September 2001

WIND RIVER
WATERSHED RESTORATION
IN FOUR VOLUMES

Annual Report 1999

DOE/BP-00004973-1

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views of this report are the author's and do not necessarily represent the views of BPA.

This document should be cited as follows:

Connolly, Patrick J. - U.S. Geological Survey, Columbia River Research Laboratory, 2001, Wind River Watershed Restoration 1999 Annual Report In Four Volumes, Report to Bonneville Power Administration, Contract No. 00004973, Project No. 199801900, 235 electronic pages (BPA Report DOE/BP-00004973-1)

This report and other BPA Fish and Wildlife Publications are available on the Internet at:

http://www.efw.bpa.gov/cgi-bin/efw/FW/publications.cgi

For other information on electronic documents or other printed media, contact or write to:

Bonneville Power Administration
Environment, Fish and Wildlife Division
P.O. Box 3621
905 N.E. 11th Avenue
Portland, OR 97208-3621

Please include title, author, and DOE/BP number in the request.

Wind River Watershed Restoration

1999 Annual Report

In Four Volumes

September 2001

Edited by:

Patrick J. Connolly

U.S. Geological Survey
Columbia River Research Laboratory
5501-a Cook-Underwood Road
Cook, WA 98605

Prepared for:

Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number: 1998-019-01
Contract Number 00004973
(previously 98-AI-09728-002)

Contents

Executive Summary

This document represents work conducted as part of the Wind River Watershed Restoration Project during its first year of funding through the Bonneville Power Administration (BPA). The project is a comprehensive effort involving public and private entities seeking to restore water quality and fishery resources in the basin through cooperative actions. Project elements include coordination, watershed assessment, restoration, monitoring, and education. Entities involved with implementing project components are the Underwood Conservation District (UCD), USDA Forest Service (USFS), U.S. Geological Survey – Columbia River Research Lab (USGS-CRRL), and WA Department of Fish & Wildlife (WDFW).

Following categories given in the FY1999 Statement of Work, the broad categories, the related objectives, and the entities associated with each objective (lead entity in boldface) were as follows:

<u>Coordination</u>

Objective 1: Coordinate the Wind River watershed Action Committee (AC) and Technical Advisory Committee (TAC) to develop a prioritized list of watershed enhancement projects. [**UCD**]

See Report A.

<u>Monitoring</u>

Objective 2: Monitor natural production of juvenile, smolt, and adult steelhead in the Wind River subbasin. [**USGS**, **WDFW**, USFS]

See Report D, E, and F.

Objective 3: Evaluate physical habitat conditions in the Wind River subbasin. [**USGS**, **USFS,** UCD]

See Report G, H, and I.

<u>Assessment</u>

Objective 4: Assess watershed health using an ecosystem-based diagnostic model that will provide the technical basis to prioritize out-year restoration projects. [**WDFW**, USGS, USFS, UCD]

No report provided, but will be covered in next year's annual report.

<u>Restoration</u>

Objective 5: Reduce road related sediment sources by reducing road densities to less than 2 miles per square mile. [**USFS**]

See Report C.

Objective 6: Rehabilitate riparian corridors, flood plains, and channel morphology to reduce maximum water temperatures to less than 61°F, to increase bank stability to greater than 90%, to reduce bankfull width to depth ratios to less than 30, and to provide natural levels of pools and cover for fish. [**USFS, UCD**]

See Report C.

Objective 7: Maintain and evaluate passage for adult and juvenile steelhead at artificial barriers. [**USFS**]

No report provided, but will be covered in next year's annual report.

<u>Education</u>

Objective 8: Promote watershed stewardship among students, the community, private landowners, and local governments. [**UCD, USFS**]

See Report B.

Progress towards six of eight of these objectives is described within nine separate reports included in a four-volume document.

Wind River Watershed Restoration

Volume I: Coordination and Education

1999 Annual Report

September 2001

Edited by:

Patrick J. Connolly

U.S. Geological Survey
Columbia River Research Laboratory
5501-a Cook-Underwood Road
Cook, WA 98605

Prepared for:

Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number: 1998-019-01
Contract Number 00004973
(previously 98-AI-09728-002)

Volume I: Coordination and Education

Contents

Report A: Coordination

Wind River Watershed Project

1999 Annual Report

(Report of activities for: August 1, 1999 to March 31, 2000)

September 2001

Prepared by:

Susan J. James

Underwood Conservation District
P.O. Box 96
White Salmon, WA 98672

Introduction

An important characteristic of the Wind River Watershed Project (WRWP) is the high degree of multi-entity collaboration. All stakeholder groups within the basin, including public agencies, citizens and private landowners are integrated into this comprehensive restoration effort. The structure for this coordination was established just prior to the BPA funded effort and continued to be refined and expanded during FY 1998 and 1999 funding.

Wind River Watershed Council

In 1997, The US Fish & Wildlife Service provided funding to Underwood Conservation District (UCD) to establish a pilot watershed project in the basin. A stakeholder group, dubbed the "Wind River Action Committee" (AC), was responsible for selecting 2 "demonstration" restoration projects to be implemented on private lands. The AC was also given the responsibility of planning the future direction of watershed restoration in the basin. At the onset of the BPA project, the AC decided to affirm its position and permanence in the basin and adopted the name "Wind River Watershed Council" (WRWC) to better describe its operation. Current membership is listed in Figure 1.

The Council adopted the following mission statement:

"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 Council developed the following goals:

- Sustain and <u>restore water quality</u>, water quantity, and watershed function
- <u>Restore and enhance fish and wildlife habitat</u> with a current emphasis on wild steelhead
- <u>Provide local input and knowledge</u> to watershed enhancement activities
- Promote the mission and goals of the Wind River project through <u>community and school education / involvement</u> programs
- Assure that the current <u>condition of the basin and activities</u> within it are adequately <u>monitored and evaluated</u> for results consistent with these goals
- Provide a <u>unified voice to promote the group's mission and goals</u> and to facilitate the implementation of watershed enhancement activities
- <u>Address the concerns of landowners, land managers, and resource users</u>, while providing a forum for discussion of natural resource issues related to the Wind
- <u>Protect the customs, culture, and economic stability</u> of the Wind River basin
- <u>Ensure coordination</u> and integration of watershed enhancement activities

The Wind River Watershed Council provides overall vision and direction to the Wind River Restoration Project. Importantly, the WRWC facilitates learning, providing a forum for all viewpoints to be heard. In this capacity, the WRWC reviewed several project proposals to be submitted for grant funding through the Lower Columbia Fish Recovery Board and the Salmon Recovery Funding Board. Watershed Council members were also kept current on activities and progress under the Wind River Restoration Project. The Watershed Council hosted several informational and "stakeholder" presentations as well.

A total of eight WRWC meetings were held during the period of August 1, 1999 to March 20, 2000. The range of topics included: Stabler Cut-Bank project phase III progress; Hemlock Dam study results; Dept. of Ecology's Total Maximum Daily Load (TMDL) project;, possible changes at Carson National Fish Hatchery; Limiting Factors Analysis for WRIA 29; student project presentations from Stevenson High School, Wind River Middle School, and Carson Elementary; and project review for late-1999 SRFB grant submissions.

