Unknown	Soil
<i>Galerina cerina</i>	Fungus	Rare	Unknown	Soil
<i>Galerina hetoreystis</i>	Fungus	Rare	Unknown	Soil
<i>Galerina sphagnicola</i>	Fungus	Rare	Unknown	Soil
<i>Hemphillia pantherina</i>	Slug	Rare	Unknown	Riparian zone potentially
<i>Histrionicus histrionicus</i>	Bird	Uncommon	Often	Aquatic, Rosgen B and C channels and riparian zone
<i>Hydrotheria venosa</i>	Lichen	Rare	Always	Aquatic
<i>Juga (Oreobasis) n.spp. 2</i>	Juga	Rare	Always	Aquatic, springs
<i>Kurzia makinoawa</i>	Moss	Rare	Often	
<i>Leptogium burnetiae</i> var. <i>hirsutum</i>	Lichen	Rare		Canopy
<i>Leptogium saturninum</i>	Lichen	Uncommon	Often	Canopy
<i>Leptogium teretiusculum</i>	Lichen	Rare	Often	Canopy
<i>Lyogyrus n.spp 1</i>	Snail	Rare	Always	Aquatic
<i>Marsupella emarginata</i> var. <i>aquatica</i>	Liverwort	Rare	Always	Aquatic
<i>Monadenia fidelis minor</i>	Snail	Rare	Unknown	Aquatic, springs
<i>Nephroma occultum</i>	Lichen	Rare	Almost always	
<i>Platismatia lacunose</i>	Lichen	Uncommon	Often	
<i>Plethodon vandykeii</i>	Salamander	Rare	Unknown	Splash zones, waterfalls, cliff seeps, montane lake edges
<i>Polyzellous multiplex</i>	Fungus	Rare	Often	
<i>Prophysaon coeruleum</i>	Slug	Rare	Unknown	Unknown
<i>Ramalina thrausta</i>	Lichen	Uncommon	Often	
<i>Schistostega pennata</i>	Moss	Rare	Almost always	Old-growth rootwads
<i>Tetriphis geniculata</i>	Moss	Rare	Almost always	Downed logs
<i>Thamnobryum neckeroides</i>	Moss	Uncommon	Often	
<i>Tritomeria exsectiformis</i>	Liverwort	Rare		
<i>Usnea longissima</i>	Lichen	Uncommon	Often	Canopy
<i>Vertigo n. sp.</i>	Snail	Rare	Almost always	Old growth

## Species Guilds

The following species guilds represent riparian species that are dependent upon late successional or old-growth habitat. The species in these guilds are critical to the ecological functioning of the riparian ecosystem as are their associated habitat components. Many of these are species that are listed in the **Record of Decision for Late-Successional and Old-Growth Forest Related Species within the Range of the Northern Spotted Owl** but are also, or equally, riparian dependent. Key habitat components for these guilds are:

### Mollusks

- Coarse woody debris
- Forest litter, leaf mold
- Leafy lichens
- Moist mixed forest, including hardwoods
- Moss

### Salamanders

- Duff and other organic ground layers
- Large down wood
- Leaf litter
- Moss
- Rocky substrates

### Arthropods

- Multi-layered coniferous canopy
- Well-developed litter layer

### Mammals

- Ericads (plants such as huckleberries, rhododendrons in the Ericaceae family)
- Insect production
- Loose or platy bark on trees
- Moist mixed forest, including hardwoods
- Remnants of old-growth, including high-cut stumps, live trees, snags, and down wood
- Snags and coarse woody debris in various decay classes and dimensions
- Vertical canopy layers (used as a ladder for movement)

### Land birds (Altman 1999)

- Berry, nut, and insect production
- Complex forest floor
- Deeply fissured bark
- Dense and diverse native shrubs
- Forest with sub-canopy and understory
- Lichens, leaves, and moss
- Moist mixed forest, including hardwoods
- Remnants of old-growth, including high-cut stumps, live trees, snags, and down wood
- Riparian reserves serve as migration corridors
- Snags, hollowed-out snags, and coarse woody debris in various decay classes and dimensions
- Vertical canopy layers (used as a ladder for movement)

### Mosses

- Coarse woody debris
- Moist organic soil
- Hardwoods

### Lichens

Multi-layered coniferous canopy  
Old trees

### Fungi

Coarse wood  
Moss  
Leaf litter, duff  
All organic layers on the mineral soil.

### Vascular plants

Duff, mycorrhizae  
Forests that have not been intensively managed (e.g., fire regenerated or railroad logged)

## Channel Morphology (Vegetation and Stream Interface)

### Introduction

Stream morphology (also known as Rosgen stream channel types) indicates the type of landform at a site. Species-of-concern associated with these habitats were previously identified. Further definition of the habitat comes from the dominant vegetation occurring along those channel types. Combining these two geographic features on the Wind River provides us with a predictive model of where restoration efforts should occur and can indicate the importance of the Riparian Reserve radiating out from stretches of channel. Plant association and community data should be taken from the entire watershed in order to better employ the riparian classification guide entitled *Riparian Ecological Types*, which will assist with restoration activities.

### Wind River Channels

Rosgen Type A channels dominate the Wind River riparian habitat. This channel type includes the myriad of feeder tributaries. Main stem sections of Upper Wind, Middle Wind, Trout, Panther, Falls, and Trapper have long sections of Rosgen Type C channels. Major segments of Rosgen Type B channels are also in most sub-basins above, and sometimes below, the Type C sections. Type B is the second most common channel type represented in this watershed and includes the main stem of the Lower Wind. Shorter, but significant, segments of Type E channels are in Falls and Trout Creek and also in the headwaters near McClellan's Meadow. There are only two short sections of Type F and they are found in Trout Creek (see Figure F-11 elsewhere in this report). Further linkages between channel type and habitat can be found on Table R-6, below.

Table R-6. Rosgen channel types (Rosgen, 1996) compared to associated vegetation in the Wind River and habitat components listed above. Information in this table is primarily from Diaz et al. 1996, but substantiated by field work.

Channel Types	Landform Description	Common Vegetation	Habitat Components
Channel Type A	Steep. Upper slopes and higher elevations. Narrow creek beds. Most intermittent streams here.	Alder, brook saxifrage, coltsfoot, hedge nettle, oxalis, stink currant, salmonberry, vine maple, willow	Seeps and springs Splash zones Most like upland terrestrial habitat, lateral riparian zone narrow

Channel Type B	Bedrock, slopes more gently sloping, boulders. Sometimes intermittent.	Alder, arrowleaf groundsel, cedar, cold water corydalis, lenticular sedge, salmonberry, skunk cabbage, thimbleberry, vine maple, yellow monkey flower	Aquatic, alluvial mtn valleys, mod gradient, lentic riparian possible
Channel Type C	Broad, gravel bars	Black cottonwood, blue wildrye, cedar, hedge nettle, miner's lettuce, monkey flower, red alder, red osier dogwood, oxalis, youth-on-age	Hardwoods Soil saturation Winter range Wide lateral rip
Channel Type D	Braided streams, broad, unstable. Vegetation helps deposition.	coltsfoot, hedge nettle, lady fern horsetail, maidenhair fern, St. John's wort, skunk cabbage, small-fruited bulrush, and other species common to all channel types	Hardwoods Soil saturation Islands Down wood Winter range Wide lateral rip
Channel Type E	Stable, meandering cut slopes. Meadows.	(Same as Channel Type D above)	Lentic zones and wetlands Winter/summer range areas Sensitive areas
Channel Type F	Broad but cut down, gorge.	(same as Type D above)	Splash zones Aquatic Down wood

## Data Gaps

- Collect data and implement the *Riparian Ecological Types* guidebook for riparian forests to assist with restoration activities.
- Mapped information on riparian plant associations and communities.
- Survey riparian area for species of concern.
- Inventory snag and down wood resources in naturally regenerating and managed riparian forests by various ages and origin (e.g. railroad logged, fire-regenerated, tractor logged).

## Opportunities for Restoration and Management Recommendations

1. A great deal of restoration, primarily in-stream work and riparian planting has already occurred in the Wind River riparian area. Because it is a key watershed for threatened anadromous fisheries, more extensive restoration projects are anticipated. These management activities are subject to the same ecological scrutiny as are logging and road construction. In his strategy for restoration, Frissel (1997) asks: What processes are causing habitat loss? And, What is the risk that unwanted side effects could accrue from a particular set of treatments?

2. Prioritize timber stand improvement activities within pole-sized or smaller forest stands in Falls Creek and in all areas between HPNH areas. Overlay the 70-11-40 sub-watershed map with the HPNH and management history maps to locate these areas. Types of pre-commercial thinning attributes that we want to retain include conifer and hardwood species diversity, shrub component, and clumps of advanced regeneration.

3. Prioritize commercial thinning harvest in small sawtimber forest stands with an intensively-managed history. Place second priority to moderately-managed stands. Both of these stand types lack complexity in forest structure.
4. Develop silvicultural prescriptions that take advantage of existing structural attributes and species diversity.
5. Provide connectivity across the landscape. Where RRs have breaks in connectivity or are below threshold, take a look at alternative upland linkages to ensure Matrix (timber lands) provides connectivity between LSRs (USDA 1995) during project planning. Maintain habitat connectivity in the upland areas, particularly within and between High Potential Nesting Habitat areas for spotted owls until other RRs develop.
6. Design yarding operations to minimize overall impacts on existing forest litter development, areas with advanced regeneration, snag, down wood, rootwads, high-cut stumps and overall forest floor complexity. Staying on designated skid trails is important in maintaining these habitat components.
7. For projects thinning or removing trees, ensure LSR and RR stands entered are not currently deficient in CWD and snag habitat and meet those DFCs first before removing trees.
8. Take an interdisciplinary (project-level) look at forest stands regenerated from fire, ice and wind storms when prescribing silvicultural treatments because these areas have the greatest structural diversity.
9. Inventory hardwood regeneration in riparian treatment areas. Is regeneration occurring at an acceptable level, is it heavily browsed, or is it lacking altogether? Based on these findings, develop silvicultural prescriptions that provide a diversity of hardwood tree species in all diameter sizes and decay classes.
10. Retain large diameter hardwoods  $\geq 17$  inches dbh; these will serve as living, surrogate snags. Hardwoods are susceptible to decay and limb breakage sooner than most conifer species of the same age, and thus provide earlier opportunities for cavity use. Their spreading canopies contain great amounts of foliage that provide a base for caterpillar larvae, food for a host of birds, and thick leaf litters on the forest floor.
11. For projects within Riparian Reserves, collect project-level stand condition information including quantitative descriptions of live trees, snags, and down wood in project areas. For previously managed younger (30-80 years) Riparian Reserves, design projects to meet recommended DFCs described above in the short-term to the extent practicable while setting residual stands on a trajectory to meet recommended DFCs in the long-term (several decades). Balance the short-term needs for snag and down wood creation with the long-term needs for snags, down wood, and vertical canopy layering.
12. Collect more data on Riparian Reserve snags and down wood in a range of stand ages and origins within the Wind River watershed to determine existing conditions. Quantify down wood in multiple ways including biomass/unit area, volume/unit area, and percent ground cover to characterize relationships between different units of measure for down wood.
13. From the literature review, the following findings and criteria describe recommended DFCs for down wood in Wind River Watershed Riparian Reserves:
  - Young (30-80 years) and old stands (>200 years) contain greater amounts of down wood than mature stands (80-200 years).
  - Riparian reserves contain greater amounts of down wood than upslope areas.
  - Manage down wood in Riparian Reserves to meet biological objectives for Riparian Reserves, including addressing the needs of spotted owls, Survey and Manage species, and Appendix J2 species.

- Recommended DFC shall be inventoried and described as percent ground cover based on wood pieces greater than 3 inches in diameter and at least 5 feet in length (these size criteria match those in the GPNF plant association guide for western hemlock plant zone).

Based on the above supporting documentation and assumptions, recommended DFCs for down wood in Riparian Reserves in the Wind River watershed are recommended as follows:

Table R-7. Recommended DFC for down wood in Wind River Riparian Reserves (RR).

Stand Age or Site Condition	% Ground Cover in Down Wood	% Distribution by Decay Class	
		1,2, and 3	4 and 5
<100 years	15-20%	45%	55%
100-200 years	15-20%	60%	40%
>200 years	20-25%	70%	30%
Steep-sloped or infrequently burned RR	>25%	70%	30%

In stands <100 years resulting from natural origin, we might expect 20% ground cover or more. However, in young plantations, current levels are likely very low. Down wood data collected in 50 year old, previously logged riparian stands along the Wind River revealed average ground cover of 8.6% over 12, 1/10-acre plots (La Marr and Burgdorf, in progress). It may be more desirable in these areas to strive for 15% ground cover rather than 20% because, as described below, these stands also have a shortage of snags and it may be more desirable to provide for more future snag recruitment in these stands by leaving more standing trees until diameters reach a point of being more desirable for snags.

14. From the literature review, the following two tables describe recommended DFCs for snags in Wind River Watershed Riparian Reserves:

Table R-8. Recommended DFC snag levels for Wind River watershed Riparian Reserves. Figures are adapted from the Gifford Pinchot National Forest Plant Association Guide for Western Hemlock Plant Zone (Topik et al. 1986). *Only the seven wet and moist-site plant associations were referenced.*

Stand Age	Desired Future Mean Number of Snags/Acre	Desired Future Mean DBH
30-100 years Managed	Between current mean & DFC	Between current mean & DFC
30-100 years Natural Disturbance	20-25 snags/acre	32 inches
100-200 years Natural Disturbance	21-25 snags/acre	29 inches
200+ years Natural Disturbance	14 snags/acre	38 inches

Table R-9. Recommended DFC % distribution of snags by decay class calculated for young (30-80 years), mature (80-200 years), and old-growth (>200 years) Douglas-fir stands resulting from natural disturbances. Values are based on bar graph data from Spies and Cline (1988).

Decay Class	Stand Age		
	30-80 years	80-200 years	>200 years
1	7%	11%	15%
2	21%	32%	41%
3	22%	26%	26%
4	36%	21%	11%
5	14%	10%	7%

# TERRESTRIAL ASSESSMENT

## VEGETATION

### Introduction

There have been changes in vegetative classes within the watershed since the watershed analysis of 1996. The following questions drive the need for an update of the vegetation analysis provided in the initial WRWA:

1. What are the current vegetative stages within the Matrix?
2. What is the desired future condition of the Matrix lands?
3. What probable sale quantity (PSQ) is appropriate for Matrix?
4. What are vegetative conditions within the Riparian Reserves?
5. What stand treatments are acceptable for restoration?

### Changes in Current Conditions

Table V-1 displays the vegetative condition changes since the initial WRWA.

Table V-1. Changes in Vegetation

Vegetation Class	1996 Watershed Analysis	2000 Watershed Analysis	Difference
Non-Forest	9887	10314	+427
Early-Successional	34118	34810	+692
Mid-Successional	67628	64958	-2670
Late-Successional	31816	33599	+1783
	143449	143681	

The vegetation classes above are grouped into four classes: non-forest, early-successional, mid-successional, and late-successional. The Non-Forest class contains all lands that do not support forested habitat. These include rock, water, meadows, administrative, and rural areas. The Early-Successional class includes all forestlands from grass/forb, seedlings, saplings, and trees up to 9 inches in diameter. The Mid-Successional class includes all forestlands with small trees - tree diameters between 9 inches and 21 inches in diameter. The Late-Successional class includes all forestlands with large trees - trees diameters greater than 21 inches in diameter.

Changes in vegetation class resulted from areas added to the watershed area, timber harvest, and site reclassifications within the vegetation database. Part of the increase in non-forest resulted from land base additions to Wind River at the confluence with the Columbia. The Early-Successional class increased. Timber harvest accounts for 323 acres. The remaining acres are a result of reclassification of the database. The decrease in Mid-Successional is due to harvest and reclassification. There is no explanation for the increase in Late-Successional other than reclassification of areas within the database. The vegetation database is updated periodically to reflect new information and data.

## Current Vegetation Conditions by New 6<sup>th</sup> Field Watersheds

Table V-2 displays the current vegetation conditions for the entire Wind River watershed by the new 6<sup>th</sup> field watersheds. The percentage of Late-Successional is also shown because this is a significant element. Only one watershed, Watershed A, is currently below the minimum level of 15% late-successional specified in the ROD (page C-44). In total, the entire watershed contains 23.4% late-successional which exceeds the minimum 15% level.

Table V-2. Current vegetation conditions by sixth field subwatershed.

6 <sup>th</sup> Field	Non-forest	Early Successional	Mid Successional	Late Successional	% Late Successional
Lower Wind	2843	3613	8775	2141	12.3
Bear Creek	601	1389	5770	1757	18.4
Trout Creek	1971	6889	7884	4994	22.9
Mid. Wind	883	4487	8870	2982	17.3
Dry Creek	1065	2328	8171	5816	33.4
Falls Creek	702	4178	5841	3173	22.8
Upper Wind	1117	5398	10190	3397	16.9
Panther Cr.	1132	6537	9457	9339	35.3
%	7.1	24.2	45.3	23.4	

The Lower Wind River subwatershed is made up of the drainages Lower Wind, Brush Creek, and Little Wind. The drainages occur in the LSR and will not be programmed for timber harvest.

## Current Vegetation Conditions within Riparian Reserves

Riparian Reserve land totals 38,863 acres within the LSR and 8,817 acres within the Matrix.

Table V-3 and Figure V-1 displays the current and desired vegetation classes in acres for Riparian Reserve areas within the watershed. Current levels reflect information in the vegetation database. Note the low percentage of area in the large tree category compared to the desired future condition.

Table V-3. Current and desired vegetation conditions in Riparian Reserves.