Our accomplishments included:

1) Reviewed two proposals for submission to the SRF Board: Riparian Guardians; Upper Trout Creek Riparian Restoration.
2) Facilitated listening and understanding between various stakeholder groups.
3) Increased community knowledge through informational presentations & discussions.

Work in progress includes:

1) Increase membership and stakeholder representation, especially landowners.
2) Writing down bylaws and procedures.
3) Identifying project sponsors to take on projects and continuing to solicit new projects.
4) Continuing to support goals and mission statement (see 1998 Annual Report).

Figure 1. Carson Elementary School students perform their "salmon song" for the Wind River Watershed Council.

WIND RIVER WATERSHED COUNCIL

as of July, 1999

Martin Auseth	Southwest Washington Health District
Khozrow Bazrafshan	Delano Wind River Mine
Joe Birkenfeld	Wind River Logging Company, Landowner
Jeff Breckel, Rich Kolb	Lower Columbia Fish Recovery Board
Jan Camp	Williams Gas Pipeline - West
Anita Gahimer	Port Of Skamania County
Kwang Ho Baek, Jordan Kim	Carson Hot Springs
Daniel Gundersen	Landowner
Steve Hansen, Chris Lipton	Longview Fibre
Howard Houston	Economic Development Council
Ole Helgerson	Washington State Univ. Cooperative Extension
Kevin Kilduff	Central Cascades Alliance
Don Lane	Wind River Resorts International Inc.
Dave Howard, Tom Loranger	Washington State Department of Ecology
Gary Morningstar	Sportfishing, Fish Recovery Board, landowner
Jim Mickel	High Cascade Inc. / WKO
Chris Neilson, Adam Jagelski	NorthWest Service Academy
Kevin O'Rourke	Wind River Middle School
Gary Owen	Skamania County Public Works Department
Rich Rush	Fisherman
Al McKee, Harpreet Sandhu	Skamania County
Bill Thorson	USFWS - Carson National Fish Hatchery
Cheri Anderson	USFWS – Information and Education
Lee Carlson	Yakama Nation
Bill Weiler	Washington Department of Fish & Wildlife
Ken Wieman	US Forest Service - Wind River Ranger District

Technical Advisory Committee

as of July 1999

Cheri Anderson, Education / Outreach	US Fish & Wildlife Service
Bengt Coffin, Hydrology	US Forest Service - Wind River Ranger District
Pat Connolly, Fisheries	USGS - Columbia River Research Laboratory
Tim Cummings, Fisheries	US Fish & Wildlife Service
Mark Engel and Mary McDonald, Forestry	WA Dept. of Natural Resources
Ole Helgerson, Forestry	WSU Coop Extension Service
Steve Stampfli, Water Quality	Underwood Conservation District
Chris Lipton, Forestry	Longview Fibre Corporation
Dan Rawding, Fisheries	WA Dept. of Fish & Wildlife
Susan Shaw, Geomorphology	WA Dept. of Natural Resources
Lee Carlson, Fisheries	Yakama Nation
Ken Wieman and Brian Bair, Fisheries	USFS - Wind River Ranger District

Wind River Technical Advisory Committee

A Technical Advisory Committee provides technical support to the Council. This group is composed of resource specialists in fisheries, water quality, forestry, geomorphology, and education. Current membership is listed in Figure 1.

Five meetings of the TAC were held during the period July 1999 – March 2000:

Sept 15, 1999

- Reviewed draft Operations/Overview manual
- Projects update
- Clarification of TAC member's roles

Oct 27, 1999

- Projects update
- Steelhead count results
- Salmon life cycle
- Fish tagging procedures
- Epistylis (parasite) infections
- Thermograph data sharing
- Proposed project review: Dry Creek restoration
- Timeline for review of SRFB project proposals/ grant applications

Nov 23, 1999

- Projects update
- Ranked project proposals/ grant applications (riparian guardians/ trout creek)

Jan 18, 2000

- Project updates
- Project wish list

Mar 21, 2000

- Reviewed Centennial Clean water funds grant proposals/ applications
    - Carson Stormwater
    - Stabler Water Quality
- Discussed notice of proposed Carson Hot Mineral Springs Hotel expansion
- EDT analysis progress
- Identified missing data and where to find it
- Columbia River Conference IV
    - Wind River display set up for viewing

Report B: Education

Wind River Watershed Project

1999 Annual Report

(Report of activities from July 1999 to March 2000)

September 2001

Prepared by:

Susan J. James

Underwood Conservation District
P.O. Box 96
White Salmon, WA

and

Kenneth J. Wieman

USDA Forest Service
Mt Adams Ranger District
2455 Highway 141
Trout Lake, WA

Introduction

Incorporating educational components into the watershed project is a crucial part of our efforts. Education components of the watershed project include: programs in local schools, community outreach programs and technical assistance to landowners. Progress on each of these components is described below.

This annual report covers the period of time from 1 June 1999 through 20 March 2000. The 1998 annual report covered the period of time up to May 30 1999. The funding cycle/ fiscal year contract covered the period from March 21, 1999 to March 20, 2000)

Programs in Local Schools

Programs during this reporting period included continuation of previous efforts and growth into new areas with different teachers and students from three schools: Stevenson High School, Wind River Middle School, and Carson Elementary. Stevenson High School was largely independent, conducting water quality monitoring and macro-invertebrate studies at three locations, as before, with the addition of “Hobo” thermograph temperature data loggers, and the building of websites from information gathered. Wind River Middle School students continued to help with monitoring the success of restoration projects on the Wind River; their program name changed from JETS to Outdoor Education due to changes at the school. Carson Elementary School involvement grew from a simple tree-planting day to the initiation of an Adopt-a-Stream program on Kanaka Creek with the help and mentorship of the Middle School Outdoor Ed. Program.

Stevenson High School

Streamwalk–based curriculum work continued with the Advanced Biology class from Stevenson High School under teacher Don McAndie. Staff from UCD and USFS helped establish the program in Fall of 1998 with guest lectures and field trip presentations on sediment, stream habitat types, macro-invertebrate and vegetation sampling and identification, water quality, etc. Classroom reports were used by the teacher to monitor the success of student learning.

In 1999 students monitored water quality, sediment and identified stream habitat types, sampled and identified macro invertebrates and vegetation from the Wind River, Little Wind River, Rock Creek and Kanaka Creek. Because of their experience from the previous year, the teachers were largely independent at this stage, needing little further input from the UCD or USFS. The students also reared and studied salmon in the classroom.

Students also monitored water temperature over time using four Hobo thermograph units and a shuttle provided for use by the class by the UCD. Personnel from UCD met with the teachers to show them placement techniques and how to use the equipment. Students learned how to program and deploy the hobos in class, placed them in the streams, used a shuttle to capture data from the hobos, and graphed the data on the computers back in the classroom.

The program expanded with the inclusion of a second teacher and class; Pam McAndie and the "Columbia River Studies" class added the components of gathering history, identifying issues to the water quality data and utilized website design as a reporting medium for their discoveries. An impressive presentation of these was made at the Wind River Watershed Council meeting in January of 2000. A CD-Rom of these "online reports" was made available to attendees of the Columbia River Conference IV as part of a bigger Wind River Watershed Restoration Display in March of 2000 and received high praise from attendees. It is hoped that when the website for Stevenson High School goes online, these web pages will be included and made available for public viewing.

Wind River Middle School

Students in Kevin O'Rourke's Outdoor Education class monitored the success of the Stabler cut-bank stabilization project with help from the UCD and USFS during the late fall/winter of 1999. A classroom lecture was done by UCD staff to introduce students to the concepts of stream restoration, erosion, and familiarize them with the terminology and methods used. USFS staff gave a tour of the structures onsite and background on the history of Steelhead in the Wind River. During the field trip, students measured stable and eroding areas, sketched maps of the area, and counted tree seedling mortality and tallied Large Woody Debris with help from UCD, USFS and USFWS (US Fish & Wildlife Service) personnel. Students and staff also took photographs at the site using the photo-documentation stands established by WRMS students and UCD staff in the previous year. Upon returning to the classroom, students created reports of their data using excel and other programs and later presented these reports along with photographs in a PowerPoint presentation to the Wind River Watershed Council in January of 2000. According to the students' calculations, the Stabler project was very close to its goal of 80% stability and 100 pieces of LWD per mile. Observers at the Watershed Council meeting were impressed by the students' presentation.


Figure 1. Students examine the Wind River stream bank at the Stabler cut-bank stabilization project for signs of erosion with Fisheries Biologist, Brian Bair.

Carson Elementary

Carson elementary students adopted Kanaka creek in January of 2000. Using elements of the Adopt-a-stream, Project Learning Tree, Project Wet, Project Aquatic Wild, and Pond and Stream Safari curricula, UCD personnel led a series of classroom lectures and field trips designed to help students "do something meaningful" to help the salmon they had been learning about in class. Using an aquarium and chiller provided for under the 1998 BPA grant, USFWS personnel helped the 5^{th} grade students in Sherrie Geiger's classroom to raise and learn about salmon in the classroom through the fall and winter of 1999. In January of 2000, representatives from UCD, USFWS, and the Port of Skamania met with teachers Sherrie Geiger and Kevin O'Rourke. A series of four field trips were planned, with specific learning objectives to be taught in the classroom beforehand to better prepare the students for each experience.

During the field trips, the Middle School students were to act as mentors and assist the younger children with assigned tasks. Additional field trip help came from USACOE Park Rangers from Bonneville Dam and several parent-volunteers. The first two field trips covered tree planting and noxious weed and garbage removal, a tour of the area including information on the history and features affected by the 1996 floods and highway construction above the park. Additional field trips were planned, also with accompanying classroom lectures to teach the students about water quality monitoring, macro-invertebrates, stream health & ecology and stewardship of an area. Field trips were very successful, and a photo with some information was published by the Skamania County Pioneer about the first field trip.

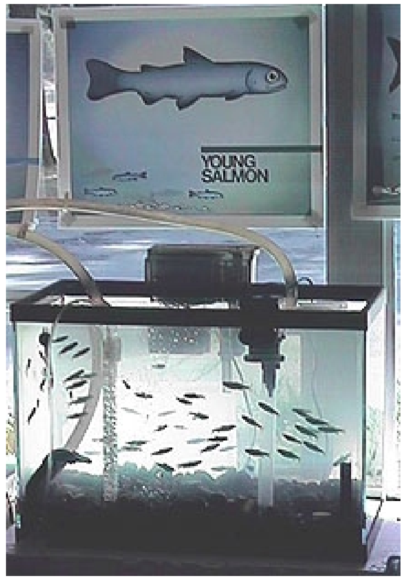


Figure 2. Learning and growing together, students raised salmon in the classroom.

Community Outreach Programs

Outreach projects are designed to increase public awareness of, and involvement in, watershed activities and issues. Interpretive signs, informational brochures and hosting or participating in community events are just a few of the ways that the Wind River Watershed Restoration Project is kept in the public eye.

Watershed Identification Signs

The Wind River Watershed Restoration Project is a cooperative partnership of public and private stakeholders aimed at restoring fish habitat and water quality in the Wind River basin through voluntary measures. Road signs were created to mark the location of watershed boundaries and streams in order to:

- inform watershed area residents and visitors of their "watershed address"
- convey the concept of watersheds reaching beyond the river channel
- remind people that their actions will affect down-slope and downstream neighbors
- advertise the watershed project

A total of 26 signs were placed at 18 locations throughout the Wind River Watershed in the fall of 1999. Locations were carefully chosen to mark entrance and exit points of the watershed, to raise community awareness. The artwork was an adaptation of the Wind River Watershed Council Logo, drawn by a Wind River Middle School Student. The signs were generously installed, with posts donated where needed, by the USDA Forest Service (six locations on Forest roads) and the Skamania County Road crew (12 locations, all on county roads). (see table of locations & descriptions, and map –Figure 2 - for more details.) The following is a sample design. Five of the signs are 24" x 30" and 23 of the signs are 18" x 24" non-reflective aluminum with vinyl lettering. Most of the stream crossings consist of two signs, one facing each direction of travel. The watershed boundary signs are one directional, indicating entry into the watershed.

Figure 3. Example watershed identification sign.