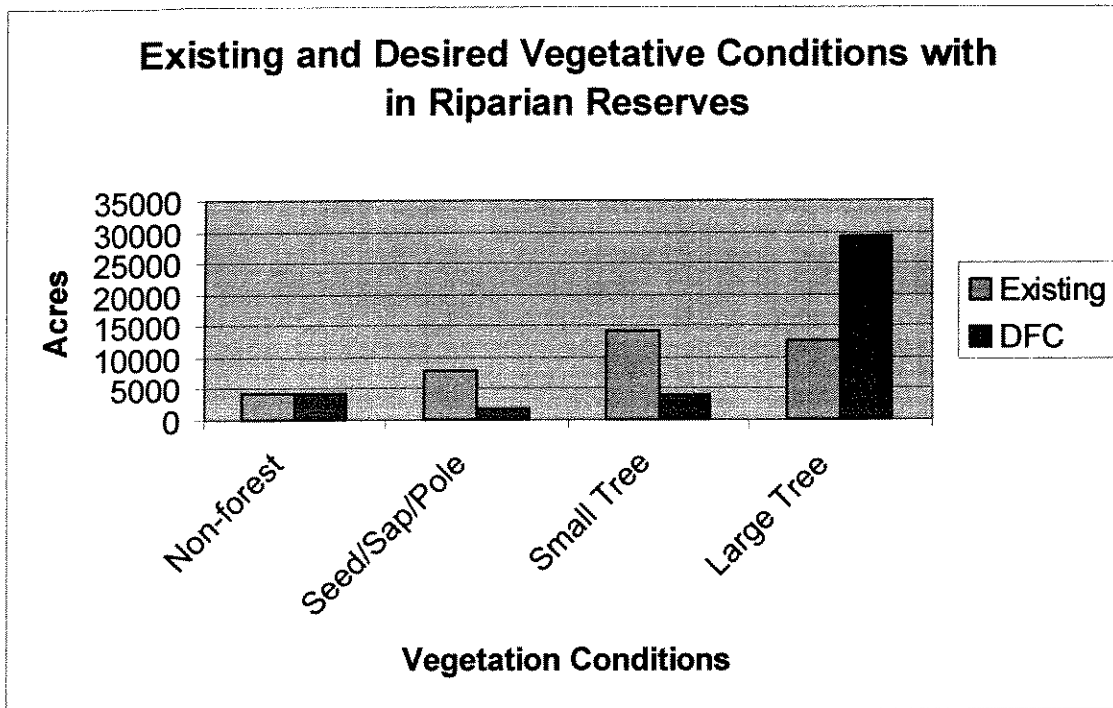
Vegetation Class	Current Conditions (ac)	Current %	Desired Future Conditions (ac)	DFC %
Non-forest	4,130	10.7	4,130	10.7
Seed/Sap/Pole	7,782	20.0	1,699	04.3
Small Tree	14,187	36.5	3,886	10.0
Large Tree	12,764	32.8	29,148	75.0
	38,863		38,863	

The desired future condition for vegetation within the Riparian Reserve is a stable late-successional stand of trees. The vegetation conditions that correspond to a stable late-successional state are in the Large Tree category. Under stable conditions, up to 75% of the area would be maintained in large trees. Stand disturbances resulting from fire, flood, insects, disease, storms, and landslides would be at a low level indicated by the figure of 14.3% in the early and mid-successional classes. The 10.7% of non-forest will likely remain the same or increase slightly on lands outside the Forest boundary.

It can be calculated from the values in Table V-3 that 16,384 acres of young stands (seedlings, saplings, poles, and small trees) currently exist within Riparian Reserves over and above the desired future level.

These stands are plantations composed of seedlings, saplings, poles, and trees less than 21 inches in diameter. The primary element required to move these stands toward the desired future condition is time. Large tree sizes can be achieved in approximately 100 to 120 years. For stands to develop late-successional attributes (multiple layers, trees over 30 inches in diameter, large snags, and large down logs) 200 years or more are required. There are however management actions that can be taken to accelerate the development of the young stands toward late-successional. The most important and beneficial action is the control of stand density in these young stands. Stands that are overstocked do not develop large tree characteristics and become susceptible to reduced vigor and growth and losses from insects and diseases. Due to high stand densities, some of these stands may never develop large tree classes without some degree of density management.

Figure V-1. Current and desired vegetation conditions in Riparian Reserves.



## Future Vegetation Management Options

### Matrix Land Management

The number of acres available for timber harvest on Matrix lands was determined using an even-flow calculation the same as was done in 1995. A rotation age of 110 years was used as an average for all timber types and productivity classes. Dividing the net Matrix acres by the rotation length of 110 years and multiplying by 10 years calculated available regeneration harvest acres per decade. Acres available for intermediate harvest per decade are the same as regeneration harvest. It is estimated that each stand will have at least one intermediate harvest entry during a rotation. The available acreage stayed about the same with a minor increase due to database figure changes. Table V-4 displays the net Matrix acres available for harvest. Not included in the available acre calculation were Riparian Reserves, non-forest acres, and the 20% area requirement needed for retention and future snags. The sub watersheds shown in the table are the old 6<sup>th</sup> fields (currently referred to as 7<sup>th</sup> field subwatersheds). These are used because they breakdown into smaller sized areas which facilitates project planning.

## Commercial Timber Harvest in Matrix

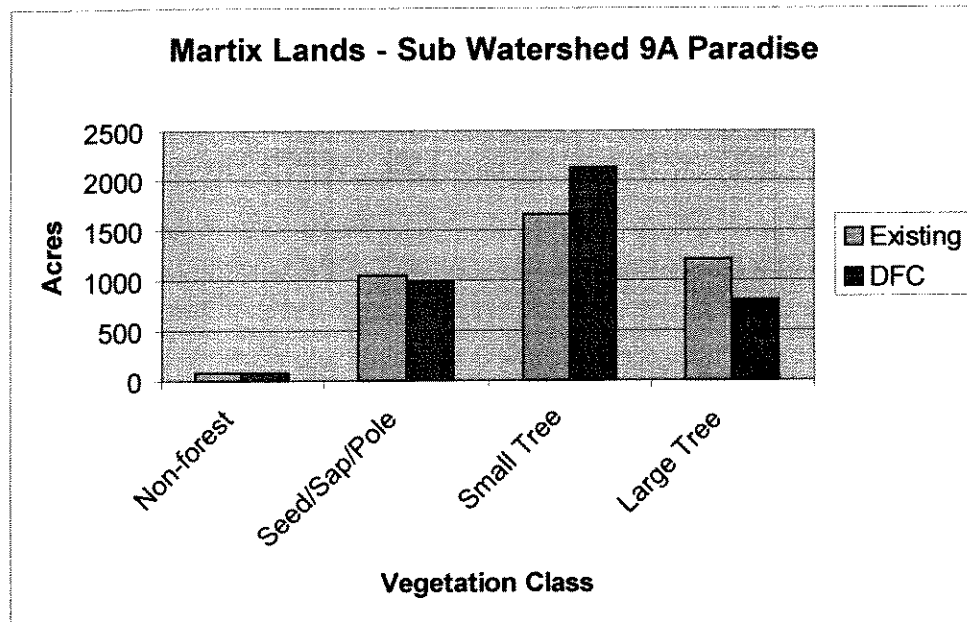
Subwatersheds that contain Matrix lands are where timber harvesting to contribute to the District and Forest Probable Sale Quantity (PSQ) will take place. Opportunities to harvest in any one sub-watershed are dependent upon the availability of suitable timber while meeting the needs of fish, wildlife, watershed, and recreation. The following groups of tables and charts display the current vegetation conditions within each sub-watershed as compared to the desired future condition of each sub-watershed. This information will be a useful tool when planning timber sale activities over the next decade.

The Desired Future Condition (DFC) was determined based on requirements for Matrix lands. Twenty percent of the area is to remain in late-serie condition. The Large Tree class represents this. The Small Tree class is where the future timber harvest will come from. In some sub-watersheds, there may be an "excess" of stands in the Large Tree class. These stands are part of the pool of stands that will be considered for regeneration harvest. Numbers were calculated using a rotation age of 110 years. Small Tree stands are stands between the ages of 35 and 110 year old. Seedling/Sapling/Pole stands are stands up to 35 years old.

## Sub-watershed 9A – Paradise

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	85	85
Seed/Sapling/Pole	1,043	990
Small Tree	1,659	2,127
Large Tree	1,215	*800
	4,002	4,002

\*This value represents a minimum required as opposed to a desired future condition.

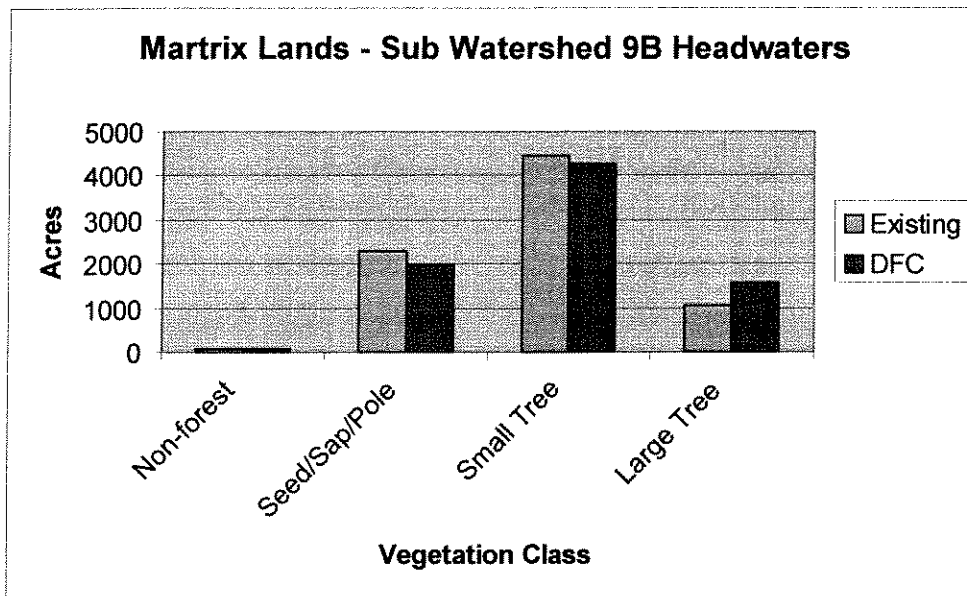


- There are approximately 415 acres of large trees for potential harvest.
- Look for chances to thin stands in the Small Tree class.
- Look for opportunities to accelerate growth of young stands to small trees.

Sub-Watershed 9B – Headwaters Wind

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	76	76
Seed/Sapling/Pole	2,313	1,988
Small Tree	4,457	4,262
Large Tree	1,061	*1,581
	7,907	7,907

\* This value represents a minimum required as opposed to a desired future condition.

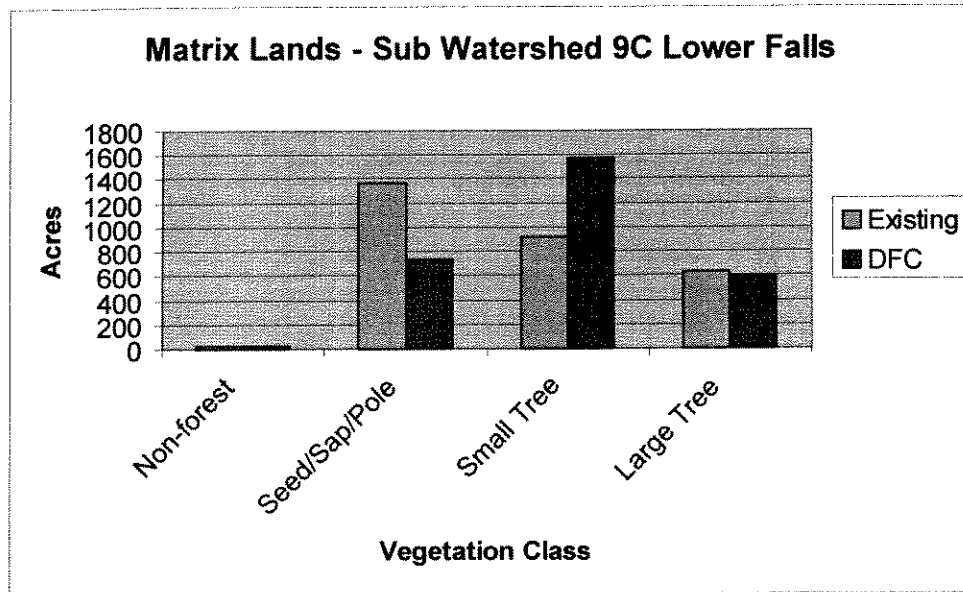


- The Large Tree component is lacking.
- There may be opportunities to thin or regen the Small Tree class.
- Look for opportunities to accelerate the growth of young stands to Small Trees.

## Sub-watershed 9C – Lower Falls Creek

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	22	22
Seed/Sapling/Pole	1,360	738
Small Tree	921	1,583
Large Tree	626	*586
	2,929	2,929

\* This value represents a minimum required as opposed to a desired future condition.

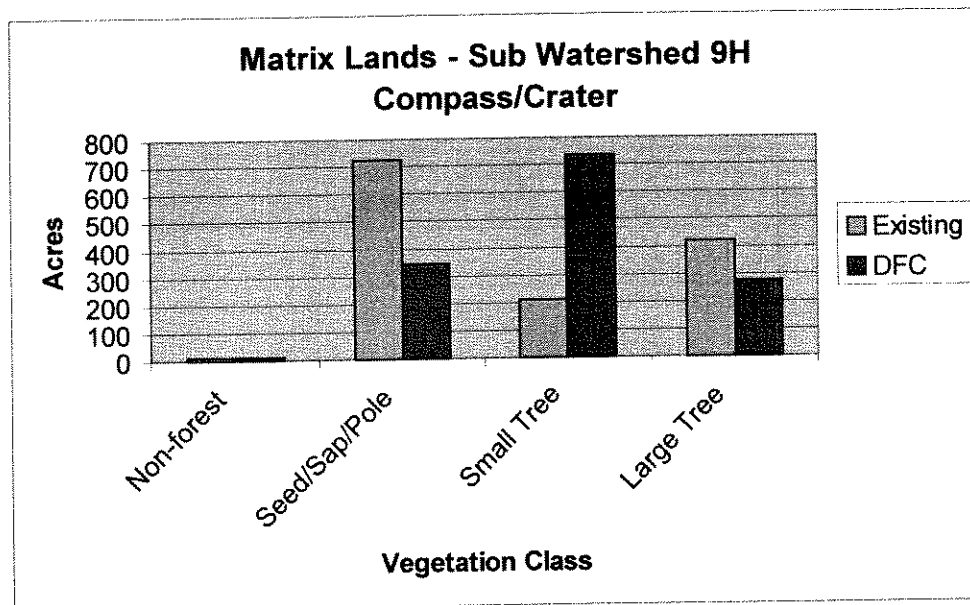


- Limited opportunities to harvest from the Large Tree class with only 40 acres available.
- The Small Tree class is under-represented. There could be some thinning opportunities here.
- Look for opportunities to accelerate the growth of young stands to the Small Tree class.

## Sub-watershed 9H – Compass/Crater Creek

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	9	9
Seed/Sapling/Pole	724	344
Small Tree	210	738
Large Tree	421	*273
	1,364	1,364

\* This value represents a minimum required as opposed to a desired future condition.

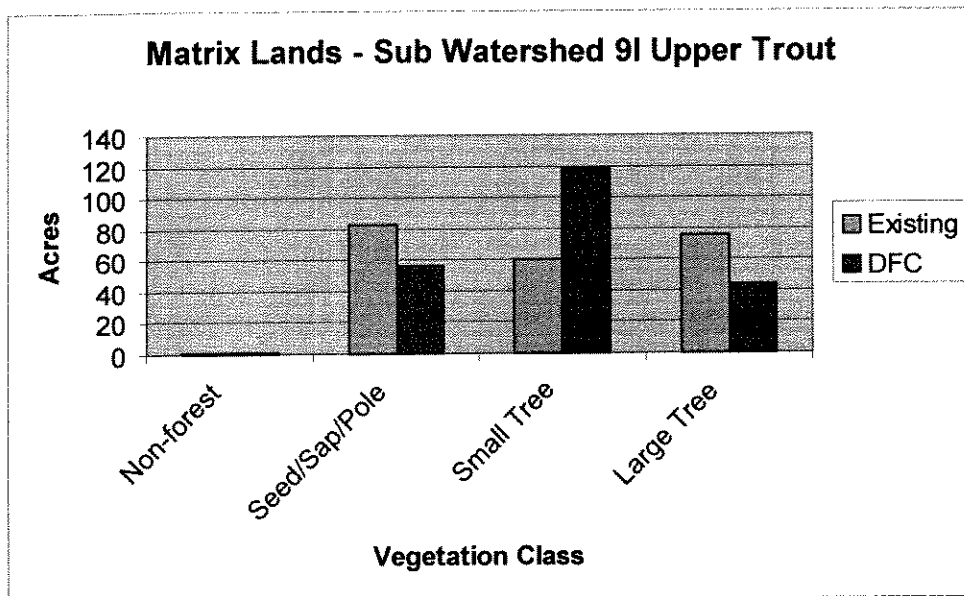


- There is potential to harvest 148 acres of Large Trees.
- The Small Tree class is very under-represented in this sub watershed.
- Young stands are very over-represented. Look for opportunities to accelerate the growth of young stands to Small Trees.

## Sub-watershed 9I – Upper Trout Creek

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	1	1
Seed/Sapling/Pole	83	56
Small Tree	60	119
Large Tree	76	*44
	220	220

\* This value represents a minimum required as opposed to a desired future condition.