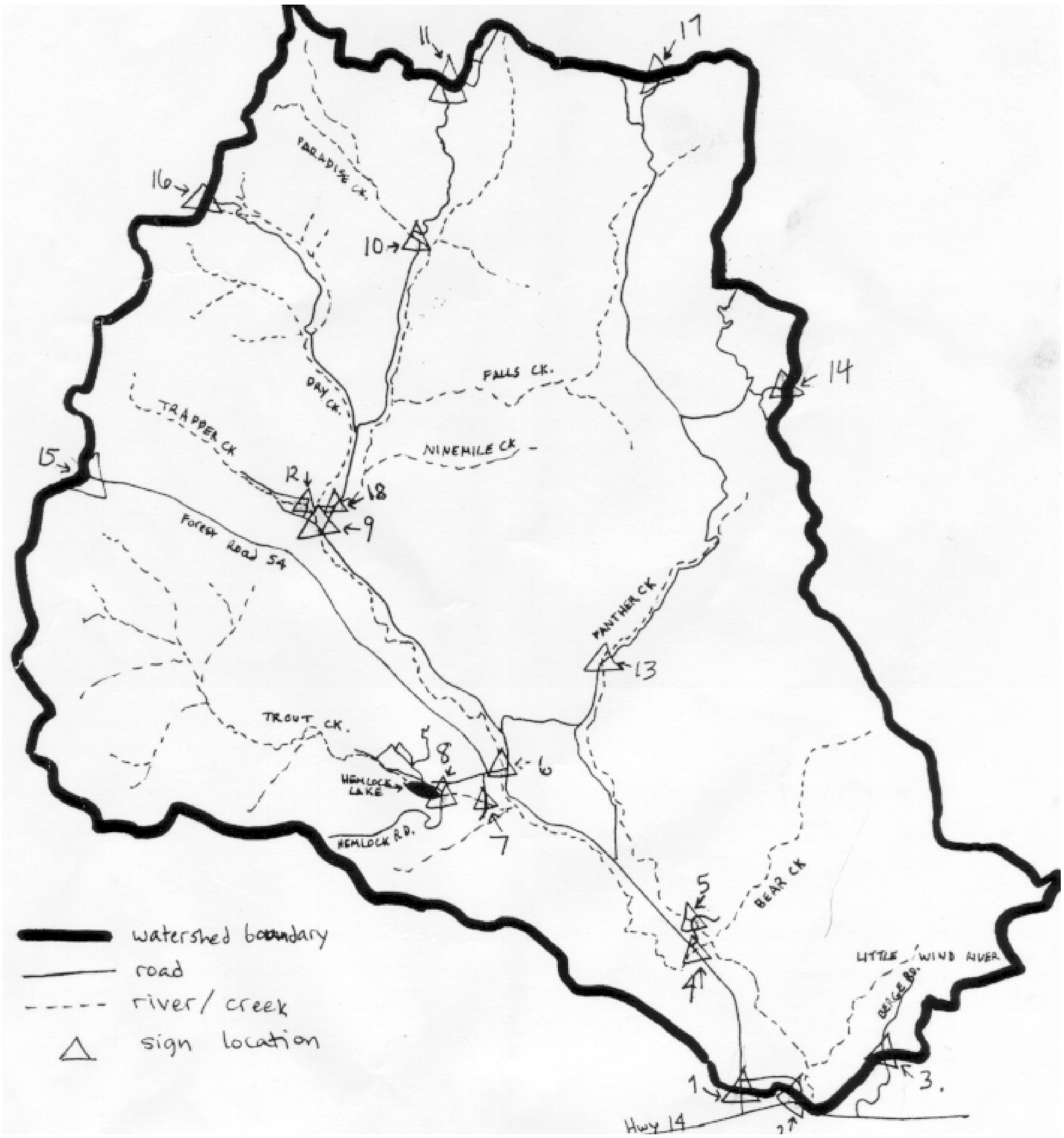


Figure 4. This map shows the proposed sign locations (numbered, cross-reference with Table 1) in the Wind River watershed with respect to major roads and waterways.

Table 1. Description of Wind River watershed sign locations.

# on map	Location description	Sign message	1 or 2-way	Size	Road Ownership
1	Wind River Hwy. in Carson at watershed boundary	Entering Wind River Watershed	1	Large	Skam. County
2	Sandhill Rd. at watershed boundary	Entering Wind River Watershed	1	Small	Skam. County
3	Berge Rd. at watershed boundary	Entering Wind River Watershed	1	Large	Skam. County
4	High Bridge over Wind River	Wind River	2	Large	Skam. County
5	Bear Creek Rd. at Panther Creek crossing	Panther Creek – Wind River Watershed	2	Small	Skam. County
6	Hemlock Rd. at Wind River crossing	Wind River	2	Small	Skam. County
7	Trout Creek Rd. at Trout Creek crossing	Trout Creek – Wind River Watershed	2	Small	Skam. County
8	Hemlock Rd. at Trout Creek (Hemlock Lake) crossing	Trout Creek – Wind River Watershed	2	Small	Skam. County
9	Gov. Mineral Springs Road (3065 road) at Wind River crossing	Wind River	2	Small	Skam. County
10	Wind River Hwy (30 Road) at Paradise Creek crossing	Paradise Creek – Wind River Watershed	2	Small	Skam. County
11	Old Man Pass	Entering Wind River Watershed	1	Large	Skam. County
12	Forest Road 5401 at Trapper Creek crossing	Trapper Creek – Wind River Watershed	1	Small	USFS
13	Forest Road 65 at lower Panther Creek crossing	Panther Creek – Wind River Watershed	2	Small	USFS
14	Forest Road 60 at watershed boundary	Entering Wind River Watershed	1	Small	USFS
15	Forest Road 54 at watershed boundary	Entering Wind River Watershed	1	Small	USFS
16	Forest Road 64 at watershed boundary	Entering Wind River Watershed	1	Small	USFS
17	Forest Road 65 at watershed boundary	Entering Wind River Watershed	1	Small	USFS
18	Wind River Hwy at Upper Wind River crossing	Wind River	2	Small	Skam. County
	Extra	Entering Wind River Watershed	1	Small	

Total # of signs: 28 (23 small; 5 large) Sizes: – large = 24” x 30” small = 18” x 24”

Representation at Fairs and Conferences

Educators Evening at the Discovery Center

Display with Wind River Watershed Project photos, informational brochures, etc.

Attendance: 30 teachers and educators from the Columbia River Gorge community.

Skamania County Fair

Blue ribbon won for booth/display with Wind River Watershed Project photos, informational brochures, etc.

Spring Creek National Fish Hatchery Open House

Same display as at Skamania Co. Fair.

Columbia River Conference IV (planned under 2000 SOW)

A multi-agency cooperative display detailing all of the works on the Wind River to date is planned. This display will include History, Education, Restoration and Monitoring efforts.

Watershed Brochures

A new brochure titled "Ten Things" (actions you can do to help maintain water quality and salmon habitat) is in the planning stages.

The UCD also compiled an informational statistics page for the Wind River Watershed, summarizing such data as acreage/ river miles, etc. (see Figures 5 and 6).

The USFS designed and published three informational brochures for public distribution from past designs and woodcut artwork. The message of the publications focused on the Wind River and discussed three important issues facing the watershed, including: wild fish catch and release, maintaining a healthy riparian area, and recognition of steelhead throughout their life history. Approximately 200 brochures were distributed at USFS visitor centers and other public outlets and events. (See Figures 7, 8 and 9).

An Overview
of the
Wind River Watershed

Watershed Facts and Figures:

Location and Setting: The Wind River system begins its downstream course above McClellan Meadows at an elevation of 3,900 feet in the western Cascades. The main-stem flows 31 miles southeast to the Columbia River confluence near Carson, WA at R.M. 154.5. The upper 24.5 miles of the river flows through the USFS Wind River Ranger District. The lower 6.5 miles of the waterway crosses lands controlled by the Washington Department of Natural Resources (DNR), large timber companies (LTCs), large private owners (LPOs) and small private owners (SPOs).

Size: 139,580 acres (225 square miles).

River Flows: Low - 250 cfs (late summer); High - 2,000 cfs (winter)

Major Tributaries: Little Wind, Trout Creek, Panther Creek, Bear Creek, Brush Creek and Trapper Creek.

Land Ownership: USFS - 125,762 acres (90.1%); DNR - 3,595 acres (2.6%); Large Timber Companies - 2,320 acres (1.7%); Large Private Ownerships (>160 acres) - 3,184 acres (2.2%); Small Private Ownerships (<160 acres) - 4,689 acres (3.4.

Land Uses include: Forest, Transportation/Utility Corridors, Hayland, Residential, Industrial/Commercial, Parks/Recreation, Surface Mines.

Native Vegetation: The drainage is characterized by large areas of even-aged coniferous forest that vary in age from 65-150 years, interspersed with remnants of older forests (up to 500 years) and clearcuts less than 40 years old. Stands below 3,500 feet are in the Hemlock plant association, while higher elevations are characterized by the Pacific Silver Fir zone.

Fish Species Present: spring and summer steelhead, spring and fall Chinook, cutthroat trout, rainbow trout, brook trout brown trout, pacific lamprey, whitefish, sculpin and three spine stickleback.

Fish Barriers: Shepard Falls at R.M. XX on main stem; Hemlock Dam at R.M. XX on Trout Creek; culverts and waterfalls.

Watershed Condition:

All streams within the watershed are classified as either Class AA (extraordinary) or Class A (excellent) by the WA Department of Ecology. The watershed has a number of important beneficial uses that drive the need for water quality protection. The uses identified by the USFS include the Carson municipal watershed, domestic water supplies, Carson fish hatchery, anadromous fish, resident fish and high recreation use. Other beneficial uses include log shipping and agriculture.

Current understanding of basin hydrology, water quality and biological condition is limited. Existing assessment work includes a 1996 watershed analysis performed on USFS portions of the basin in 1996. Results of this work indicate that water quality is currently degraded with respect to increased water temperatures, sediment delivery, turbidity, dissolved oxygen and lack of large woody debris. All of these factors have been altered by means of road building, timber harvest, forest fire, landslides, construction and other human activities.

Figure 5. Page 1 of the informational statistics brochure for the Wind River Watershed

Watershed Needs and Challenges:

Recent inventory and assessment work by the USFS has identified several restoration challenges on the watershed. The USFS analysis prescribes actions on the national forest aimed at reforestation of riparian corridors, road decommissioning, slide stabilization, improvements to trails, and enhancement of fish habitat. A similar analysis of the lower watershed, and overall view of the entire basin, has not been completed. If determined beneficial by watershed inhabitants, a basin-wide examination may be helpful for a number of reasons. First, a combined analysis would allow determination of whether or not currently perceived problems (e.g., erosion, sedimentation, water temperature increases, etc.) are responsible for observed problems in the lower Wind and tributaries (e.g., the current build-up of sediment at the mouth and interference with shipping). Second, this knowledge would enable developing strategies and funding for enhancing the watershed for water quality, forestry, wildlife habitat, commercial and other human activities.

If desired by watershed inhabitants and interests, the specific watershed enhancement techniques which might be employed within the overall Wind system include:

- river bank stabilization
- slide stabilization
- road and trail restoration
- culvert and road upgrading
- dredging
- reforestation
- fish habitat improvement
- solid waste clean-up
- septic system upgrading
- etc.

Recent Watershed Accomplishments:

The USFS in cooperation with Underwood Conservation District (UCD) and US Fish & Wildlife Service (USF&WS) is working to restore degraded sections of Trout Creek and Layout Creek for the benefit of wild steelhead runs and reduction of sediment input to the Wind. Since 1992, this effort has restored 21 miles of unused road, planted 54,000 riparian trees, and stabilized over one mile of eroded channel. Also in 1997, the USFS conducted work on the Stabler slide involving the planting of 7,000 conifers/hardwoods, placement of 4,000 live stakes and installation of 5,000 feet of living water bars.

More of this work could be expected in the future. In 1996, the USF&WS funded the UCD and Skamania County to develop two demonstration watershed improvement projects on the Wind in conjunction with landowners. Completion of the two projects will be a citizen-driven process, and a watershed “action committee” will be responsible for determining which two projects are undertaken. Organization of the committee and committee meetings is targeted for spring of 1997. Once projects are inventoried, identified and coordinated with involved landowners, cost-share moneys will be utilized to accomplish on-ground work.

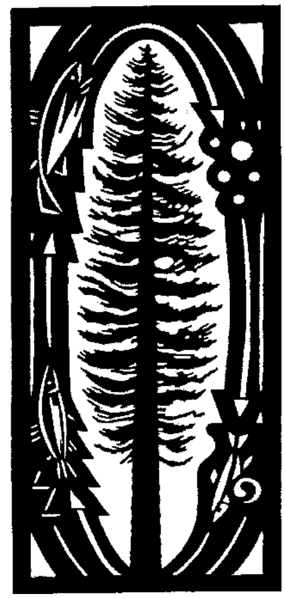
Figure 6. Page 2 of the Wind River informational statistics brochure.

The USDA Forest Service and partners are rehabilitating fish habitat. Between 1992 and 1998, 77,000 conifers and 200,000 shrubs were planted along streams to provide shade and bank stability. A thousand pieces of large woody material were placed in Wind River streams to recover lost habitat and improve living conditions.

For more information or to find out how you can help write:
Fisheries Biologist
Mt. Adams District
Wind River Work Center
1262 Hemlock Road
Carson, WA 98610

Trout Need Trees?

Fish have it made in the shade.



Plenty of Trees, Plenty of Trout

Trees shade streams, keeping water temperatures cool. Water temperature determines what kind of fish thrive in a stream. Trout do well in water chilly by human standards—less than 58°F. Oxygen levels are higher in cool streams. Trout and salmon are active fish, needing water nearly saturated with oxygen. Warm stream temperatures can cause disease outbreaks, change behavior, and alter growth rates. A temperature of 75°F may be fatal for steelhead.

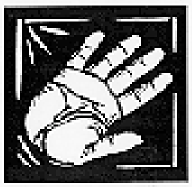
Tree roots reduce erosion by holding soil on the stream bank. Trout eggs and hatchling baby fish hide in the gravel covered area of the stream. The pebbles offer protection and allow water to flow through, bringing the eggs and baby fish oxygen. If the gravel is covered with mud they will smother. Older fish depend on insects and other small animals that hide between gravel and stones for food. Food is not available if these spaces fill with mud.

Trees provide cover for fish. Anglers know there are more fish in streams having adequate hiding cover. Fish need a place to hide from bigger fish and other animals looking for a meal. Downed trees serve as fish apartments. When a large tree falls into a stream, small fish can hide in the branches. Bigger fish can hide in the pool carved under the fallen tree. Standing tree roots give structural support to undercut banks, creating underwater hideouts.

Figure 7. “Trout Need Trees” brochure, riparian shade.

The USDA Forest Service and partners are rehabilitating fish habitat. Between 1992 and 1998, 77,[illegible] conifers and [illegible] shrubs were planted along streams to provide shade and bank stability. A thousand pieces of large woody material were placed in Wind River streams to create lost habitat and improve living conditions.