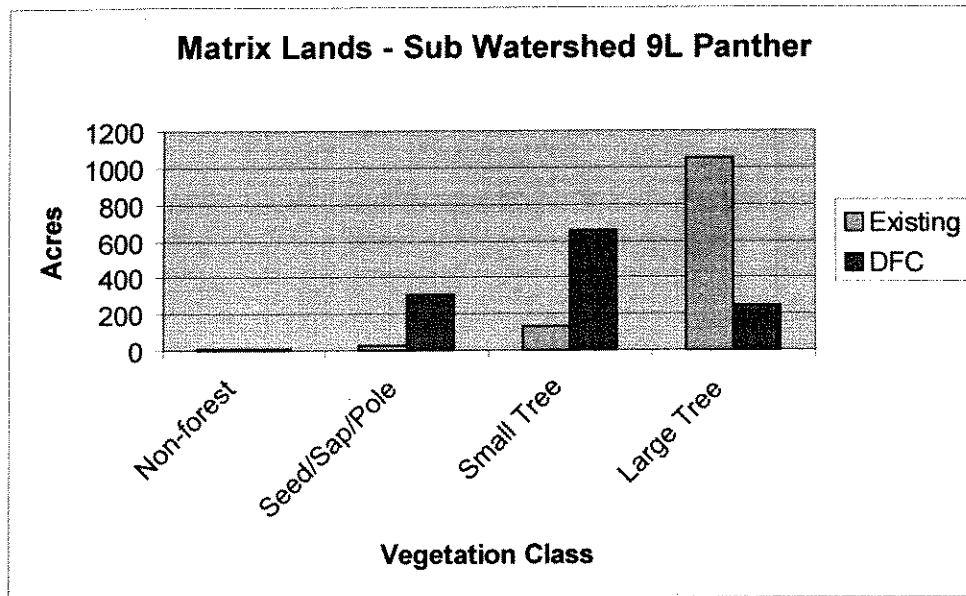


- There are limited opportunities to harvest from the Large Tree class with only 32 acres available.
- The Small Tree class is lower than desired.
- Look for chances to accelerate growth of young stands to Small Trees.

## Sub-watershed 9L – Upper Panther

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	8	8
Seed/Sapling/Pole	22	304
Small Tree	128	653
Large Tree	1,048	*241
	1,206	1,206

\* This value represents a minimum required as opposed to a desired future condition.

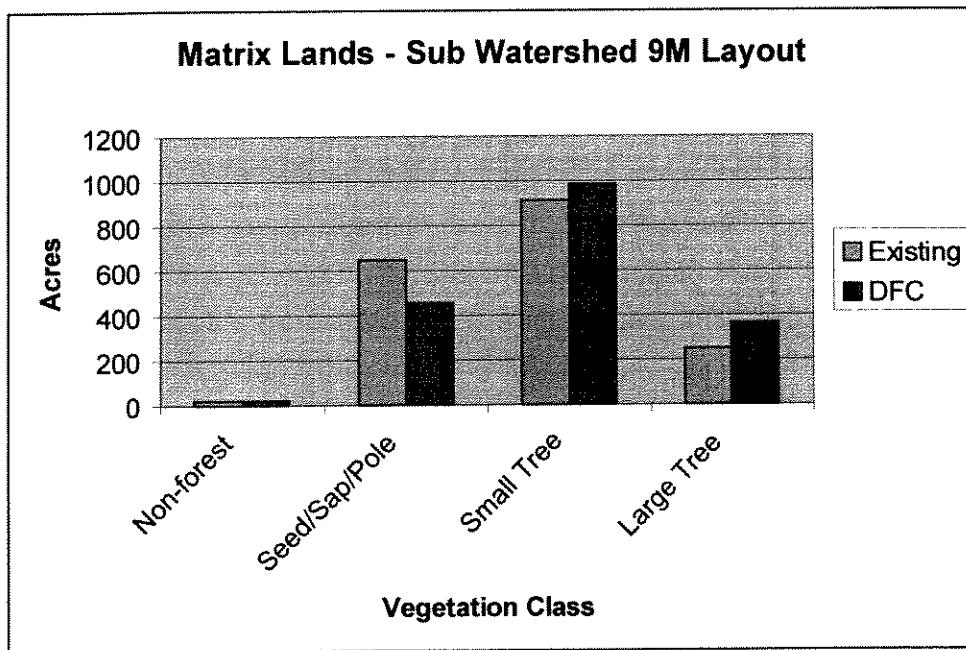


- The Large Tree class harvest potential is 807 acres.
- Both young stands and Small Trees are low.

## Sub-watershed 9M – Layout Creek

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	24	24
Seed/Sapling/Pole	647	460
Small Tree	916	985
Large Tree	249	*367
	1,836	1,836

\* This value represents a minimum required as opposed to a desired future condition.

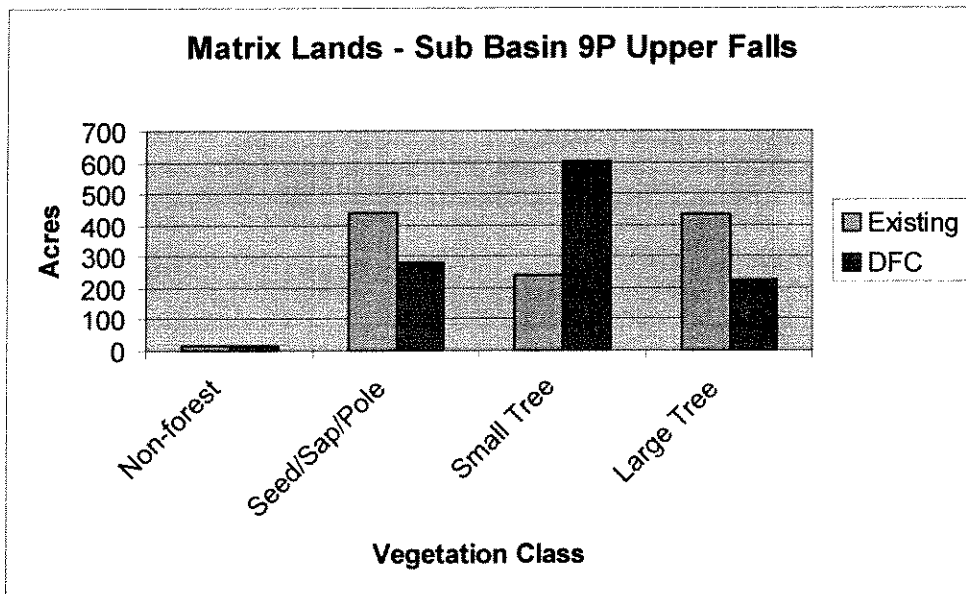


- The Large Tree class is lacking.
- There is potential to thin or regen stands in the Small Tree class.
- Accelerate the growth of young stands to Small Trees.

## Sub-watershed 9P – Upper Falls Creek

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	15	15
Seed/Sapling/Pole	437	281
Small Tree	238	602
Large Tree	433	*225
	1,123	1,123

\* This value represents a minimum required as opposed to a desired future condition.

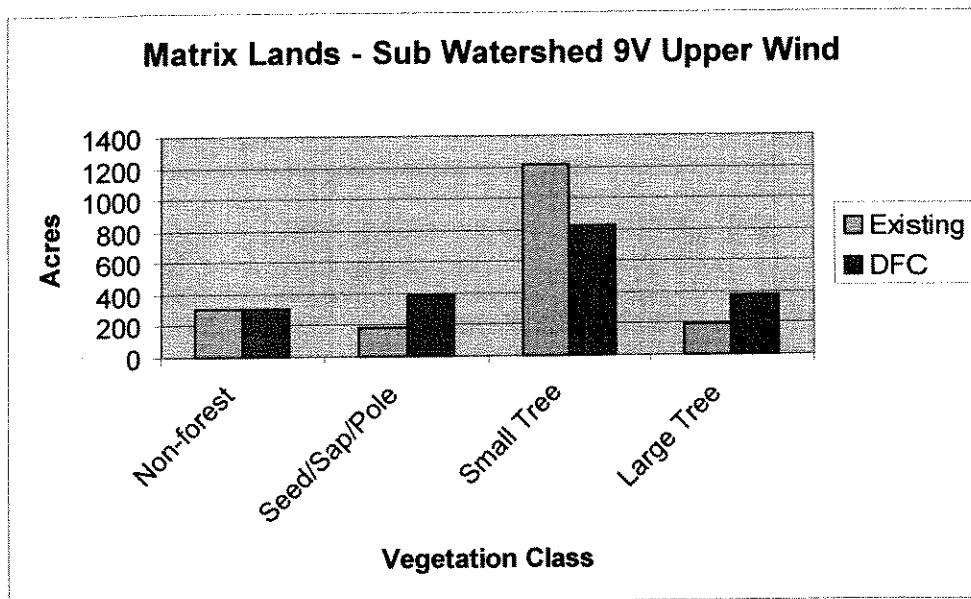


- There are potentially 208 acres of stands in the Large Tree class for harvest.
- The Small Tree class is low.
- Look for chances to accelerate the growth of young stands to Small Trees.

## Sub-watershed 9V – Upper Wind River

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest		302
Seed/Sapling/Pole		388
Small Tree	1,220	831
Large Tree	199	*380
	1,901	1,901

\* This value represents a minimum required as opposed to a desired future condition.

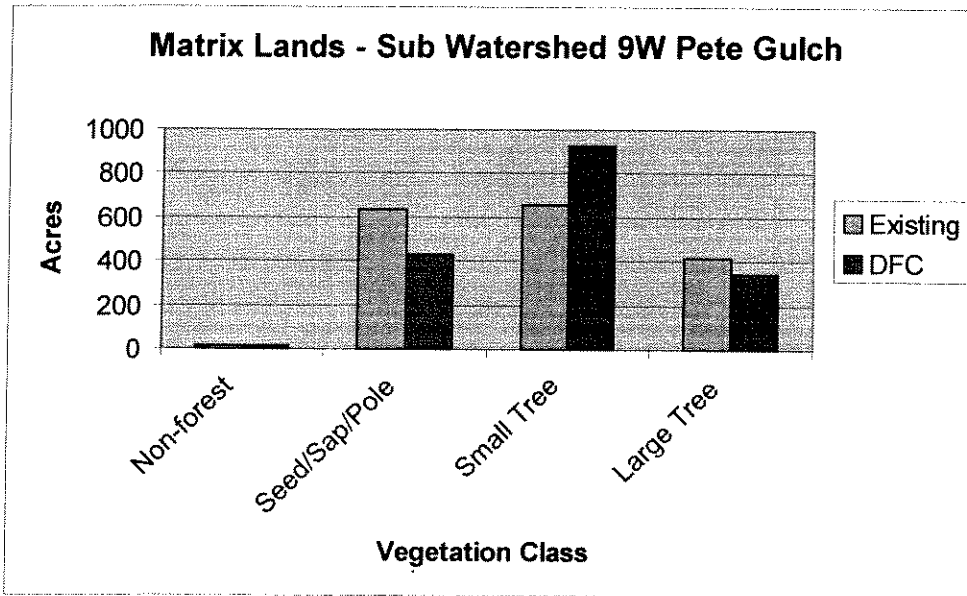


- The Large Tree class is less than DFC.
- There are opportunities to thin or regenerate Small Tree class stands.

Sub-watershed 9W – Pete’s Gulch

Vegetation Class	Current Vegetation Condition	Desired Future Condition
Non-forest	18	18
Seed/Sapling/Pole	635	433
Small Tree	656	928
Large Tree	415	*345
	1,724	1,724

\* This value represents a minimum required as opposed to a desired future condition.



- There are up to 70 acres of Large Tree class stands available for harvest.
- There are some chances to thin Small Tree stands.
- Look for chances to accelerate the growth of young stands to Small Trees.

# WILDLIFE

## Introduction

This document updates the previous watershed analysis report dated 1996. Changes and additional information have occurred since the original report came out. Specifically, sub-watershed boundaries changed. The changes addressed in this report include updates on several years' survey effort of S&M species, the Federal listing of the lynx as threatened, and a change in how USF&WS models habitat for the northern spotted owl. In addition, this report covers information on the Late-successional Reserve, Riparian Reserves, and a recalculation of landscape connectivity based on the new sub-watershed boundaries.

## Late-Successional Reserve

### Objective

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...[and] will ensure that the full range of biodiversity will be conserved (USDA 1998).

### Desired Future Condition (DFC)

1. Meet or work toward biological function based on research findings showing optimum levels of habitat for species associated with late-successional forest. This includes research findings for snags and coarse woody debris (CWD) levels in forests of various age classes.
2. Promote or retain forest diversity in the following categories when prescribing stand treatments (Hayes et. al. 1997; Carey and Johnson 1997; USDA 1998; REO Letters).
  - a. Plant species composition including multi-species canopies; deciduous trees and shrubs, shade-tolerant seedlings, and herbs.
  - b. Include stand layers with well-developed understories and areas where a continuous column of vegetation exists from low shrub-seedlings, tall shrub-saplings, and midstory trees.
  - c. Promote a variety of tree age and size classes.
  - d. Retain snag and CWD in different stages of deterioration.
  - e. Develop forested floor litter layers.
  - f. Promote leave-tree structural characteristics (large crowns and limbs, high live-limb ratio; cavities, dead tops, multiple leaders, epicormic and ramicormic branches, mistletoe brooms, presence of deep furrows in bark, and characteristics that induce disease and defect).

### Tools to Determine DFC

Base guidelines at a project level for forested stands using management history, stand age and plant association. These three tools will give managers a picture of the current condition and the future potential for sites to meet the various LSR DFCs.

1. Snag and CWD structure are influenced by management history and its intensity; therefore, evaluating habitat components is best quantified by differentiating stands by these influencing factors.
  - a. Naturally-regenerated, unmanaged or lightly (e.g. post-fire planting) managed stands following wildfire or ice and windstorms. These stands contain the greatest amount of structural complexity and diversity, particularly if they did not burn multiple times. The corporate database does not

reflect all stands originating from these types of stand origin.

- b. Intensively-managed stands (e.g. clearcut or shelterwood harvest with clean logging practices such as removal of in stream woody debris, yarding non-merchantable material to landings and burning, broadcast burning, and single-species planting). These stands contain the least amount of structural complexity, usually more down wood than snags, and diversity.
- c. Moderately-managed stands or dirty-logging practices followed by planting (e.g. railroad logging or salvage cut). These stands retain some intermediate range of structural complexity and diversity from the time of stand origin when compared to the previous two stand conditions.

2. Identify connectivity corridors and contiguous areas with a USF&WS model called High Nesting Habitat Potential at the landscape level.

3. If research studies, showing optimum levels of habitat for species associated with late-successional forest, are not readily available, the following set of four plant association tables may serve as guidelines for determining structural (snags and CWD) levels to retain or recruit within various age classes. Note that these levels were used in the LSR Assessment report to reflect the DFCs rather than the minimum condition levels also described in a series of LSRA tables (3-3, 3-5, 3-8) by plant association.

4. Plant associations indicate moisture conditions of site. As quoted by Spies and Franklin 1991 from a secondary source, amounts of debris and numbers and sizes of debris pieces generally increase with site moisture, probably as a result of higher site productivity, lower fire frequencies (which can consume some of the wood), and possibly because of lower rates of decay resulting from excessively high moisture in the wood. Examples include the riparian reserves in Paradise Creek, Wind River mining reach, Trout Creek and Dry Creek for examples.

Table W-1. Fallen trees per acre surveyed for multiple western hemlock plant associations by stand age and decay classes 1-3. Reference: Western hemlock plant association guide for the Gifford Pinchot National Forest (Topik 1986).

Decay Class	Number of Fallen Trees / Acre by Stand Age		
	30-100 years	100-200 years	>200 years
1	8	14	8
2	167	169	104
3	207	237	145

Table W-2. Average number of snags ( $\geq 10''$  dbh and  $\geq 10''$  height) per acre surveyed for multiple western hemlock plant associations by stand age and decay classes 1-5 under natural disturbance. Reference: Western hemlock plant association guide for the Gifford Pinchot National Forest (Topik 1986).

Decay Class	Number of Snags / Acre by Stand Age		
	30-100 years 32"dbh avg.	100-200 years 29"dbh avg.	>200 years 38"dbh avg.
1	7	3	4
2	18	25	8
3	8	12	6
4	6	5	7
5	8	7	9

This table shows a general distribution of snags by decay class. This can serve as a management tool when prescribing treatments.

Tables W-3. and W-4. describe structural conditions for stands >200 years and serve as an optimal DFC for upland areas. Snag and CWD data are not available for the Pacific-silver fir plant associations.

Table W-3. Range of snags per acre surveyed for multiple western hemlock plant associations in stands >200 years by decay classes 1-5. Median number is in parenthesis. Reference: Western hemlock plant association guide for the Gifford Pinchot National Forest (Topik 1986).

Number of Snags / Acre by Decay Class 1-5				
1	2	3	4	5
0-8 (1)	0-44 (12)	0-20 (6)	0-12 (5)	2-19 (9)

Table W-4. Range of CWD levels per acre ( $\geq 3''$  diameter &  $\geq 5$  ft. length) surveyed for multiple western hemlock plant associations in forest >200 years by decay classes 1-4. Median number is in parentheses. Reference: Western hemlock plant association guide for the Gifford Pinchot National Forest (Topik 1986).

CUFT / acre by Decay Class			# Pieces / acre by Decay Class		
1	2	3&4	1	2	3&4
0-593	0-3640	0-4781	0-17	0-184	0-312
(151)	(2009)	(2463)	(6)	(160)	(204)

## Key Findings for Stands Less than 80 Years Old

1. Naturally-regenerated, unmanaged planted stands following ice and windstorms or wildfires which have not burned multiple times contain greater structure and vegetative complexity.
2. Intensively-managed stands are structurally and compositionally simpler.
3. Moderately-managed stands retain some level of structure between the previous two descriptions.
4. Remnant, old-growth high stumps in young stands serve as snag substitutes by northern flying squirrels, a major prey item for the northern spotted owl, as well as other arboreal and forest-floor rodents (Carey 1995; Carey and Johnson 1995).
5. Sciurid populations in young forests with old-forest legacies and with understory development may equal those in old growth (Carey 1995).
6. An article by Weikel and Hayes 1999 cites that legacy snags (large diameter snags from the previous stand) in young forest are especially important resources for cavity-nesting birds as both nesting and foraging substrates.
7. Foraging needs of birds are important when managing habitat for cavity-nesting birds. In a study published by Weikel and Hayes 1999, it was found in 30-45 year old Douglas-fir forests that deciduous trees, large diameter conifers including those with deeply furrowed bark, large diameter, heavily decayed snags and logs in young forests were important components of foraging habitat.
8. According to Carey and Johnson's 1995 study in western hemlock zone forest of Washington, most small mammals consume (in order of relative frequency) invertebrates, conifer seeds, lichens, and fungi. They cite that increased emphasis on insectivory may be tied to the abundance and variety of decaying organic matters on the forest's floor. Furthermore, their study cites, decaying wood and forest's litter support vast numbers of invertebrates, including the kinds consumed by insectivorous [animals].