For more information or to find out how you can help write:
Fisheries Biologist
Mt. Adams District
Wind River Work Center
1262 Hemlock Road
Carson, WA 98610



The United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, and marital or familial status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means of communication of program information (braille, large print, audiotape, etc.) should contact the USDA Office of Communications at 202-720-2791 (voice). To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, Washington, D.C. 20250, or call [illegible] (voice) or 202-720-1127 (TDD). USDA is an equal employment opportunity employer.

Their Future is in YourWet Hands

Fragile—please handle with care

Careful release of your wild catch is an investment in your fishing future.

Return wild fish back to the stream. Let them spawn and produce young for future years of fishing. When correctly handled, released fish have an excellent chance of survival. The following tips will help you release your fish unharmed.

Use artificial bait. Quickly setting the hook prevents the fish from swallowing the lure or fly.

Keep your release tools ready. The best release method is using pliers, gently rotating the shaking the barb free. Cut the leader if the hook cannot be removed easily. Eventually the hook will work its way out.

Leave the fish in the water. Fish need water to breathe. Removing them causes suffocation.

Avoid handling fish. If you must, wetting your hands before touching fish lessens the removal of the protective scales and mucous coating that safeguards them from disease. Slime is a coat of armor for fish. Avoid squeezing the fish or touching the gills.

Revive exhausted fish. Hold the fish underwater in a swimming position, gently moving it back and forth. Gills will take oxygen out of the water flowing over them.

Figure 8. Catch and Release brochure.

The Same but Different

No way to know until they are ready to go.

The USDA Forest Service and partners are rehabilitating fish habitat. Between 1992 and 1996, 77,000 conifers and 200,000 shrubs were planted along streams to provide shade and bank stability. A thousand pieces of large woody material were placed in Wind River streams to recover fish habitat and improve living conditions.

For more information or to find out how you can help write:

Fisheries Biologist
Mt. Adams District
Wind River Work Center
1262 Hemlock Road
Carson, WA 98610

The United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, and marital or familial status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means of communication of program information (braille, large print, audiotape, etc.) should contact the USDA Office of Communications at 202-720-2791 (voice). To file a complaint, write to the Secretary of Agriculture, U.S. Department of Agriculture, Washington, D.C. 20250, or call 800-245-6340 (voice) or 202-720-1127 (TDD). USDA is an equal employment opportunity employer.

Give it a chance to become a steelhead. Release today to catch tomorrow.

Did you know that steelhead and rainbow trout are the same fish? Both begin life in freshwater streams of the Wind River watershed and are impossible to tell apart when very young. In late spring or early summer of their second year some of the fish will change physically. They take on a silvery appearance and travel to the ocean where there is abundant food that supports growth. In about two years they return to their home stream. These fish are called steelhead trout. Those who spend their whole lives in the stream are called rainbow trout.

Since young steelhead and rainbow look the same, Washington State requires you release any trout less than 14 inches caught in the stream. For every 1,500 steelhead eggs spawned in Wind River streams, only one fish will survive long enough to return from the ocean. Help keep the steelhead from disappearing forever. The small trout you release today may return from the ocean as a 30-inch steelhead. Maybe you will have the opportunity to catch the same fish or one of its offspring in the future.

Figure 9. Steelhead and Rainbow Trout brochure.

Community Events

Community events are conducted to involve the public in restoration, monitoring, or educational activities about the watershed and salmon. In 1998 and 1999 these activities included tree-planting events, trash clean-ups, fish snorkeling, and fish education days.

Snorkel Survey

WDFW and USFS co- sponsored the annual snorkel survey in August 1998. The purpose of the survey was to update index snorkel counts of hatchery and wild steelhead in the Wind River. USFS, USFWS, UCD, USGS-Columbia River Research Lab, Clark-Skamania Fly fishers, and others volunteered in the survey.

Carson NFH Free Fishing Day

Carson National Fish Hatchery hosted a free fishing day for local children. Several members of the Wind River Watershed Council and TAC were present to help children land their first fish. The Hatchery also had an educational miniature golf course depicting the life cycle of the Salmon on hand to entertain and inform while parents and children waited their turn to catch a fish.

USFS Fish Education Day

The USFS sponsored an environmental education event with a focus on fish. Educational components of the event featured fish identification, cultural significance of salmon in the Pacific Northwest, proper methods of handling fish and a living laboratory of aquatic organisms. The event was attended by approximately 200 kids ages 5-12.

National Fishing Week activities on the Forest are ever-popular events that have evolved into much more than catching fish. Mt. Adams Ranger District works with a multitude of partners to provide fishing fun for entire families. About 200 children participated in one of the three district fishing clinics in the spring. A variety of events provided kids with educational opportunities while having a barrel of fun. For example, children created artistic fish designs on a complementary t-shirt. Fish tanks with steelhead and salmon smolts helped get people interested in learning more about salmon. Everybody enjoyed the traditional legends of a Native American storyteller. There were devoted anglers who taught fishing skills like fly tying, casting lures, and knot tying. Our local hatcheries filled up the stream with rainbows and made many a kid's dream come true when they landed their first fish. Nobody goes home hungry because of the generous donations of partners who kept the grill full of hot dogs and lots of other goodies. There was a lot of excitement when Frank and Francis fish made their round through the crowd, followed by marching procession of costumed kids parading through the site. This is a day that kids (big and small) don't soon forget! (Major Partners: Washington Department of Fish and Wildlife, Franz Bakery, Trout Lake General Store, Wal-Mart, Luhr Jenson, Trout Unlimited - Vancouver)

Teachers in the Woods

Five teachers volunteered their time to the Teachers in the Woods Program on the GPNF during each summer of 1999. The teachers assisted with fieldwork in a variety of scientific projects across the Forest. Their participation was funded through a partnership between the USFS and Portland State University (PSU), Wolftree, and Oregon State University. During the 4-5 week program, the teachers attended training sessions run by PSU, volunteered with survey and monitoring projects on the Forest, and developed a project involving science inquiry and fieldwork in which to involve their students the following year.

Teachers on the GPNF completed five projects during the summer of 2000:

- Concentrated Use Areas Inventory – Inventoried concentrated use areas in riparian areas (dispersed recreational sites), measuring the impact of these sites on the Forest and mapping their locations on the Forest's Geographic Information System
- Trout Creek Restoration Monitoring – Monitored restoration work on Trout Creek implemented in 1994 and completed in 1996. Teachers collected data on this restoration site to determine whether original restoration project goals are being met.

Mt. Adams Ranger District Environmental Education

The 2000 Mt Adams Environmental Education Program involved students of all ages. Our wide reaching program emphasized watershed restoration and land management and techniques, exposed students to potential career opportunities and gave students an appreciation for how to responsibly recreate on the National Forest.

Kids were thrilled when Frank and Francis Fish appeared at the county fair and provided youngsters with entertaining lessons about fish habitat needs. The "fashion a fish" program was presented at local elementary schools to educate fourth graders about fish physiology and adaptations. Kids walked away with an understanding of importance for native fish.

An entire curriculum was presented to the Carson elementary school. Trout creek is a living laboratory and prime example of many regional fish management issues (agriculture, forest management, recreation and dams). A variety of field activities and classroom experiments give the junior biologists a chance to learn first hand how land-use issues effect fish habitat and water quality. Students are then asked to put on the managers hat and make some tough decisions on just how to balance the equation between fish and human needs.

The Heritage Institute provides high school teachers within southwest Washington State with continuing education credits toward environmental sciences. USFS fish biologists were involved with teaching teachers about aquatic and riparian ecology during the 1999 field season. Teachers were presented with a historical context of watershed management, impacts and recovery efforts within the watershed.

Fish Awareness

District Fish Biologist and puppet friend Francis the Fish introduced kindergarten and preschool age children in the Carson/Stevenson area to aquatic conservation principals. Children were shown specimens of native fish and given examples of how each of them could help preserve water quality and their aquatic cousins.

Career Day

District Fish Biologist presented "What the heck does a Biologist Do!" to Wind River Middle School students as part of Skamania County Public Schools Career Day. Approximately 120 students were given a slide show depicting the wide array of duties a biologist performs. Students were also given the opportunity to ask questions on education requirements, likes/dislikes and expected salaries.

Community Education Class: Let's Go Fish'in

If you want to get a kid excited, take him or her fishing. That's why the USFS fish biologists assist with a three-day community education class teaching kids the fundamentals of fishing. Not too many fish were caught but there were plenty of smiles to go around. Other Partners: Skamania County Community Education, Carson Middle School, Grant High School, Heritage Institute, Stevenson Library, Anna Bates, WSU Extension Office.

Riparian Guardians

Represents a network of non-profits, businesses and agencies working with students from Alpha High School, Stevenson High School, Metropolitan Learning Center, Center for Agriculture, Science and Environmental Education, and Green Thumb program. The goal of this program is to assist the USDA Forest Service riparian reforestation efforts by involving the community in learning about Forest management techniques and to participate in re-vegetating, maintaining and monitoring sites along the Wind River.

Three hundred and twelve students were involved in the Riparian Guardians program in the 1999-2000 school year and accomplished the following:

- Students collected cottonwood and willow cuttings from the Wind River watershed and are currently propagating them in school greenhouses.
- Students planted over 450 western red cedar and cottonwood trees on the Middle Reach of the Wind River.
- Students established 12 plant survival and growth monitoring plots on the Upper and Middle Reaches of the Wind River.
- The Oregon Forest Resource Institute (OFRI) joined the Riparian Guardians partnership and is developing a proposal to secure funding that would build a 3,000 square foot greenhouse to grow trees and shrubs for the Wind River re-vegetation effort.

Other Partners

Portland State University, Oregon State University, Washington State University, Oregon Graduate, Institute of Science and Technology, Saturday Academy, Mt. Hood Community College, Portland Public Schools, Multnomah Education Service District, Battle Ground School District, Stevenson School District, Oregon Tilth, The Nature Conservancy, Portland Audubon Society, Orlo, Portland, Area Career Training Center, Business Education Compact, Expeditionary Learning Outward Bound, Earth Institute, Project Learning Tree, The Rebuilding Center, Washington State University Master Gardeners Association, Friends of Trees, City of Portland, Multnomah County Employment Department, METRO - Environmental Education Department, Clark County Utilities, NRCS Natural Resources Conservation Services, Underwood Soil, Conservation District, Oregon Fish and Wildlife, Washington Department of Natural Resources, Clark Count Parks Department, Northwest Service Academy, Americorps volunteers.

Media

Advertising the Wind River Watershed Restoration project in the local paper and radio is an effective way to keep residents up to date on activities and to advertise specific events. A total of five articles relating to the watershed project have been published in the Skamania County Pioneer. Also, Two press releases on stream restoration were published and received wide distribution in the Oregonian and Skamania County Pioneer newspapers. The content of these articles focused on fish passage at Hemlock Dam and cooperative efforts to restore threatened and endangered steelhead in the Wind River.

Professional Information Sharing

- Watershed Council - 8 meetings, 6 presentations, 85 people reached
- PIEC meetings- 2 presentations 45 people reached
- Washington State Conservation Commission - Participated in a Limiting Factor Analysis for the Wind River basin by providing fish distribution information, identifying potential limiting factors, and editing a draft report.

Technical Assistance

Technical assistance was provided via workshops, informational presentations, grant review and grant writing help, and interaction with landowners, private and public. Each of these activities is described below. The UCD also assists landowners involved with conducting restoration-type projects on their land. Site visits, technical information, and implementation assistance was provided to several landowners throughout the reporting period.

Wind River Watershed Restoration

Volume II: Restoration Efforts

1999 Annual Report

September 2001

Edited by:

Patrick J. Connolly

U.S. Geological Survey
Columbia River Research Laboratory
5501-a Cook-Underwood Road
Cook, WA 98605

Prepared for:

Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number: 1998-019-01
Contract Number 00004973
(previously 98-AI-09728-002)

Volume II: Restoration Efforts

Contents

Report C: Restoration Activities in the Wind River Watershed

Wind River Watershed Project

1999 Annual Report

September 2001

Prepared by:

Brian Bair

USDA Forest Service
Gifford Pinchot National Forest
Wind River Administration Site
Carson, Washington

Introduction

Stream surveys (1989-1997), sub-basin assessments (1992) and Wind River watershed analysis (1996, 2000 draft) were used to evaluate limiting factors in the Wind River subbasin (Figure 1). Fish habitat and water quality has 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 is getting worse.

The goal of restoration efforts within the Wind River has been to accelerate the recovery of fish habitat and water quality by reducing road densities, reforesting and rehabilitating riparian areas, floodplains and stream channels. The U.S. Forest Service, U.S. Fish and Wildlife Service, and Underwood Conservation District have made significant progress in rehabilitating hydraulic processes and critical fish habitat. Approximately 90 miles of road have been decommissioned, 160 acres of floodplain have been reclaimed, 1,300 riparian acres have been replanted, and more than 3,000 trees and logs have been reintroduced to 11 miles of stream.

In 1998 funding was secured from the Bonneville Power Administration (BPA) to accelerate the restoration efforts on both public and private lands. This document details the accomplishments of riparian, in-stream and road restoration projects completed with 1999 BPA ratepayer restoration funds.

The objectives of road decommissioning are: 1) restore the timing and magnitude of peak flows by eliminating overland and subsurface flow interception of roads, and 2) reduce road-related sediment and prevent mass fill failures associated with culvert plugging and incompetence.

The goals for riparian rehabilitation are to increase the stream shade and potential LWD to provide a long-term self-sustaining ecosystem. The objectives are to increase growth rates and diversity of streamside vegetation.

The goals for stream channel rehabilitation are to accelerate the recovery of natural processes in which steelhead and other aquatic organisms evolved. The objectives are to restore LWD, bank stability, width-to-depth ratios, and pool quality and quantity to undisturbed, historic levels and conditions.