## Current Habitat Condition in LSR

The condition of LSR habitat is described using the Gifford Pinchot spotted owl habitat coverage which employs more structural components related to biological functions than the vegetative layer does. The 1996 Wind River report defines the habitat components: dispersal (D), roosting-foraging (RF), and nesting (N) with the latter two further qualified as suitable habitat. Table W-5. summarizes the distribution of LSR habitat within the Wind River watershed.

Table W-5. LSR acres and percent by sub-watershed in Dispersal, Roosting-Forage, and Nesting habitats. The remaining land is non-suitable habitat for spotted owls.

Sub-watershed	Dispersal Acres (%)	Roosting-Forage Acres (%)	Nesting Acres (%)	Unsuitable Acres (%)	Total Sub-water- shed
Bear (07)	1435 (10.6)	4001 (18.3)	1910 (8.3)	1758 (7.3)	9,111
Dry (03)	2157 (15.9)	3085 (14.1)	3110 (13.6)	2937 (12.2)	11,289
Falls (02)	224 (1.6)	1288 (5.9)	784 (3.4)	1701 (7.0)	3,997
Lower Wind (08)	449 (3.3)	2124 (9.7)	1850 (8.1)	1111 (4.6)	5,534
Middle Wind (04)	3593 (26.4)	3752 (17.2)	2667 (11.7)	4218 (17.5)	14,230
Panther (06)	2440 (17.9)	5092 (23.0)	8732 (38.2)	7334 (30.4)	23,598
Trout (05)	3273 (24.1)	2482 (11.4)	3834 (16.7)	5054 (21.0)	14,643
Upper Wind (01)	22 (0.2)	16 (0.1)	0 (0.0)	3 (0.0)	
TOTAL Watershed	13,593	21,840	22,887	24,116	82,443 or 82,436

## Habitat Connectivity across the Wind River Watershed

Landscape connectivity is now evaluated on a sub-watershed basis rather than by ¼ township. An entire sub-watershed meets the recommended connectivity threshold when  $\geq 50\%$  of its area comprises forested stands averaging  $>11$  inches dbh and  $\geq 40\%$  canopy cover. Table W-6. summarizes sub-watershed connectivity using the 50-11-40 Rule. The sub-watersheds below the threshold help identify where potential restoration opportunities may improve the current condition.

Table W-6. Connectivity of forested stands averaging  $\geq 11$ " dbh and  $\geq 40\%$  canopy cover by Wind River sub-watershed. Recommended threshold is met when percent is  $\geq 50\%$ . ***Bold and italicized*** sub-watershed is below recommended threshold.

Sub-watershed	11-40 Acres	Total sub-watershed Acres	Percent
Bear (07)	7595	9516	80
Dry (03)	13,823	17,382	80
<b><i>Falls (02)</i></b>	<b><i>9255</i></b>	<b><i>20,092</i></b>	<b><i>46</i></b>
Lower Wind (08)	10,635	17,375	61
Middle Wind (04)	11,896	17,222	69
Panther (06)	18,425	26,467	70
Trout (05)	14,269	21,735	66
Upper Wind (01)	13,625	20,092	68

The sub-watershed approach results in a broader overview when compared to the ¼ township method. The ¼ township method provides site-specific evaluation and is also a reliable, alternative method.

## Species Survey Updates (1996-2001)

### Survey and Manage (S&M) Species

Surveys for S&M species are completed where proposed projects trigger survey protocols. Project activities surveyed in the last four years include timber sales, road decommissions, recreational sites and trails, Wind River mine, fisheries restoration, commercial thinning, and special-use permits. Habitats surveyed include upland forest and riparian mixed conifer-hardwood forest in small sawtimber or larger. No project work was proposed in Bear and Lower Wind sub-watersheds during this period. All other sub-watersheds had project activities.

1. Terrestrial Salamanders (Larch Mountain PLLA and Van Dyke's salamander PLVA): One new location for PLLA occurs in Trout Creek sub-watershed (Within Timber Sale). No new sites are located for PLVA.

2. Terrestrial Mollusks (Hemphillia, Prophysaon, Cryptomastix): Thus far, several locations for all genres listed above occur in upland forests within Dry, Falls, Middle Wind, Panther, Trout, and Upper Wind sub-watersheds.

3. Aquatic Mollusks: Historic surveys and S&M records are documented at Tye Springs in the Middle Wind sub-watershed. One survey effort was completed using the S&M protocol at Tye Springs in 1999 with no detections.

4. Great Gray Owl: Surveys focused on McClellan Meadows in Upper Wind sub-watershed (McToo Timber Sale). No nest sites or other detections were identified.

## Lynx

The lynx became Federally listed as threatened in spring 2000 under the Endangered Species Act. Regional S&M surveys have occurred yearly since 1998. Sub-watersheds receiving survey effort include Falls, Panther NE, and Upper Wind. Critical habitat is identified preliminarily but will be refined as new information and understanding become available. Habitat occurs within cooler sub-alpine plant associations at higher elevations. The preybase includes snowshoe hare and Douglas squirrel on the westside. Under the current Forest Service definition for lynx habitat, none occurs within Wind River watershed.

## Northern Spotted Owl

A model developed by the Gifford Pinchot USF&WS team in 1999 to identify areas across the Gifford Pinchot National Forest that provide sufficient habitat conditions to be conducive to successful spotted owl nesting (USF&WS 1999). The model was derived by a literature review and by Forest Service survey records. This has been used in place of planning area surveys to determine Limited Operating Period (LOP) restrictions for proposed actions; however, USF&WS is now in a lawsuit, which may change the use and interpretation of this model. Table W-7. identifies HPNH by sub-watershed.

Table W-7. High-potential nesting habitat (acres and percent) identified by Wind River sub-watershed.

Sub-watershed	Acres	Percent
Bear (07)	5355	11
Dry (03)	10,166	20
Falls (02)	4838	9
Lower Wind (08)	5696	11
Middle Wind (04)	4573	9
Panther (06)	10,434	20
Trout (05)	4960	10
Upper Wind (01)	5017	10
TOTAL Watershed	51,039	100

## Data Gaps

1. Snag habitat data stratified by vegetative class and management history are lacking. Snag data are collected with stand examinations; however, sample plot configuration does not adequately sample the naturally clumpy distribution of snags across the landscape. A more representative sampling regime uses a rectangular plot configuration and is stratified by similar vegetative types (Bate 1997).

2. The same data gap occurs for coarse woody debris.

## Management Recommendations

1. Within moderately-managed stands, maintain the snag and CWD resources as larger snags and CWD in different stages of deterioration as well as large, defective trees for future snags.
2. Take a closer, interdisciplinary look at stands generated from fire, ice and wind storm when prescribing silvicultural treatments; these areas have the greatest structural diversity.
3. Treatment of second-growth forests *early-on* in both the stand- initiation and stem-exclusion stages can maintain plant species diversity and eliminate the long interval between the stem-exclusion stage and understory-reinitiation stage (Oliver and Larson 1999).
4. Minimize site preparation (scarification, piling of slash and CWD, and prescribed burning) within stands with understory development in order to retain CWD, existing shrubs, young trees, and forest litter.
5. Design yarding operations to minimize overall impacts on existing forest litter development, pockets of advanced regeneration, snag and CWD. Staying on designated skid trails is important in maintaining these habitat components.
6. For projects that thin or remove trees (e.g. fisheries in stream projects), ensure LSR stands entered are not currently deficient in CWD and snag habitat and will meet DFCs following harvest treatment.
7. Use the LSRA DFC objectives described in Tables 1 and 2 for CWD and snags within stands <80 years old that are moderately managed or originating from natural disturbance.
8. For upland stands <80 years old that are intensively managed, use the CWD and snag levels described within the Gifford Pinchot National Forest Late-Successional Reserve Assessment (USDA 1998, Tables 4-29 and 4-30, page 4-98).
9. Use project-level data collected on CWD and snags in combination with the DFC recommended objectives.
10. Prioritize timber stand-improvement activities within pole-sized or smaller stands in Falls Creek and in all areas between HPNH areas. Overlay the 50-11-40 sub-watershed map with the HPNH and management history maps to locate these areas. Types of pre-commercial thinning attributes that we want to retain include conifer and hardwood species diversity, diversity of snag size and decay class, shrub component, and clumps of advanced regeneration.
11. Prioritize commercial thinning harvest in small sawtimber stands with an intensively managed history. Place second priority to moderately managed stands. Both of these stand types lack some degree of complexity in forested structure.
12. Provide connectivity between LSR and RRs. Where RRs have breaks in connectivity, take an extra effort during project planning to look at alternative upland linkages to ensure Matrix provides connectivity between LSRs (USDA 1995). Maintain habitat connectivity in the upland areas, particularly within and between HPNH areas, until other RRs develop.

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# APPENDIX A: FISH CONSULTATION SUPPORT--CURRENT CONDITIONS

(Based on the NMFS Matrix of Pathways and Indicators)

This section of the fisheries assessment generally follows the National Marine Fisheries Service (NMFS) *Matrix of Pathways and Indicators*. The format includes major headings identified in the Matrix. Where necessary to provide a more cohesive and logical report, some topics were combined and are presented in a different order than they are found in the Matrix. The tables below are summaries of 5<sup>th</sup> and 6<sup>th</sup> field watershed conditions relative to the NMFS criteria.

**Table AA-1. Fifth field watershed condition summary based on the National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species, Wind River, Skamania County, Washington.**

NMFS Matrix and Pathways Criteria	Wind River 5th Field Watershed	Sources and Comments
<b>Water Quality</b>		
Maximum Water Temperature	17	The average of all maximum temperatures for all major tributaries is 17.5 degrees Celsius (USFS water quality baseline station data 1977-present & USFS water quality monitoring data 1995-present) maximum temperature recorded near the mouth of the Wind River was 17 degrees Celsius (Underwood Conservation District, 1999 to present)
Substrate (% fines < 1.6mm)	13%	Average fines <1.6mm found in spawning gravel of major tributaries was 13% (USFS sediment core data 1988-present)
Turbidity (Max NTU)	107	Maximum turbidity recorded at the mouth of the Wind River was 107 NTU (11/28/95 USFS turbidity monitoring)
Chemical contamination	PF	There has been no toxic chemical analysis however agriculture and mining within the basin are limited. Underwood Conservation District water quality monitoring found only trace elements of fecal coliform, nitrate and nitrite.
<b>Habitat Access</b>		
Migration barriers	Dam and Culverts	Hemlock Dam has a fish ladder but is thought to create a thermal block for adult steelhead in summer months and a serious impediment to Parr emigration. At this time Oldman Creek and Youngman Creek have culverts that block adult and juvenile steelhead migration. A culvert analysis is in progress and will provide detailed list of culverts impeding migration of all life stages.
<b>Habitat Elements</b>		
Substrate (% fines < 1.6mm)	13%	Average fines <1.6mm found in spawning gravel of major tributaries was 13% (USFS sediment core data 1988-present)
LWD Pieces/River Mile	18	Average LWD for all surveyed streams (USFS stream survey data 1990-present)
Pools/Mile	4	Average pools per mile for all surveyed streams (USFS stream survey data 1990-present)
Pool Surface Area/Volume Ratio	61	Average pool surface area/volume ratio for all surveyed streams (USFS stream survey data 1990-present)
Off channel habitat	5%	Average percent off-channel habitat for all surveyed streams (USFS stream survey data 1990-present)
% Riparian area within Early Seral	17%	Average percent of early seral vegetation within riparian areas (USFS Vegetation data 2000)
% Riparian Area within Late Seral	30%	Average percent of early seral vegetation within riparian areas (USFS Vegetation data 2000)
<b>Channel Conditions &amp; Dynamics</b>		
W/D Ratio (Low Flow)	1	Average Width/Depth ratios for all surveyed streams (USFS stream survey data 1990-present)
Streambank condition	NPE	The alluvial reaches within the Wind River are very unstable due to riparian timber harvest and stream clean-outs. Bank stability within these reaches is poor (Pfanckuk stream survey data 1983-present and professional judgment)
Floodplain Connectivity	FAR	The alluvial reaches within the Wind River are very unstable due to riparian timber harvest and stream clean-outs. Channelization due to down-cutting is the predominant process associated with the loss of flood plain function within the Wind River (Pfanckuk stream survey data 1983-present, bank stability monitoring 1998 and professional judgment)
<b>Flow/Hydrology &amp; Watershed Conditions</b>		
Increased Peakflows	FAR	Peakflow conditions were evaluated against the percentage of watershed within the rain on snow zone, Aggregate Recovery Percentage (ARP) and Drainage Network Increase. The Wind River watershed is recovering from regeneration harvest in the rain on snow zone. In addition, approximately 100 road miles have been decommissioned and will in the long term assist with recovery of the hydraulic regime (2001 USFS Hydrology Assessment)
% Watershed in Rain on Snow	33%	The Upper 33% of the watershed exist within the rain on snow zone
ARP	92	An ARP value of >70 is considered hydrologically recovered (2001 USFS Hydrology Assessment)
Drainage network Increase	41%	Drainage network increase due to road construction is 41% (2001 Hydrology Assessment) increases above 25% impact the timing and magnitude of peakflows (Wemple, 1994 & Siskow 1995)
Road density	2.9	Road densities within the basin are 2.9 m/mi <sup>2</sup> (2001 Hydrology Assessment) Road densities >2mi/mi <sup>2</sup> impact the timing and magnitude of peakflows (USFS 1995)
PF = Properly Functioning FAR = Functioning at Risk NPE = Not Properly Functioning ND = NO DATA		

Table AA-2. Sixth field watershed condition summary based on the National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species, Wind River, Skamania County, Washington.

NMFS Matrix and Pathways Criteria	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
<b>Water Quality</b>								
Maximum Water Temperature	16	17	25	21	17	16	16	12
Substrate (% fines < 1.6mm)	ND	ND	11%	14%	11%	ND	15%	14%
Turbidity (Max NTU)	107	26	46	39	25	4	35	45
Chemical contamination	PF	PF	PF	PF	PF	PF	PF	PF
<b>Habitat Access</b>								
Migration barriers	None	Falls/	Dam	None	Falls	Falls	Culverts	None
<b>Habitat Elements</b>								
Substrate (% fines < 1.6mm)	ND	ND	11%	14%	11%	ND	15%	14%
LWD Pieces/River Mile	ND	ND	26	40	35	81	51	78
Pools/Mile	ND	ND	25	23	31	31	35	56
Pool Surface Area/Volume Ratio	ND	ND	52	38	49	54	67	46
Off channel habitat	ND	ND	3%	3%	7%	6%	5%	ND
% Riparian area within Early Seral	17%	9%	40%	24%	16%	22%	15%	15%
% Riparian Area within Late Seral	30%	40%	21%	33%	37%	34%	23%	47%
<b>Channel Conditions &amp; Dynamics</b>								
W/D Ratio (Low Flow)	ND	ND	4	11	7	ND	8	7
Streambank condition	PF	ND	NPF	NPF	NPF	PF	NPF	FAR
Floodplain Connectivity	PF	ND	NPF	NPF	FAR	PF	FAR	ND
<b>Flow/Hydrology &amp; Watershed Conditions</b>								
Increased Peakflows	PF	PF	NPF	FAR	PF	FAR	NPF	NPF
% Watershed in Rain on Snow	33%	71%	85%	59%	78%	70%	84%	72%
ARP	92	95	85	87	94	82	82	85
Drainage network Increase	41%	12%	31%	30%	10%	24%	29%	26%
Road density	2.9	1.4	2.4	2.6	1.1	1.6	2.2	2.2
Landslide Risk								
PF = Properly Functioning								
FAR = Functioning at Risk								
NPF = Not Properly Functioning								
ND = NO DATA								

Water Quality

**Water Temperature**

The Wind River watershed has been severely impacted by both natural and human caused disturbances. Riparian timber harvest, splash dams, stream clean-outs, and floods have removed stream shade, in-stream large woody debris, and reduced channel stability. The cumulative effects have led to extreme width to depth ratios and bank erosion within Trout Creek, Dry Creek, Middle and Upper Wind River 6<sup>th</sup> field watersheds. Many salmonids tolerate temperatures exceeding 18°C, but higher temperatures increase stress and mortality usually occurs around 25°C (Jobling 1981). The poor channel conditions (large width/depth low flow ratios) combined with low summer flows and poor stream shade have produced lethal maximum water temperatures for salmonids ( $\geq 24^\circ\text{C}$ ) within the Trout Creek watershed. Bell (1987) demonstrated that 50% steelhead mortality occurs after 17 hours of exposure at 24°C.

Maximum water temperatures do not negatively affect Spawning and incubation. The Wind River steelhead spawn from March to late May/early June with maximum water temperatures during this period below 45-50°F, which are near optimal conditions for spawning. Maximum water temperatures negatively affect adult steelhead migration and juvenile rearing. Adult steelhead enter the watershed every month of the year and the majority of juvenile steelhead rear in tributaries and the main-stem Wind River for two years.

National Marine Fisheries Service Criteria for water temperature are: 50-57°F = *Properly Functioning*, 57-64°F = *Functioning at Risk*, >64°F = *Not Properly Functioning*.

Maximum water temperatures have exceeded the lethal limits for steelhead (25°C or 75°F) during recent years (1987, 1990, 1991, 1992, 1994 and 1998) in Trout Creek and sub-lethal temperatures (21°C) have been recorded in the Middle Wind River and are therefore categorized as *Not Properly Functioning* for migration and rearing. Bear and Dry Creek sub-watersheds have recorded maximum water temperatures above 16°C, which exceeds both the NMFS criteria and State of Washington water quality standards and therefore was categorized as *Functioning at Risk*. The Lower Wind River, Upper Wind River, Falls Creek and Panther Creek 6<sup>th</sup> field watershed meet both the NMFS criteria and state water quality standard of 16°C and are categorized as *Properly Functioning*.

**Table AA-3. Maximum water temperature matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: *National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species*)**

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Maximum Water Temperature (Main Stem)	16	17	25	21	17	16	16	12
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	Layote	Nine Mile	Trapper	L Falls	Paradise	Eight-Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	U Panther
			Compass / Crater				Headwaters Wind	Cedar
								Mouse
PF = Properly Functioning (Max Temp. <17)								
FAR = Functioning at Risk (Max Temp. 17-19)								
NPF = Not Properly Functioning (Max Temp. >19)								
ND = NO DATA								

## Sediment and Turbidity

Sediment and sediment transport are natural processes that provide streams with a source of substrate and nutrients. Sediment is naturally delivered to streams by a variety of mechanisms such as landslides and bank erosion. All streams and their associated aquatic organisms evolved to a natural "sediment load" or regime. The sediment load is the quantity and size of the material a stream typically transports. The sediment regime and composition determines the quantity and quality of aquatic habitat. When streams or watersheds are disturbed by fire, logging, or road construction, excess sediment can be delivered to the stream altering both the quantity and composition of the substrate. This shift in the sediment composition can directly and indirectly affect aquatic organisms by altering water quality, incubation, larval development, and juvenile rearing habitat (WTFW, 1993).

Turbidity is the visible suspension of smaller particles of sediment typically carried by all streams. Turbidity meters measure the clarity of the water by passing a beam of light through a sample. A sensor assigns a NTU (nephelometric turbidity units) value for the amount of light that passes through the sample. Turbidity levels are typically tied to stream flow levels. At higher flow levels, sediment inputs are usually greater, and streams have greater capacity to entrain and maintain finer sediments in suspension. High turbidities / suspended sediment can affect aquatic organisms by killing them directly, by reducing growth rates and resistance to disease, by preventing successful development of eggs or larvae, by modifying natural movement or migration patterns, or by reducing the natural availability of food (USEPA, 1986). Landslides and accelerated bank erosion have altered the sediment budgets of Panther Creek, Trout Creek, Dry Creek, Upper and Middle Wind River 6<sup>th</sup> field watersheds. The majority of sediment within the alluvial valleys of Trout Creek, Dry Creek, Upper and Middle Wind River watersheds comes directly from bank erosion and within stream sources such as eroding, unconsolidated bank erosion and exposed point gravel bars. This erosion is caused by: LWD removal, lack of vegetative roots and peak flows. Roots from trees and shrubs are needed to hold soil and rock together along the stream/bank interface. In-stream LWD protects banks and gravel bars by reducing and dampening water velocities along them. Large streamside trees are needed for self-maintaining / potential in-stream LWD.

Trout Creek, Panther Creek and Lower Wind River 6<sup>th</sup> field watersheds has the highest turbidity and potential for sediment delivery. Grab samples of turbidity were taken along major tributaries and the main-stem Wind River at three stream stages in 1995 to evaluate suspended sediment/turbidity. Results are presented in the following table along with turbidity levels found in the Wind River during the same sampling period.

Table AA-4. Turbidity (NTU's) for the Wind River and tributaries during low, medium and high flows [ 11/28/95, 11/20/95 and 12/9/96], Skamania County, Washington.

Turbidity in Wind River, 1995 (rising limb), 1996 (falling limb).				
Location	Estimated Streamflow (1)			
	Medium (12/9/96)	Low (11/20/95)	Medium (11/24/95)	High (11/28/95)
Bear	6.4	1.73	3.43	26.70
Dry		1.66	3.10	25.34
Falls		1.68	2.36	4.97
Martha	3.7		3.03	21.35
Mouse	11.1	2.21		41.65
Ninemile		1.78		14.07
Panther, Lower	9	2.18		46.25
Panther, Upper	5	1.57	3.31	18.93
Paradise	3.8	2.52	4.67	23.36
Tenmile		1.46		12.18
Trapper	1.7	1.34	2.26	9.38
Trout	2.2	2.42	6.26	46.69
Wind, Lower	8.3	3.57	10.03	107.20
Wind, Middle	4.1	1.88	4.81	39.02
Wind, Upper	2	2.34	6.00	35.38
Trout, Lower	3.6			
(1) Field estimate of streamflow based on bankfull channel				
where: High is equivalent to 2/3 bankfull to bankfull; Medium				
is equivalent to approximately 1/3 to 2/3 bankfull; and Low				
is equivalent to 1/3 bankfull or less.				

turbidity in Wind River, 1995-96.

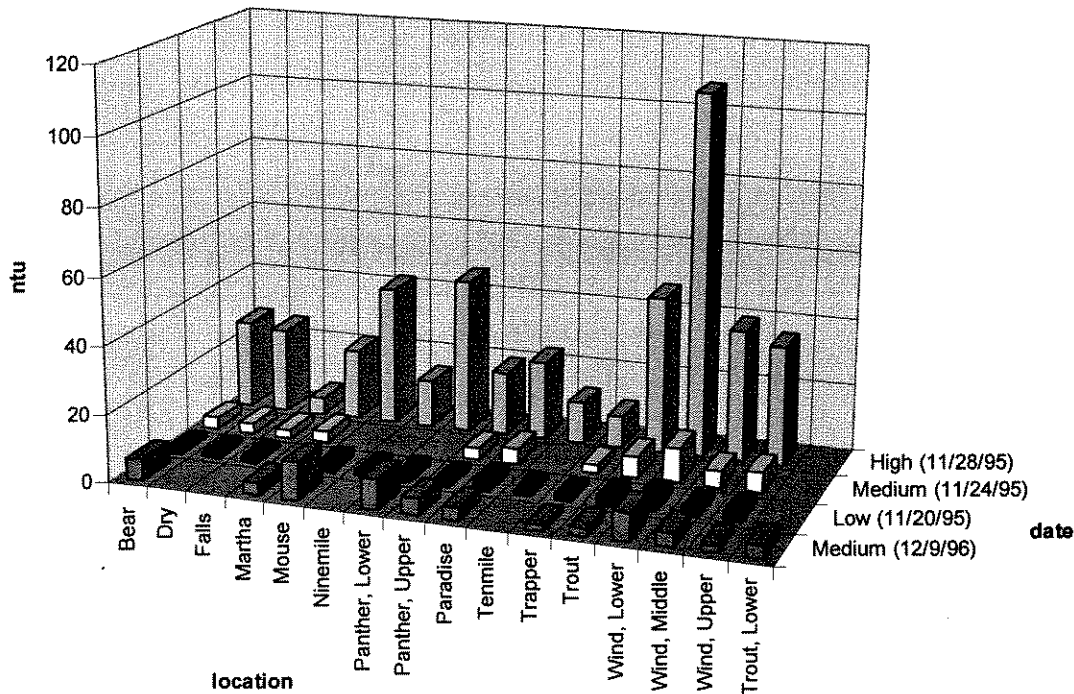


Figure AA-1. Turbidity (NTU's) for the Wind River and tributaries during low, medium and high flows [ 11/28/95, 11/20/95 and 12/9/96], Skamania County, Washington.

State water quality standards do not define maximum levels of turbidity, but allow for 5% increases above "background" turbidity levels. The data presented here are primarily used to index turbidity levels during a range of flow conditions across major tributaries in the Wind River watershed, not to compare against state standards.

The data shows that during the high flow sampling period, Trout Creek, Panther Creek and Lower Wind River turbidity was 21, 23 and 30 times greater than the respective low flow turbidities. The average increase in turbidity for all measured tributaries at high flow was 15 times greater than low flow. The lowest increase in turbidity was recorded at Falls Creek with an increase of only three times greater than low flow. *Because of the limited number of samples collected, it is important to note that this data may be more a reflection of very localized or short term inputs of sediment or disturbances in the stream channel than of broader scale or chronic erosion/sediment processes in the sub-watersheds where they were taken.* Continued collection of turbidity data will hopefully begin to reinforce or discount the apparent spatial patterns in turbidity across the watershed and through a range of flows, and may help in establishing "background levels" for the watershed. Sediment sources in the sub-watersheds of interest appear to be a combination of natural and human-induced.

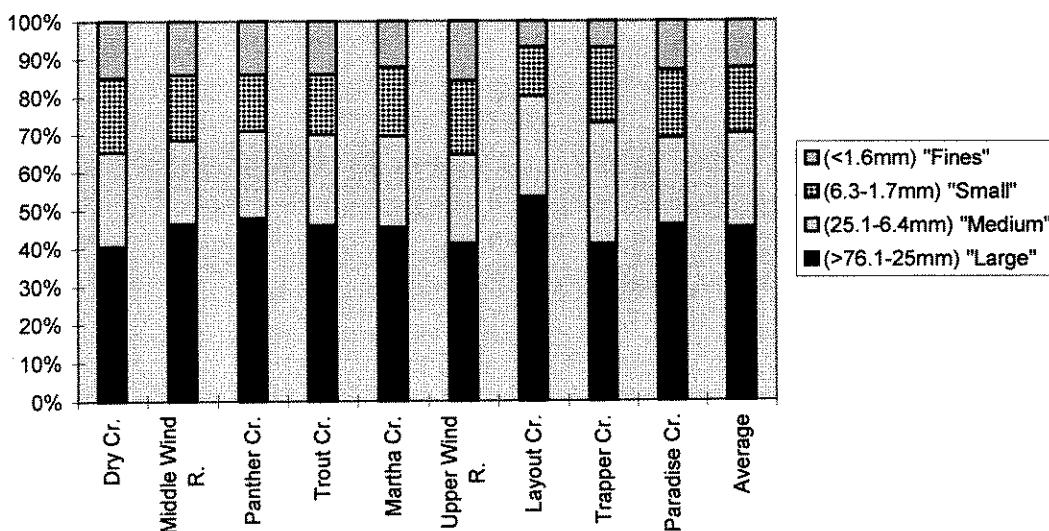
### *Substrate*

Substrate composition determines the quantity and quality of aquatic habitat. When streams or watersheds are disturbed by fire, logging, or road construction, excess sediment can be delivered to the stream altering both the quantity and composition of the substrate. This shift in the sediment composition can directly and indirectly affect aquatic organisms by altering water quality, incubation, larval development, and juvenile rearing habitat.

McNeil Core Sediment samples were taken from the Wind River and seven tributaries to evaluate the quality of steelhead spawning habitat. Sediment cores were taken in areas where steelhead have historically spawned. To avoid risk of accidentally disturbing incubating eggs samples were taken in late summer or approximately six weeks after emergence. Samples were taken in reach one of Layout Creek and reach five of Trout Creek. Table AA-5 provides a summary of the data.

**Table AA-5. 1998 spawning substrate composition for the Wind River and tributaries, Skamania County, Washington.**

<i>Stream</i>	(>76.1-25mm) "Large"	(25.1-6.4mm) "Medium"	(6.3-1.7mm) "Small"	(<1.6mm) "Fines"
Dry Cr.	41%	25%	20%	15%
Middle Wind R.	46%	22%	17%	14%
Panther Cr.	48%	23%	15%	14%
Trout Cr.	46%	24%	16%	14%
Martha Cr.	45%	24%	18%	12%
Upper Wind R.	42%	24%	20%	16%
Layout Cr.	54%	27%	13%	7%
Trapper Cr.	41%	32%	20%	7%
Paradise Cr.	46%	23%	18%	13%
<b>Average</b>	<b>45%</b>	<b>25%</b>	<b>17%</b>	<b>12%</b>



**Figure AA-2. 1998 spawning substrate composition for the Wind River and tributaries, Skamania County Washington.**

Layout Creek a heavily managed watershed and Trapper Creek a wilderness watershed contained the lowest percentage of fines (both 7%) of sampled tributaries. The Upper Wind River and Dry Creek contained the highest percentage of fines in spawning substrate; 16% and 15% respectively. *This data consist of one year of sampling and is intended to be a reference relative to conditions found in other tributaries.*

Based on substrate and water quality monitoring, baseline conditions for the sediment and substrate are: <10% fines (<1.6mm) and or Turbidity <20 NTU = **Properly Functioning**, 10-17% fines and or 20-30 NTU = **Functioning at Risk**, >17% fines and or >30 NTU = **Not Properly Functioning**.

Trout and Panther Creek, the Lower, Middle and Upper Wind all have relatively high turbidities and moderate percentages of fines found in spawning substrate and are therefore classified as **Not Properly Functioning**. Bear and Dry Creek have moderate turbidities and are classified as **functioning at Risk**. Falls Creek has extremely low turbidities and is characterized as **Properly Functioning**.

**Table AA-6. Sediment and turbidity matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington.**

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Substrate (% fines < 1.6mm)	ND	ND	11%	14%	11%	ND	15%	14%
Turbidity (Max NTU)	107	26	46	39	25	4	25	26
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	Layout	Nine Mile	Trapper	L Falls	Paradise	Eight-Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	L Panther
			Compass / Crater				Headwaters Wind	Cedar
								Moosa
PF = Properly Functioning								
FAR = Functioning at Risk								
NPF = Not Properly Functioning								
ND = NO DATA								

## Chemical Contamination and Nutrients

The majority of agriculture within the Wind River has been in the form of timber management. The Wind River Nursery located along Trout Creek, farmed trees for reforestation from the early 1900's to 1997. There has been no known water quality monitoring within the watershed to detect pesticides or herbicides. Underwood Conservation District has evaluated the watershed for nitrate +, nitrite +, nitrogen, total phosphorus, fecal and total coliform. All test were barley above detection limits and could only be considered as "trace".

All sub-watersheds are considered to be **Properly Functioning** with respect to chemical and nutrient contamination.

**Table AA-7. Chemical contamination and nutrients matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: *National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species*)**

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Chemical contamination	PF	PF	PF	PF	PF	PF	PF	PF
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	Layout	Nine Mile	Trapper	L Falls	Paradise	Eight-Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	U Panther
			Compass / Crater				Headwaters Wind	Cedar
								Mouse
PF = Properly Functioning FAR = Functioning at Risk NPF = Not Properly Functioning ND = NO DATA								

## Habitat Access

## Migration Barriers

A culvert inventory to evaluate fish passage is in progress at this time. Results from the inventory will be added to the watershed analysis as an addendum upon completion. The known migration impediments and barriers to fish passage are: Hemlock Dam on Trout Creek, Bear Creek municipal water diversion and culverts on Oldman and Youngman Creeks. Trout Creek and the Upper Wind, which contains Oldman and Youngman Creek, are considered *Not Properly Functioning*. Bear Creek is considered *Functioning at Risk* due to a waterfall at the mouth blocks anadromous access to the watershed. The municipal water diversion blocks resident rainbow up-stream migration in the lower two river miles above the falls.

Table AA-8. Migration barriers matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: *National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species*)

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Migration barriers	None	Falls/ Diversion	Dam	None	Falls	Falls	Culverts/ Falls	None
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	Layout	Nine Mile	Trapper	L Falls	Paradise	Eight-Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	U Panther
			Compass / Crater				Headwaters Wind	Cedar
								Mouse
PF = Properly Functioning FAR = Functioning at Risk NPF = Not Properly Functioning ND = NO DATA								

## Habitat Elements

### Substrate

Refer to previous Water Quality, Sediment and Turbidity section for discussion.

Baseline conditions for the substrate conditions within the Wind River are: <10% fines (<1.6mm) = *Properly Functioning*, 10-17% fines = *Functioning at Risk*, >17% fines = *Not Properly Functioning*.

Table AA-9. Substrate

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Substrate (% fines < 1.6mm)	ND	ND	11%	14%	11%	ND	15%	14%
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	Layout	Nine Mile	Trapper	L Falls	Paradise	Eight-Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	L Panther
			Compass / Crater				Headwaters Wind	Cedar
								Mouse
PF = Properly Functioning								
FAR = Functioning at Risk								
NPF = Not Properly Functioning								
ND = NO DATA								

**Large Woody Debris**

Large woody debris, is defined in the PACFISH standards and guidelines as wood >12" in diameter, >50' in length. Large wood within a stream has both physical and biotic impacts on salmonid streams. The physical effect LWD has on streams includes changes in stability of stream banks and channels, storage of sediment, dissipation of stream energy, and alteration of channel flows (Bryant, 1983, Everest and Meehan 1981, Harmon et al 1986).

Large woody debris within undisturbed reaches of the Wind River watershed was evaluated to set the baseline conditions for properly functioning streams. Undisturbed reaches were evaluated with respect to Rosgen channel types to further refine criteria and are presented below:

Table AA-10. Range of LWD/mile by Rosgen Channel type for undisturbed reaches within the Wind River, Skamania County, Washington.

Rosgen Channel Type	Maximum LWD/Mile	Average LWD/Mile	Minimum LWD/Mile
A (N=13)	134	106	75
B (N=8)	124	101	76
C (N=11)	308	130	75

Table AA-11. Baseline conditions by channel type for LWD within the Wind River, Skamania County, Washington.

Rosgen Channel Type	Properly Functioning (Pieces/mile)	Functioning At Risk (Pieces/mile)	Not Properly Functioning (Pieces/mile)
A	>106	75-106	<75
B	>101	76-101	<76
C	>130	75-130	<75

Stream clean-outs, riparian timber harvest have negatively impacted LWD within the majority of watersheds within the Wind River. Trout Creek, Dry Creek, Middle and Upper Wind River 6<sup>th</sup> field watersheds are *Not Properly Functioning*. Falls and Panther Creek watersheds fall within the lower range of natural variability and are ranked as *Functioning at Risk*.



### Pool Quantity and Quality

Pool quantity (pools/mile) was based on the USDA Forest Service, Section 7 Fish Habitat Monitoring Protocol for the Upper Columbia River Basin. The protocol evaluates pools per mile on a stream width basis. Pool quality was evaluated in the 1995 Wind River watershed analysis by analyzing pool surface area/maximum pool depth ratios by Rosgen Channel type and will be used here to establish the baseline criteria for this analysis.

**Table AA-14. Pool Quantity criteria; USDA Forest Service, 1994. Section 7 Fish Habitat Monitoring Protocol for the Upper Columbia River Basin.**

Channel Width (feet)	Pools/Mile
5	184
10	96
15	70
20	56
25	47
50	26
75	23
100	18

**Table AA-15. Range of pool quality (pool surface area/maximum pool depth) by Rosgen Channel type for undisturbed reaches within the Wind River, Skamania County, Washington.**

Rosgen Channel Type	Maximum Pool Quality Ratio	Average Pool Quality Ratio
A (N=23)	58	51
B (N=24)	58	49
C (N=11)	69	57

**Table AA-16. Baseline conditions by channel type for pool quality (pool surface area/maximum pool depth) within the Wind River, Skamania County, Washington.**

Rosgen Channel Type	Properly Functioning <i>(Pool Quality Ratio)</i>	Functioning At Risk <i>(Pool Quality Ratio)</i>	Not Properly Functioning <i>(Pool Quality Ratio)</i>
A	<51	51-58	>58
B	<49	49-58	>58
C	<57	57-69	>57

The averages for pools/mile of all 6<sup>th</sup> field watersheds fell below the Forest Service criteria and were ranked *Not Properly Functioning* except Panther Creek, which on average met the pools/mile standard and was classified as *Properly Functioning*. When all pool quality ratios by stream reach were averaged, Trout, Dry, Falls, Upper Wind and Panther 6<sup>th</sup> field watersheds had moderate values and were ranked *Functioning at Risk*. While the numbers of pools per mile was low in the Middle Wind River watershed, the pools that did exist contained high quality habitat and were ranked as *Properly Functioning*.

**Table AA-17. Average Pools/mile and pool quality (pool surface area/maximum pool depth) matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species)**

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Pool Surface Area/Volume Ratio	ND	ND	52	38	49	54	67	46
Pools/Mile	ND	ND	25	23	31	31	35	56
7th Field Sub-watersheds	Brush	NF Bear	Layout	Nine Mile	Trapper	L Falls	Paradise	Eight Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	U Panther
			Compass Crater				Headwaters Wind	Cedar
								Mouse

**PF = Properly Functioning**  
**FAR = Functioning at Risk**  
**NPF = Not Properly Functioning**  
**ND = NO DATA**

**Table AA-18. Pools/mile and pool quality (pool surface area/maximum pool depth) stream survey data, Wind River, Skamania County, Washington. (National Marine Fisheries Service Pathways and Indicators Criteria)**

Trout Creek 6th Field Watershed										Dry Creek 6th Field Watershed									
Stream Name	River Miles	7th Field H2Oshed	PNW Standard Pools/Mile	Pools/Mile	Pool Quality Rating	Pool Area/Volume Ratio	Reogen Channel Type	Stream Name	River Miles	7th Field H2Oshed	PNW Standard Pools/Mile	Pools/Mile	Pool Quality Rating	Pool Area/Volume Ratio	Reogen Channel Type				
COMPASS CREEK, rm 1.7-2.1, 09 93	0.4	Crtr/Cmpa	75	33	1	30	A	TRAPPER	4	Trapper	56	1	1	34	B				
CRATER CREEK, rm 1.5-1.8, 09 93	0.3	Crtr/Cmpa	70	34	1	34	A	TRAPPER	6	Trapper	56	1	1	34	B				
COMPASS CREEK, rm 1.1-1.7, 09 93	0.6	Crtr/Cmpa	75	21	1	36	A	TRAPPER	3	Trapper	70	1	0	49	B				
CRATER CREEK, rm 1.1-1.5, 09 93	0.4	Crtr/Cmpa	70	26	1	36	A	TRAPPER	1	Trapper	70	1	0	57	C				
CRATER CREEK, rm 1.5-1.9, 09 93	0.4	Crtr/Cmpa	70	27	1	67	A	TRAPPER	2	Trapper	75	0	0	57	C				
CRATER CREEK, rm 0.8-1.1, 09 93	0.3	Crtr/Cmpa	70	23	1	36	B	DRY CREEK, rm 3.4-3.8, 09 92	2	Dry Cr	79	0	1	40	C				
CRATER CREEK, rm 0.5-0.8, 09 93	0.3	Crtr/Cmpa	70	25	1	33	C	DRY CREEK, rm 3.8-4.4, 09 92	3	Dry Cr	91	0	0	59	C				
COMPASS CREEK, rm 1.5-2.4, 07 97	0.9	Crtr/Cmpa	75	27	1	69	B	DRY CREEK, rm 1.6-3.4, 09 92	1	Dry Cr	91	0	0	58	C				
CRATER CREEK, rm 0.0-0.3, 09 93	0.3	Crtr/Cmpa	70	24	1	67	C	Average	72					48					
COMPASS CREEK, rm 0.0-1.5, 07 97	1.5	Crtr/Cmpa	75	28	1	61	B	<b>Falls Creek 6th Field Watershed</b>											
CRATER CREEK, rm 0.0-1.6, 07 96	1.6	Crtr/Cmpa	70	28	0	45	D	FALLS CREEK, rm 6.0-6.5, 09 98	3.5	Upper Fth	64	0	0	63	C				
CRATER CREEK, rm 0.3-0.5, 09 93	0.2	Crtr/Cmpa	70	28	2	95	C	FALLS CREEK, rm 9.5-11.4, 09 98	1.9	Upper Fth	62	0	0	66	B				
CRATER CREEK, rm 0.0-1.5, 09 93	1.5	Crtr/Cmpa	70	27	0	71	A	FALLS CREEK, rm 2.6-6.0, 09 98	3.1	Lower Fth	69	0	0	66	B				
COMPASS CREEK, rm 0.0-1.1, 09 93	1.1	Crtr/Cmpa	75	27	0	65	C	FALLS CREEK, rm 1.8-2.9, 09 98	1.3	Lower Fth	56	0	0	66	B				
LAYOUT CK, rm 2.3-2.5, 09 91	0.2	Layout	91	21	1	65	A	FALLS CREEK, rm 0.8-1.6, 09 98	1	Lower Fth	43	0	1	38	B				
LAYOUT CK, rm 0.0-1.9, 07 98	1.9	Layout	91	28	1	67	C	FALLS CREEK, rm 0.0-0.6, 09 98	0.6	Lower Fth	35	0	0	51	B				
LAYOUT CK, rm 1.1-2.3, 09 91	1.2	Layout	81	28	1	63	B	Average	53					54					
LAYOUT CK, rm 1.9-2.5, 07 98	1.6	Layout	91	29	1	86	B	<b>Upper Wind River 6th Field Watershed</b>											
LAYOUT CK, rm 0.0-1.1, 09 91	1.1	Layout	91	33	0	67	C	OLDMAN CK, rm 0.0-1.1, 09 93	1.1	Headwat	114	0	0	40	B				
LAYOUT CK, rm 1.9-2.5, 07 98	1.6	Layout	91	33	0	64	C	YOUNGMAN CK, rm 0.0-0.9, 09 93	0.9	Headwat	131	0	0	80	B				
SF PLANTING CK 09 92	0.5	Lower Trt	114	32	1	23	A	YOUNGMAN CK, rm 0.9-1.7, 09 93	0.8	Headwat	131	0	0	89	A				
PLANTING CK, rm 0.4-0.9, 09 92	0.5	Lower Trt	96	49	0	48	A	OLDMAN CK, rm 1.6-2.1, 09 93	0.5	Headwat	131	0	0	120	B				
TROUT CK, rm 2.4-4, 09 95	1.8	Lower Trt	31	18	1	23	A	OLDMAN CK, rm 1.1-1.6, 09 93	0.6	Headwat	131	0	0	89	A				
TROUT CK, rm 2.4-2.8, 09 95	0.4	Lower Trt	31	17	1	45	B	UPPER WIND R, rm 27.5-29.5, 09 91	0.8	Headwat	47	0	0	143	A				
SF PLANTING CK 09 92	0.5	Lower Trt	114	27	0	45	B	UPPER WIND R, rm 29.3-27.0, 09 91	1.7	Headwat	45	0	0	95	A				
PLANTING CK, rm 1.9-2.4, 09 95	0.5	Lower Trt	96	28	1	25	B	UPPER WIND R, rm 28.5-29.0, 09 91	0.5	Headwat	44	0	0	95	A				
PLANTING CK, rm 0.0-0.4, 09 92	0.4	Lower Trt	96	27	0	49	B	UPPER WIND R, rm 27.0-27.9, 09 91	0.8	Headwat	43	0	0	85	A				
PLANTING CK, rm 1.1-2.0, 09 92	0.9	Lower Trt	96	27	1	63	B	UPPER WIND R, rm 27.4-28.4, 07 96	1	Hdwtrs W	42	41	0	53	B				
TROUT CK, rm 8.7-9.4, 09 95	0.7	Lower Trt	39	26	1	37	B	UPPER WIND R, rm 28.4-29.5, 07 96	0.6	Hdwtrs W	40	97	0	91	A				
TROUT CK, rm 0.6-1.1, 09 92	0.5	Upper Trt	91	26	1	37	B	UPPER WIND R, rm 25.3-27.4, 07 96	2.1	Hdwtrs W	36	36	0	49	B				
E FK TROUT CK, rm 0.3-0.8, 09 92	0.5	Upper Trt	91	26	0	64	C	UPPER WIND R, rm 28.9-29.7, 07 96	0.8	Hdwtrs W	36	42	1	44	D				
E FK TROUT CK, rm 0.0-0.6, 09 92	0.6	Upper Trt	91	27	0	58	E	PETE'S GULCH CK II, rm 0.5-0.6, 09 95	0.1	Pete's	91	75	0	44	E				
TROUT CK, rm 5.4-6.1, 07 96	1.3	Upper Trt	45	31	0	34	C	PETE'S GULCH CK, rm 0.0-0.8, 09 95	0.8	Pete's	91	0	0	43	A				
TROUT CK, rm 6.8-8.7, 09 95	1.9	Upper Trt	52	24	1	34	C	PETE'S GULCH CK, rm 0.8-1.6, 09 95	0.8	Pete's	91	1	1	24	A				
TROUT CK, rm 6.7-7.8, 07 96	1.2	Upper Trt	52	25	0	47	C	PETE'S GULCH CK II, rm 0.0-0.5, 09 95	0.5	Pete's	91	0	0	51	A				
TROUT CK, rm 7.9-9.4, 07 96	1.5	Upper Trt	52	25	0	47	C	PARADISE CK, rm 1.0-2.3, 09 93	1.3	Paradise	70	0	0	34	B				
TROUT CK, rm 4.6-6.8, 09 95	2.2	Upper Trt	45	22	0	50	C	PROVERBIAL CK, rm 0.0-1.5, 09 95	1.5	Paradise	91	0	0	56	A				
	Average		74	27	0	52		PROVERBIAL CK, rm 1.5-3.5, 09 95	2	Paradise	91	0	0	87	B				
								PARADISE CK, rm 0.0-1.0, 09 93	1	Paradise	70	0	0	63	C				
								UPPER WIND R, rm 22.0-24.4, 09 93	2.4	Upper Wc	32	25	1	30	B				
								MIDDLE WIND, rm 22.0-24.4, 09 93	2.4	Upper Wc	32	25	1	30	B				
								MIDDLE WIND, rm 20.4-22.0, 09 93	1.8	Upper Wc	32	24	1	32	C				
								Average	72					67					
								<b>Middle Wind River 6th Field Watershed</b>											
								MIDDLE WIND, rm 18.9-20.4, 09 93	1.4	Mid Wind	34	0	1	23	D				
								UPPER WIND R, rm 23.7-25.3, 09 91	1.8	Mid Wind	33	0	0	56	C				
								MIDDLE WIND, rm 16.7-19.9, 09 92	1.2	Mid Wind	31	0	1	35	D				
								Average	33					31					

**Pool Quality (Pool Area/Maximum Pool Depth)**

NMFS Criteria	A Channel	B Channel	C Channel
PF = Properly Functioning	>81	>49	>57
FAR = Functioning at Risk	61-80	49-60	67-89
NPF = Not Properly Functioning	0-60	0-48	0-66

PNW = Pacific Northwest Regional Standards for pools/mile based on low flow width.

### Off-channel Habitat

Off channel habitat provides juvenile salmonids with refuge from peak flows and predators and can compose a significant of juvenile rearing and foraging habitat for some species such as coho salmon use side channels and braids extensively for rearing. When logjams were removed in the mid to late 1970's channels "down-cut" or degraded dropping out of their flood plain and losing connectivity with many side channels and wetlands. Because streamside riparian zones along the main-stem of the Wind River and its major tributaries were readily accessible and often contained large, high value timber, many of these areas were logged over the past 40 years. Early logging of the watershed included development of railroads along much of valley following the main-stem of the Wind River, and subsequent roads, campgrounds, and other facilities have been constructed along streams, in valley bottoms, and through riparian areas.

Gifford Pinchot, Level II Stream Habitat Survey data (1990-1999), channel type and professional judgment were used to establish off channel habitat baseline criteria for this analysis. Watersheds with averages greater than 5% side channels were considered to be *Properly Functioning*, those with 4-5% side channels were ranked as *Functioning at Risk*, and those with less than 4% side channels were ranked *Not Properly Functioning*. Trout Creek and the Middle Wind River ranked *Not Properly Functioning*, The Upper Wind River and Panther Creek ranked out as *Functioning at Risk* and Dry and Falls Creek 6<sup>th</sup> field watersheds were characterized as *Properly Functioning*.

**Table AA-19. Off channel habitat and flood plain connectivity matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: *National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species*)**

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Off channel habitat	ND	ND	3%	3%	7%	6%	5%	ND
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	Layout	Nine Mile	Trapper	L Falls	Paradise	Eight-Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	U Panther
			Compass / Crater				Headwaters Wind	Cedar
								Mouse
PF = Properly Functioning								
FAR = Functioning at Risk								
NPF = Not Properly Functioning								
ND = NO DATA								

## Refugia

Healthy riparian vegetation provides streams with shade, bank stability and LWD. The Regional Ecosystem Assessment Process (REAP) identified the "range of natural variability" for seral conditions in riparian areas across the Pacific Northwest. For the area including the Wind River watershed, the natural range of conditions in riparian areas is 5-30% for early seral vegetation and is 23-92% in late seral vegetation.

Refugia baseline criteria was based on the REAP criteria; riparian vegetation conditions; % riparian in early and late seral stages.

**Table AA-20. Baseline conditions by channel type for riparian conditions (percent riparian within early and late seral stages) within the Wind River, Skamania County, Washington.**

	<b>Properly <i>Functioning</i></b>	<b>Functioning <i>At Risk</i></b>	<b>Not Properly <i>Functioning</i></b>
<i>(% Riparian in Early seral)</i>	<23%	23-33%	>33%
<i>(% Riparian in Late seral)</i>	≥40%	30-39%	<30%

The Lower Wind River, Bear, Dry, Falls and Panther were considered *Properly Functioning*, Middle and Upper Wind River were ranked as *Functioning at Risk* and Trout Creek was the only watershed that rated *Not Properly Functioning*.

**Table AA-21. Refugia matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: *National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species*)**

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Disturbance history/ Refugia Rating	PF	PF	NPF	FAR	PF	PF	FAR	PF
% Riparian area within Early Seral	17%	9%	40%	24%	18%	22%	15%	15%
% Riparian Area within Late Seral	30%	40%	27%	33%	37%	34%	22%	47%
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	L Trout	Nine Mile	Trapper	L Falls	Paradise	Eight-Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	U Panther
			Compass / Orator				Headwaters Wind	Cedar
								Mouse
PF = Properly Functioning								
FAR = Functioning at Risk								
NPF = Not Properly Functioning								
ND = NO DATA								

## Channel Conditions & Dynamics

### Stream Width to Depth Ratios

When timber is harvested from riparian corridors, the stability of stream banks is decreased. This can substantially increase sediment delivery to streams and result in streams becoming wide and shallow (increased width to depth ratios). As width to depth ratios increase pools fill in with sediment. Fish depend on for foraging and refuge. Increased width to depth ratios can indirectly affect fish and their habitat by fill. Bank sloughing or landslides deliver both coarse and fine particles of soil which increase suspended sediments and bed load. Bed load consists of the larger particles that roll or slide across the bottom of the stream bed. Each stream has evolved to transport a certain amount of sediment. If excess sediment enters a stream the channel must compensate or adjust to the new sediment load.

Stream width to depth ratios are calculated by taking the bankfull or low channel widths divided by the average bankfull or low flow depths. These measurements are taken to evaluate the health of a stream. Without adequate large living root wads and large in-stream woody debris, streams that contain banks composed of unconsolidated soil and gravel have little lateral resistance. An increase in sediment load displaces water within the channel placing even more pressure on the banks. This accelerates erosion, increases channel width, and reduces the depth. These actions produce a wide, shallow channel that has a large surface area exposed to the sun and can increase maximum water temperatures.

Width to depth ratios were evaluated and segregated by Rosgen Channel type in the 1995 Wind River watershed and will be used here to establish the baseline criteria for this analysis.

*Table AA-22. Baseline conditions by channel type stream width to depth ratios within the Wind River, Skamania County, Washington.*

<b>NMFS Criteria</b>	<b>A Channels</b>	<b>B Channels</b>	<b>C Channels</b>
<b>PF = Properly Functioning</b>	<b>&lt;8</b>	<b>&lt;6</b>	<b>&lt;7</b>
<b>FAR = Functioning at Risk</b>	<b>8-10</b>	<b>6-8</b>	<b>7-9</b>
<b>NPF = Not Properly Functioning</b>	<b>&gt;10</b>	<b>&gt;8</b>	<b>&gt;9</b>
<b>ND = NO DATA</b>			

*Trout Creek and the middle Wind River were ranked as **Not Properly Functioning** and Dry, Panther and Upper Wind watersheds were rated as **Functioning at Risk**.*

**Table AA-23. Stream width to depth ratio matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species)**

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
W/D Ratio (Low Flow)	ND	ND	14	11	7	ND	8	7
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	Layout	Nine Mile	Trapper	L Falls	Paradise	Eight Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	U Panther
			Compass Crater				Headwaters Wind	Cedar
								Mouse

**PF = Properly Functioning**  
**FAR = Functioning at Risk**  
**NPF = Not Properly Functioning**  
**ND = NO DATA**

**Table AA-24. Width to depth ratio stream survey data for the Wind River and tributaries, Skamania County, Washington. (Based on: National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species)**

Trout Creek 6th field watershed						Dry Creek 6th Field watershed					
Stream Name	River Miles	7th Field H2Oshed	Low Flow W/D Ratio Condition Rating	Low Flow W/D Ratio	Roggen Channel Type	Stream Name	River Miles	7th Field H2Oshed	Low Flow W/D Ratio Condition Rating	Low Flow W/D Ratio	Roggen Channel Type
COMPASS CREEK, rm 1.7-2.1, 09 93	0.4	Crtr/Cmps	1	2	A	TRAPPER	4	Trapper	0	5	B
CRATER CREEK, rm 1.5-1.8, 09 93	0.3	Crtr/Cmps	1	2	A	TRAPPER	6	Trapper	0	9	B
COMPASS CREEK, rm 1.1-1.7, 09 93	0.6	Crtr/Cmps	1	4	A	TRAPPER	3	Trapper	0	9	B
CRATER CREEK, rm 1.1-1.5, 09 89	0.4	Crtr/Cmps	0	9	A	TRAPPER	1	Trapper	0	8	C
CRATER CREEK, rm 1.5-1.9, 09 89	0.4	Crtr/Cmps	1	4	A	TRAPPER	2	Trapper	0	16	C
CRATER CREEK, rm 0.8-1.1, 09 89	0.3	Crtr/Cmps	1	4	A	DRY CREEK, rm 3.4-3.8, 09 92	2	Dry Cr	0	7	C
CRATER CREEK, rm 0.5-0.8, 09 89	0.3	Crtr/Cmps	1	5	B	DRY CREEK, rm 3.8-4.4, 09 92	3	Dry Cr	1	1	G
COMPASS CREEK, rm 1.5-2.4, 07 97	0.9	Crtr/Cmps	1	5	C	DRY CREEK, rm 1.6-3.4, 09 92	1	Dry Cr	1	10	C
COMPASS CREEK, rm 0.8-0.9, 09 93	0.3	Crtr/Cmps	1	13	C			Average	1	7	
COMPASS CREEK, rm 0.0-1.5, 07 97	1.5	Crtr/Cmps	1	16	B	<b>Falls Creek 6th Field watershed</b>					
CRATER CREEK, rm 0.0-1.8, 07 96	1.6	Crtr/Cmps	1	16	D	FALLS CREEK, rm 6.0-9.5, 09 96	3.5	Upper Falls			C
CRATER CREEK, rm 0.3-0.5, 09 89	0.2	Crtr/Cmps	0	9	C	FALLS CREEK, rm 9.5-11.4, 09 98	1.9	Upper Falls			B
CRATER CREEK, rm 0.0-1.5, 09 93	1.5	Crtr/Cmps	0	9	A	FALLS CREEK, rm 2.8-6.0, 09 98	3.1	Lower Falls			B
COMPASS CREEK, rm 0.0-1.1, 09 93	1.1	Crtr/Cmps	0	9	C	FALLS CREEK, rm 1.8-2.9, 09 88	1.3	Lower Falls			B
LAYOUT CK, rm 2.3-2.5, 09 91	0.2	Layout				FALLS CREEK, rm 0.6-1.6, 09 98	1	Lower Falls			B
LAYOUT CK, rm 0.0-1.9, 07 98	1.9	Layout	1	23	C	FALLS CREEK, rm 0.0-0.6, 09 98	0.6	Lower Falls			B
LAYOUT CK, rm 1.1-2.3, 09 91	1.2	Layout	1	10	B			Average			
LAYOUT CK, rm 1.9-2.5, 07 98	1.6	Layout	1	11	B	<b>Upper Wind River 6th Field watershed</b>					
LAYOUT CK, rm 0.0-1.1, 09 91	1.1	Layout	1	11	C	OLDMAN CK, rm 0.0-1.1, 09 93	1.1	Headwater	1	3	B
LAYOUT CK, rm 1.9-2.5, 07 98	1.6	Layout	1	17	C	YOUNGMAN CK, rm 0.0-0.9, 09 93	0.9	Headwater	0	6	B
SF PLANTING CK 09 92	0.5	Lower Trt	1	1	A	YOUNGMAN CK, rm 0.9-1.7, 09 93	0.8	Headwater	0	4	A
PLANTING CK, rm 0.4-0.9, 09 82	0.5	Lower Trt	1	4	A	OLDMAN CK, rm 1.6-2.1, 09 93	0.5	Headwater	0	4	B
TROUT CK, rm 2.8-4.8, 09 95	1.8	Lower Trt	1	7	B	OLDMAN CK, rm 1.1-1.5, 09 93	0.6	Headwater	0	4	A
TROUT CK, rm 2.4-2.8, 09 95	0.4	Lower Trt	1	3	B	UPPER WIND R, rm 27.2-28.5, 09 9	0.6	Headwater	0	16	A
SF PLANTING CK 09 92	0.5	Lower Trt	1	3	B	UPPER WIND R, rm 25.3-27.0, 09 9	1.7	Headwater	0	16	A
PLANTING CK, rm 0.9-1.1, 09 82	0.2	Lower Trt	1	10	A	UPPER WIND R, rm 28.5-28.0, 09 9	0.5	Headwater	0		A
TROUT CK, rm 1.8-2.4, 09 85	0.6	Lower Trt	0	8	B	UPPER WIND R, rm 27.0-27.9, 09 9	0.9	Headwater	0	14	A
PLANTING CK, rm 0.0-0.4, 09 92	0.4	Lower Trt	1	5	B	UPPER WIND R, rm 27.4-28.4, 07 9	1	Hdwtvs Wind	0	9	B
PLANTING CK, rm 1.1-2.0, 09 92	0.9	Lower Trt	1	4	B	UPPER WIND R, rm 28.4-28.9, 07 9	0.6	Hdwtvs Wind	0	6	A
TROUT CK, rm 0.7-0.4, 09 95	0.7	Lower Trt	1	10	B	UPPER WIND R, rm 25.3-27.4, 07 9	2.1	Hdwtvs Wind	0	14	B
E FK TROUT CK, rm 0.5-0.8, 09 92	0.2	Upper Trt	1	4	G	UPPER WIND R, rm 28.9-29.7, 07 9	0.6	Hdwtvs Wind	0	9	D
E FK TROUT CK, rm 0.3-0.6, 09 92	0.3	Upper Trt	1	4	C	PETES GULCH CK II, rm 0.5-0.6, 09	0.1	Pete's	1		E
E FK TROUT CK, rm 0.0-0.3, 09 92	0.3	Upper Trt	0	7	E	PETES GULCH CK, rm 0.0-0.9, 09 9	0.8	Pete's	1	4	A
E FK TROUT CK, rm 0.0-0.8, 09 92	0.8	Upper Trt	1		B	PETES GULCH CK, rm 0.8-1.6, 09 9	0.6	Pete's	0	6	A
TROUT CK, rm 5.4-6.7, 07 96	1.3	Upper Trt	1	17	B	PETES GULCH CK II, rm 0.0-0.5, 09	0.5	Pete's	0	7	A
TROUT CK, rm 6.8-8.7, 09 95	1.9	Upper Trt	1	6	C	PARADISE CK, rm 1.0-2.3, 09 93	1.3	Paradise	0	6	B
TROUT CK, rm 6.7-7.9, 07 96	1.2	Upper Trt	1	17	C	PROVERBIAL CK, rm 0.0-1.5, 09 95	1.5	Paradise	0	7	A
TROUT CK, rm 7.9-9.4, 07 96	1.5	Upper Trt	1	19	C	PROVERBIAL CK, rm 1.5-3.5, 09 95	2	Paradise	0	7	B
TROUT CK, rm 4.6-6.8, 09 95	2.2	Upper Trt	1	13	C	PARADISE CK, rm 0.0-1.0, 09 93	1	Paradise	0	18	C
		Average	0	9		UPPER WIND R, rm 22.0-25.3, 07 9	3.3	Upper Wind	0	19	D
<b>Panther Creek 6th Field watershed</b>						MIDDLE WIND, rm 22.0-24.4, 09 93	2.4	Upper Wind	0	6	B
MOUSE CK, rm 0.0-0.5, 09 94	0.6	Mouse	0	8	B	MIDDLE WIND, rm 20.4-22.0, 09 93	1.8	Upper Wind	0	7	C
12 MILE CK, rm 0.0-0.5, 09 94	0.5	Upper Pnt	1	3	B			Average	0	8	
10 MILE, rm 0.0-0.8, 09 94	0.8	Upper Pnt	0	5	C	<b>Middle Wind River 6th Field watershed</b>					
PANTHER CK, rm 9.2-10.0, 09 94	0.8	Lower Pnt	0	6	A	MIDDLE WIND, rm 18.5-20.4, 09 93	1.4	Mid Wind		10	D
PANTHER CK, rm 5.7-8.3, 09 94	0.6	Lower Pnt	0	11	B	UPPER WIND R, rm 23.7-25.3, 09 9	1.6	Mid Wind		11	C
PANTHER CK, rm 7.7-9.2, 09 94	0.6	Lower Pnt	0	9	C	MIDDLE WIND, rm 16.7-18.9, 09 93	1.2	Mid Wind		13	D
PANTHER CK, rm 0.0-0.6, 09 94	1.5	Lower Pnt	0	9	B			Average		11	
PANTHER CK, rm 8.9-7.7, 09 94	4.5	Lower Pnt	1	0	A	<b>NMFS Criteria</b>					
PANTHER CK, rm 8.9-7.7, 09 94	0.8	Lower Pnt	1	10	B	A Channels	B Channels	C Channels			
PANTHER CK, rm 4.6-5.7, 09 94	1.1	Lower Pnt	0	9	B	PF = Properly Functioning	<6	<7			
CEDAR CK, rm 1.3-2.5, 09 94	1.2	Cedar	0	8	A	FAR = Functioning at Risk	6-10	6-8			
CEDAR CK, rm 0.4-1.3, 09 94	0.9	Cedar	1	9	B	NPF = Not Properly Functioning	>10	>9			
8 MILE CK, rm 0.0-0.8, 09 94	0.8	8 mile	0	4	E	ND = NO DATA					
8 MILE CK, rm 0.8-1.3, 09 94	0.5	8 Mile	1	9	A						
		Average	0	7							

## Channel Stability, Stream Bank Conditions and Floodplain Connectivity

Bank erosion and channel stability can significantly affect fish habitat and water quality by filling in pools with fine and coarse sediment, increasing the stream width and decreasing depth, increasing turbidity and fine sediment deposition in substrates.

The Pfankuch stability rating has been used in part to evaluate channel and bank stability. This systematic procedure developed by Pfankuch was used to evaluate the resistive capacity of stream channels to the detachment of bed and bank materials and provides information about the streams capacity to adjust and recover from changes in flows and increases in sediment production. The variables associated with evaluating channel stability are: land form, mass wasting, LWD, vegetative bank protection, width to depth ratios, bank erosion, substrate type and aquatic vegetation (Pfankuch, 1978).

Accurate flood plain and bank stability data was not available for most streams within the Wind River therefore qualitative Pfankuch surveys were used as a surrogate. Table X\$ established baseline criteria for channel and bank stability.

**Table AA-25. Baseline conditions for floodplain connectivity, bank and channel stability by channel type within the Wind River, Skamania County, Washington.**

NMFS Criteria	A Channels	B Channels	C Channels
PF = Properly Functioning	<76	<73	<90
FAR = Functioning at Risk	76-85	73-68	90-98
NPF = Not Properly Functioning	>85	>73	>98
ND = NO DATA			

The Lower Wind River and Falls Creek are generally bedrock controlled systems and were considered *Properly Functioning*, The alluvial reaches of Panther Creek produced moderate Pfanchuck ratings and was therefore ranked as *Functioning at Risk*. Trout, Middle Wind, Dry and Upper Wind alluvial reaches have poor bank and channel stability and were rated *Not Properly Functioning*.

**Table AA-26. Channel Stability, stream bank conditions and floodplain connectivity matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: *National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species*)**

6th Field Watershed	Lower Wind	Bear	Trout	Middle Wind	Dry	Falls	Upper Wind	Panther
Channel Stability and Streambank conditions	PF	ND	NPF	NPF	NPF	PF	NPF	FAR
	Little Wind	L Bear	L Trout	Middle Wind	Dry	U Falls	Upper Wind	L Panther
7th Field Sub-watersheds	Brush	NF Bear	Layout	Nine Mile	Trapper	L Falls	Paradise	Eight-Mile
	L Wind	EF Bear	Upper Trout				Pete's Gulch	U Panther
			Compass Crater				Headwaters Wind	Cedar Mouse
PF = Properly Functioning								
FAR = Functioning at Risk								
NPF = Not Properly Functioning								
ND = NO DATA								

**Table AA-27. Pfanckuch channel Stability and stream bank conditions stream survey data for the Wind River and tributaries, Skamania County, Washington. (Based on: National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species)**

Trout Creek 6th Field Watershed						Dry Creek 6th Field watershed					
Stream Name	River Miles	7th Field H20shed	Channel Stability Rating	Pfanckuch Channel Stability	Roegen Channel Type	Stream Name	River Miles	7th Field H20shed	Channel Stability Rating	Pfanckuch Channel Stability	Roegen Channel Type
COMPASS CREEK, rm 1.7-2.1, 09 93	0.4	Crtr/Cmps	0	70	A	TRAPPER	4	Trapper	1	51	B
CRATER CREEK, rm 1.5-1.8, 09 93	0.3	Crtr/Cmps			A	TRAPPER	5	Trapper	1	51	B
COMPASS CREEK, rm 1.1-1.7, 09 93	0.6	Crtr/Cmps	0	75	A	TRAPPER	3	Trapper	1	58	B
CRATER CREEK, rm 1.1-1.5, 09 93	0.4	Crtr/Cmps	1	53	A	TRAPPER	1	Trapper	1	61	C
CRATER CREEK, rm 1.5-1.9, 09 89	0.4	Crtr/Cmps	0	73	A	TRAPPER	2	Trapper	1	53	C
CRATER CREEK, rm 0.8-1.1, 09 89	0.3	Crtr/Cmps	1	83	B	DRY CREEK, rm 3.4-3.8, 09 92	2	Dry Cr	0	81	C
CRATER CREEK, rm 0.5-0.8, 09 89	0.3	Crtr/Cmps	0	83	C	DRY CREEK, rm 3.8-4.4, 09 92	3	Dry Cr	0	76	G
COMPASS CREEK, rm 1.5-2.4, 07 97	0.9	Crtr/Cmps			B	DRY CREEK, rm 1.6-3.4, 09 92	1	Dry Cr	0	87	C
CRATER CREEK, rm 0.0-0.3, 09 89	0.3	Crtr/Cmps	0	91	C	Average			1	85	
COMPASS CREEK, rm 0.0-1.5, 07 97	1.5	Crtr/Cmps			B	<b>Falls Creek 6th Field watershed</b>					
CRATER CREEK, rm 0.0-1.6, 07 96	1.6	Crtr/Cmps		76	D	FALLS CREEK, rm 6.0-9.5, 09 98	3.5	Upper Fls	0	50	C
CRATER CREEK, rm 0.3-0.5, 09 89	0.2	Crtr/Cmps		115	C	FALLS CREEK, rm 9.5-11.4, 09 98	1.9	Upper Fls	1	44	B
CRATER CREEK, rm 0.0-1.5, 09 93	1.5	Crtr/Cmps			A	FALLS CREEK, rm 2.9-6.0, 09 98	3.1	Lower Fls	1	69	B
COMPASS CREEK, rm 0.0-1.1, 09 93	1.1	Crtr/Cmps		100	C	FALLS CREEK, rm 1.9-2.9, 09 98	1.3	Lower Fls	1	71	B
LAYOUT CK, rm 7.3-2.5, 09 91	0.2	Layout	1	62	A	FALLS CREEK, rm 0.6-1.8, 09 98	1	Lower Fls	1	63	B
LAYOUT CK, rm 0.0-1.9, 07 98	1.9	Layout	0	83	C	FALLS CREEK, rm 0.0-0.8, 09 98	0.6	Lower Fls	1	65	B
LAYOUT CK, rm 1.1-2.3, 09 91	1.2	Layout		55	B	Average			1	81	
LAYOUT CK, rm 1.9-2.5, 07 98	1.6	Layout	0	95	B	<b>Upper Wind River 6th Field waters</b>					
LAYOUT CK, rm 0.9-1.3, 09 81	1.1	Layout		124	C	OLDMAN CK, rm 0.0-1.1, 09 93	1.1	Headwater	0		B
LAYOUT CK, rm 1.9-2.5, 07 98	1.6	Layout		62	C	YOUNGMAN CK, rm 0.0-0.9, 09 93	0.9	Headwater		91	B
SF PLANTING CK 09 92	0.5	Lower Trt			A	YOUNGMAN CK, rm 0.9-1.7, 09 93	0.8	Headwater		85	A
PLANTING CK, rm 0.4-0.9, 09 92	0.5	Lower Trt	1	58	A	OLDMAN CK, rm 1.8-2.1, 09 93	0.5	Headwater			B
TROUT CK, rm 2.8-4.6, 09 95	1.8	Lower Trt	1	48	A	OLDMAN CK, rm 1.1-1.6, 09 93	0.5	Headwater			A
TROUT CK, rm 2.4-2.8, 09 95	0.4	Lower Trt	1	51	B	UPPER WIND R, rm 27.9-28.5, 09 99	0.6	Headwater	1	50	A
SF PLANTING CK 09 92	0.5	Lower Trt			B	UPPER WIND R, rm 25.3-27.0, 09 99	1.7	Headwater	1	60	A
PLANTING CK, rm 0.9-1.1, 09 92	0.2	Lower Trt	1	59	A	UPPER WIND R, rm 28.5-29.0, 09 99	0.5	Headwater	1	63	A
TROUT CK, rm 1.8-2.4, 09 95	0.6	Lower Trt		76	B	UPPER WIND R, rm 27.0-27.9, 09 99	0.9	Headwater	1	66	A
PLANTING CK, rm 0.0-0.4, 09 92	0.4	Lower Trt	0	72	B	UPPER WIND R, rm 27.4-28.4, 07 99	1	Hdwtrs Wind	0	52	B
PLANTING CK, rm 1.1-2.0, 09 92	0.9	Lower Trt		104	B	UPPER WIND R, rm 28.4-28.9, 07 99	0.5	Hdwtrs Wind	0	46	A
TROUT CK, rm 8.7-9.4, 09 95	0.7	Lower Trt		74	B	UPPER WIND R, rm 25.3-27.4, 07 99	2.1	Hdwtrs Wind		100	B
E FK TROUT CK, rm 0.6-0.8, 09 92	0.2	Upper Trt	1	77	G	UPPER WIND R, rm 28.9-29.7, 07 99	0.8	Hdwtrs Wind		87	D
E FK TROUT CK, rm 0.3-0.6, 09 92	0.3	Upper Trt	1	78	C	PETES GULCH CK II, rm 0.5-0.6, 09 99	0.1	Pete's	1	86	E
E FK TROUT CK, rm 0.0-0.3, 09 92	0.3	Upper Trt	1	67	E	PETES GULCH CK, rm 0.0-0.8, 09 99	0.8	Pete's		96	A
E FK TROUT CK, rm 0.0-0.8, 09 92	0.8	Upper Trt	1	62	B	PETES GULCH CK, rm 0.8-1.6, 09 99	0.8	Pete's	0	79	A
TROUT CK, rm 5.4-6.7, 07 96	1.3	Upper Trt	1	65	B	PETES GULCH CK II, rm 0.0-0.5, 09 99	0.5	Pete's	0	83	A
TROUT CK, rm 6.9-8.7, 09 95	1.9	Upper Trt		113	C	PARADISE CK, rm 1.0-2.3, 09 93	1.3	Paradise	1	53	B
TROUT CK, rm 6.7-7.9, 07 96	1.2	Upper Trt		117	C	PROVERBIAL CK, rm 0.0-1.5, 09 95	1.5	Paradise	0	67	A
TROUT CK, rm 7.9-9.4, 07 96	1.5	Upper Trt		122	C	PROVERBIAL CK, rm 1.5-3.5, 09 95	2	Paradise		103	B
TROUT CK, rm 4.8-6.8, 09 95	2.2	Upper Trt		108	C	PARADISE CK, rm 0.0-1.0, 09 93	1	Paradise	0	82	C
Average			0	79		UPPER WIND R, rm 22.0-25.3, 07 99	3.3	Upper Wind		122	D
<b>Panther Creek 6th Field watershed</b>						MIDDLE WIND, rm 22.0-24.4, 09 93	2.4	Upper Wid		134	B
MOUSE CK, rm 0.0-0.6, 09 94	0.6	Mouse	0	70	B	MIDDLE WIND, rm 20.4-22.0, 09 93	1.6	Upper Wid		103	C
12 MILE CK, rm 0.0-0.5, 09 94	0.5	Upper Pnt	1	74	B	Average			0	97	
10 MILE, rm 0.0-0.8, 09 94	0.8	Upper Pnt	1	96	C	<b>Middle Wind River 6th Field waters</b>					
PANTHER CK, rm 9.2-10.0, 09 94	0.8	Lower Pnt	1	44	A	MIDDLE WIND, rm 18.9-20.4, 09 93	1.4	Mid Wind	0	57	D
PANTHER CK, rm 5.7-6.3, 09 94	0.6	Lower Pnt	1	91	B	UPPER WIND R, rm 23.7-25.3, 09 99	1.6	Mid Wind		141	C
PANTHER CK, rm 6.3-6.9, 09 94	0.6	Lower Pnt	0	90	C	MIDDLE WIND, rm 16.7-18.9, 09 93	1.2	Mid Wind		98	D
PANTHER CK, rm 7.7-9.2, 09 94	1.5	Lower Pnt		77	B	Average				109	
PANTHER CK, rm 0.0-4.6, 09 94	4.6	Lower Pnt			A	<b>NMFS Criteria</b>					
PANTHER CK, rm 6.9-7.7, 09 94	0.8	Lower Pnt		84	B	A Channels	B Channels	C Channels			
PANTHER CK, rm 4.6-5.7, 09 94	1.1	Lower Pnt		97	B	PF = Properly Functioning	<78	<73	<90		
CEDAR CK, rm 1.3-2.5, 09 94	1.2	Cedar	0	79	A	FAR = Functioning at Risk	76-85	73-66	90-98		
CEDAR CK, rm 0.4-1.3, 09 94	0.9	Cedar		78	B	NPF = Not Properly Functioning	>86	>72	>99		
8 MILE CK, rm 0.0-0.8, 09 94	0.8	8 Mile	1	77	E	ND = NO DATA					
8 MILE CK, rm 0.8-1.3, 09 94	0.5	8 Mile	1	52	A						
Average			0	78							

## Flow/Hydrology and Watershed Conditions

### Peak flows, Road Density, Drainage Network and Riparian Reserves

Changes in peak flows can have significant impacts on salmonid habitat and life histories. Up-slope timber harvest within the rain on snow zone can indirectly affect stream channels and fish habitat by increasing peak flows, erosion and sedimentation.

The following table details the criteria used to establish baseline values for **Aggregate Recovery Percentage ARP, Drainage Network Increase, Road Density and Riparian conditions.**

**Table AA-28. Baseline criteria for Flow/Hydrology and Watershed Conditions (Aggregate Recovery Percentage ARP, Drainage Network Increase, Road Density and Riparian conditions), Wind River, Skamania County, Washington. (Based on: *National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species*)**

NMFS Matrix and Pathways Criteria	Properly Functioning	Functioning at Risk	Not Properly Functioning
ARP	>80	70-80	<70
Drainage network Increase	<10%	10-20%	>20%
Road density (Mile/Mile <sup>2</sup> )	<2	2-3	>3
% Riparian area within Early Seral	<23%	23-33%	>33%
% Riparian Area within Late Seral	>40	30-40%	<30%

Due to the high percentage of drainage network increases, road densities, Aggregate Recovery Percentages, percentage of watershed in rain-on-snow and riparian conditions, Trout Creek was ranked as *Not Properly Functioning*. Panther Creek and the Lower, Middle and Upper Wind River sub-watersheds were ranked as *Functioning at Risk* and Dry, Bear and Falls Creek were rated as *Properly Functioning*.

**Table AA-29. Peak Flow matrix for 6<sup>th</sup> and 7<sup>th</sup> field watersheds, Wind River, Skamania County, Washington. (Based on: *National Marine Fisheries Service Pathways and Indicators Criteria for threatened and endangered species*)**

# APPENDIX B—AGGREGATE RECOVERY PERCENT (ARP) UPDATE

Over the past five years, young forest vegetation in the watershed has continued to develop toward hydrologic maturity, even while some hydrologically mature forest stands have been harvested. Because there are numerous stands in the watershed that are developing toward hydrologic maturity, and only a few stands that have been cut during the past five year period, ARP values have increased across a majority of the watershed during this time. The average ARP for the watershed has increased from 86 To 87 over the course of the past five years. More importantly, however, are the changes that have occurred at the 6<sup>th</sup> and 7<sup>th</sup> field subwatershed scales. Figure AB-1 displays the changes in ARP values over the past five years by 7<sup>th</sup> field subwatershed.

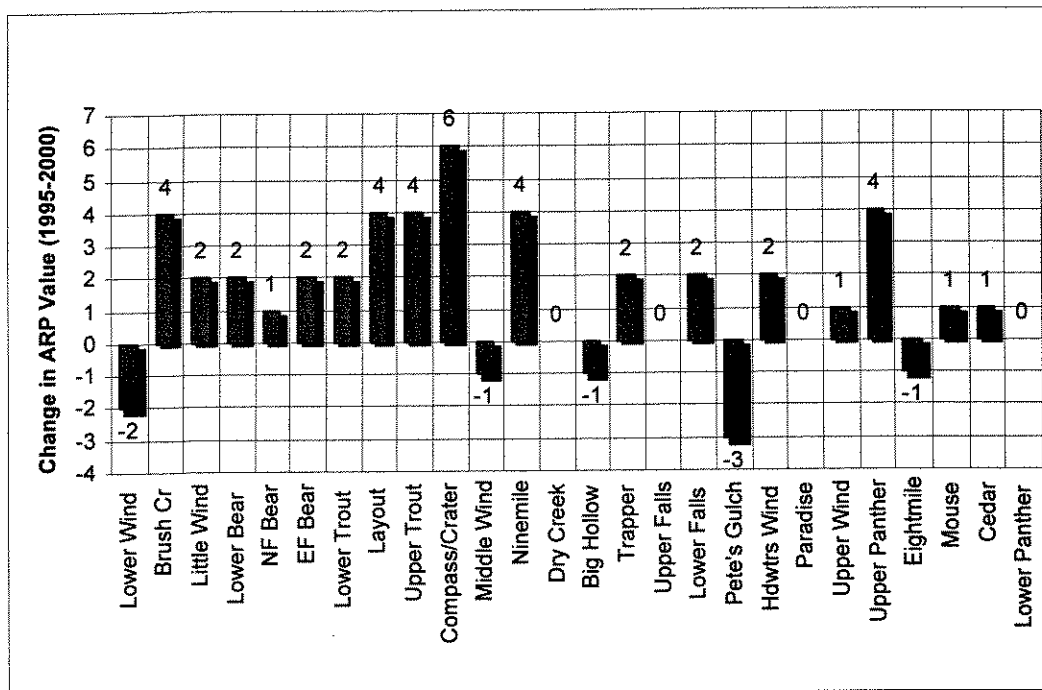


Figure AB-1. Five-year changes in ARP values by 7<sup>th</sup> field subwatershed (1995-2000).

Some of the changes in ARP values over this time period have occurred simply as a result of forest vegetation layer improvements in the GIS. These have not been quantified, but are assumed to be relatively minor. The greatest increases in ARP come in the subwatersheds where there has been no timber harvest, and where stands are rapidly moving from a hydrologically immature condition to one of greater maturity. Such is the case in Compass/Crater Creek, where the change in ARP has been the most dramatic of any subwatershed. Over the past five years, ARP's in the Compass/Crater subwatershed have increased by six points, from 74 to 80. There has been no harvest in the Compass/Crater subwatershed during this time period. The large increase in ARP there is due to the number of stands in the 10-40 year-old age class that are rapidly increasing in hydrologic function.

Although most timber sale planning and analysis continues to occur at the 3,000-10,000 acre subwatershed scale that is now represented by our 7<sup>th</sup> field subwatersheds, current ARP values are aggregated to the 6<sup>th</sup> field scale and presented in Table AB-1. Table AB-2 documents current ARP values at the 7<sup>th</sup> field scale.

Table AB-1. Summary of Current ARP Conditions—6<sup>th</sup> field Subwatershed Scale

Subwatershed Number	Subwatershed Name	ARP
01	Upper Wind	82
02	Falls	82
03	Dry	94
04	Middle Wind	87
05	Trout	85
06	Panther	85
07	Bear	95
08	Lower Wind	92
(Entire Watershed)		87

Table AB-2. Summary of Current ARP Conditions—7<sup>th</sup> field Subwatershed Scale

7 <sup>th</sup> Field Subwshed Number	7 <sup>th</sup> Field Subwatershed Name	Acres	ARP
09A	Paradise	5416	82
09B	Hdwtrs Wind	8363	77
09C	Lower Falls	8110	74
09D	Trapper	7417	99
09E	Big Hollow	4121	91
09F	Dry	5754	90
09G	Ninemile	3501	76
09H	Compass/Crater	3790	80
09I	Upper Trout	6146	80
09J	Middle Wind	13051	90
09K	Eightmile	2356	74
09L	Upper Panther	10372	78
09M	Layout	3552	83
09N	Lower Trout	8244	93
09O	Lower Bear	2045	91
09P	Upper Falls	5777	92
09Q	Lower Panther	7184	92
09R	Mouse	2580	96
09S	Cedar	3974	91
09T	North Fk Bear	3719	97
09U	Lower Wind	9465	92
09V	Upper Wind	3509	95
09W	Pete's Gulch	3498	83
09X	East Fork Bear	3751	95
09Y	Brush	1876	93
09Z	Little Wind	5931	91
09	Wind River Watershed	143502	

**APPENDIX C—DATA SUMMARY**  
**TABLES**

6 <sup>th</sup> Field	6th Field	7th Field	7th Field	Potential Unstable	Mapped Landslides	Road Erosion	Drainage Density	Stream Xing Freq	Road Density	Area in Rain-on-Snow	Max Water			
Subwatershed	No.	Acres	Subwatershed	No.	Acres	Soils (%)	(%)	Index	Incr (%)	xings/mi	(mi/mi <sup>2</sup> )	ARP	Temp	
Upper Wind	01	20,093				0.16	0.02	M	28%	1.0	2.4	84	82	16
			Pete's Gulch	W	3,498			M			1.3	44	83	
			Hdwtrs Wind	B	8,363			H			3.1	100	77	
			Paradise	A	5,416			M			2.1	91	82	
			Upper Wind	V	3,509			M			1.4	76	95	
Falls	02	13,891				0.00	0.00	H	26%	0.8	1.7	70	82	16
			Upper Falls	P	5,777			M			0.9	38	92	
			Lower Falls	C	8,110			H			2.1	92	74	
Dry	03	17,381				0.06	0.03	L	10%	0.5	1.2	78	94	17
			Dry Creek	F	5,754			L			2.2	81	90	
			Big Hollow	E	4,121			L			1.1	84	91	
			Trapper	D	7,417			L			0.3	73	99	
Middle Wind	04	17,222				0.15	0.04	M	31%	1.3	2.6	58	87	21
			Middle Wind	J	13,051			M			2.8	49	90	
			Ninemile	G	3,501			M			1.9	93	76	
Trout	05	21,735				0.09	0.01	M	35%	1.0	2.7	85	85	25
			Lower Trout	N	8,244			M			2.2	74	93	
			Layout	M	3,552			M			2.7	96	83	
			Upper Trout	I	6,146			M			2.5	91	80	
			Compass/Crater	H	3,790			H			2.6	89	80	
Panther	06	26,467				0.12	0.05	M	23%	1.1	2.2	72	85	12
			Upper Panther	L	10,372			H			2.7	79	78	
			Eightmile	K	2,356			L			1.3	91	74	
			Mouse	R	2,580			M			2.0	87	96	
			Cedar	S	3,974			M			1.7	85	91	
			Lower Panther	Q	7,184			M			2.2	43	92	
Bear	07	9,515				0.20	0.05	L	13%	0.7	1.5	71	95	17
			Lower Bear	O	2,045			M			2.7	33	91	
			NF Bear	T	3,719			L			0.7	79	97	
			EF Bear	X	3,751			L			1.4	85	95	
Lower Wind	08	17,375				0.04	0.01	M	41%	0.9	2.9	33	92	16
			Lower Wind	U	9,465			M			3.1	20	92	
			Brush Cr	Y	1,876			L			2.4	35	93	
			Little Wind	Z	5,931			L			2.7	53	91	
Total/Avg		143,679							25%	0.9	2.2			

6 <sup>th</sup> Field Subwatershed	6th Field No.	Acres	7th Field Subwatershed	7th Field No.	Acres	Risk of Comp/ Disease	LWD Rating	Riparian Rating	Pool Quality Rating	Width Depth Rating	Fish Passage Barriers	% Riparian Reserve Connectivity	50-11-40 (%)
Upper Wind	01	20,093									2	68	68
			Pete's Gulch	W	3,498	Y	Poor	Good	Exc	Exc			
			Hdwtrs Wind	B	8,363	Y	Exc	Good	Exc	Poor			
			Paradise	A	5,416	Y	Exc	Exc	Exc	Good			
			Upper Wind	V	3,509	Y	Poor	Good	Poor	Exc			
Falls	02	13,891									0	63	48
			Upper Falls	P	5,777	Y	Poor	Good					
			Lower Falls	C	8,110	Y	Poor	Good					
Dry	03	17,381									0	76	80
			Dry Creek	F	5,754	N	Poor	Poor	Exc	Poor			
			Big Hollow	E	4,121	N	Exc	Good	ND	ND			
			Trapper	D	7,417	Y	Good	Exc	Exc	Poor			
Middle Wind	04	17,222									0	66	69
			Middle Wind	J	13,051	Y	Good	Poor	Poor	Good			
			Ninemile	G	3,501	Y	ND	Good	ND	ND			
Trout	05	21,735									0	61	66
			Lower Trout	N	8,244	Y	Poor	Poor	Exc	Poor	Y		
			Layout	M	3,552	Y	Exc	Poor	Exc	Good			
			Upper Trout	I	6,146	Y	Poor	Poor	Poor	Poor			
			Compass/Crater	H	3,790	Y	Poor	Poor	Exc	Good			
Panther	06	26,467									0	70	70
			Upper Panther	L	10,372	N	Poor	Good	Exc	Good			
			Eightmile	K	2,356	N	Good	Good	Exc	Exc			
			Mouse	R	2,580	N	Exc	Good	Exc	Exc			
			Cedar	S	3,974	N	Good	Good	Good	Good			
			Lower Panther	Q	7,184	N	Good	Good	Exc	Good			
Bear	07	9,515									0	83	80
			Lower Bear	O	2,045	Y	ND	Good	ND	ND			
			NF Bear	T	3,719	Y	ND	Exc	ND	ND			
			EF Bear	X	3,751	Y	ND	Exc	ND	ND			
Lower Wind	08	17,375									0	64	61
			Lower Wind	U	9,465	Y	Poor	Exc	Exc	ND			
			Brush Cr	Y	1,876	N	ND	Good	ND	ND			
			Little Wind	Z	5,931	N	ND	Poor	ND	ND			
Total/Avg		143,679											

Exc = Excellent

ND = No Data