The 1999 funding cycle accomplishments for road decommissioning, riparian and channel rehabilitation were delayed due to changes in U.S. Forest Service policy regarding survey and manage species under the *Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl, April 1994*. In addition to Cultural Resource, threatened / endangered species surveys and consultation conducted during the normal course of NEPA analysis, surveys for amphibians, mollusk and sensitive plants and vertebrates were needed before projects could be implemented. Projects proposed

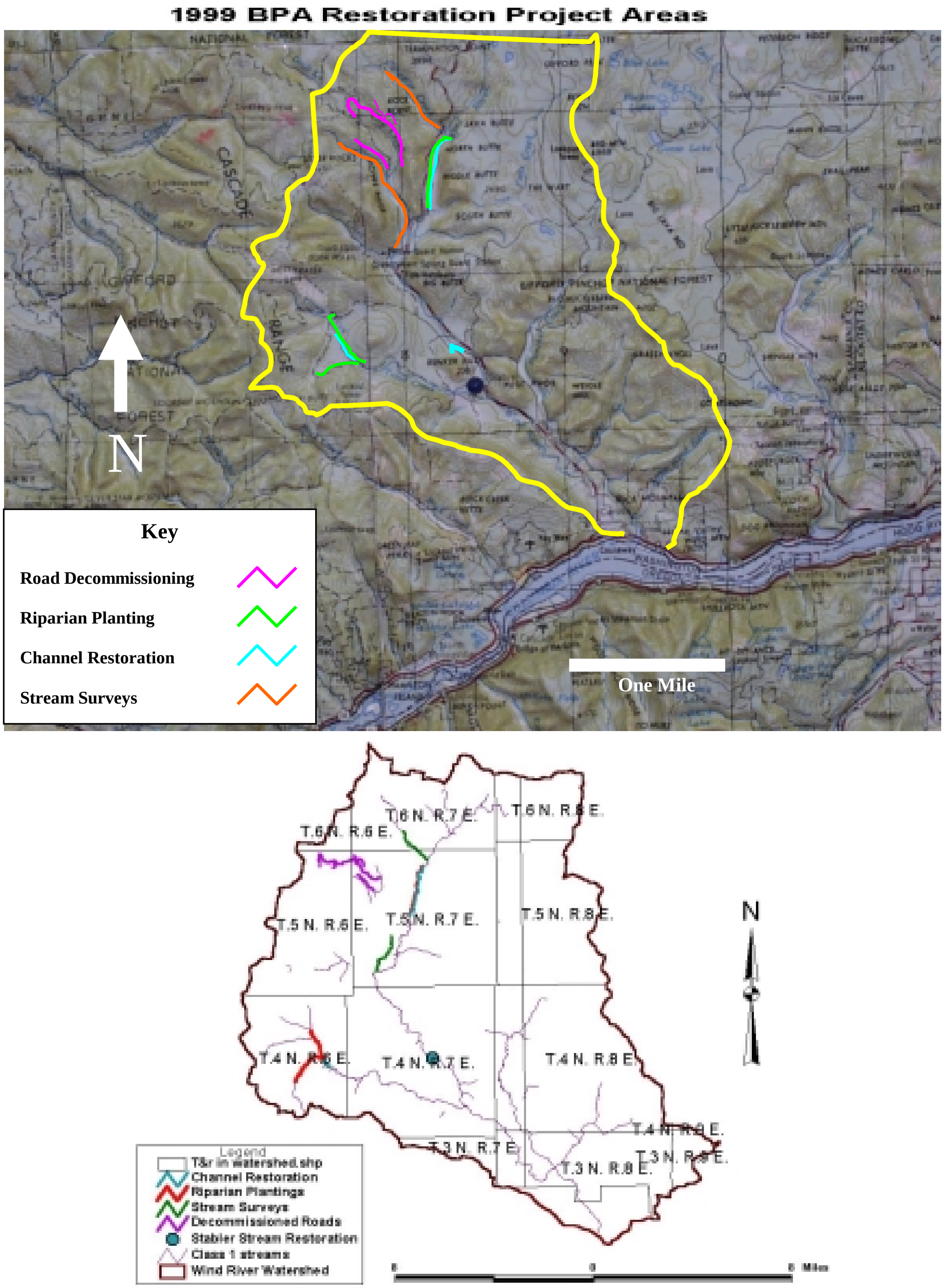


Figure 1. Project area maps for 1999 Wind River restoration projects, Skamania County, Washington, T4-5N, R6-7E.

for 1999 were set back one year because of the timing and magnitude of these surveys. Accomplishments for these projects will be reported in the 2000 Annual Report. In addition, 1999 projects were partially reported in the 1998 Annual Report (Connolly, 1999) and will be referenced in this document.

1. Road Decommissioning Efforts

Objective 5: Reduce road related sediment sources by reducing road densities to less than 2 miles per square mile. [**USFS**]

Task 5.a: Decommission and restore 3.5 miles of road within the Dry Creek watershed. (**USFS**)

A total of 4.4 road miles were decommissioned within the 1998 and 1999 calendar years. Partial results were reported in the 1998 completion report.

Methods

Monitoring of previous road decommissioning efforts within the watershed prompted modifications of the methodologies described in the USDA Forest Service "Guide for Road Closure and Obliteration, 1996". These modifications were made to prevent surface erosion of treated surfaces, reduce cost and promote re-colonization of native grasses and shrubs.

The 1998 Dry Creek decommissioning was accomplished by excavating culverts and by laying back banks to a 1.5:1 ratio or to natural contour where terrain permitted. Fill excavated from larger culverts was piled and contoured at pre-designated sites. The piled fill was then seeded with erosion control mix and mulched with straw to prevent surface erosion. Rehabilitated banks were planted with erosion control grass seed mix and mulched. Rooted shrubs were planted the following spring. Large exposed banks had log/slash/rock structures constructed at the toe of the slope. Banks were then seeded, mulched and treated with slash (coarse mulch) to prevent rilling and fine sediment from entering the water coarse. These banks were also planted with rooted shrubs the following spring. Road surfaces were "de-compacted" with the excavator bucket digging down to a minimum depth of 24" across the road surface. The disturbed road surface was mulched. Cross drains were placed on a site-specific basis to ensure proper spacing and appropriate outflow location. Access was blocked with a large "kelly hump" or berm.

Road decommissioning was accomplished in accordance with the State of Washington's Hydraulic permit, National Environmental Policy and the Endangered Species Acts.

Results and Discussion

Four and four-tenths road miles were decommissioned with BPA funds in 1998-1999 (Figure 2). Cost for decommissioning totaled $60,600 or $14,093/mile. Cost of previous road decommissioning projects within the Wind River and White Salmon River watersheds ranged from $3,200/mile to $27,000/mile. The removal of two large culverts consumed 50% of toe funds expended on the project. The removal of these culverts was necessary to prevent future mass failures, which had the potential to deliver approximately 30,000 cubic yards of sediment to spawning habitat in Dry Creek and the Middle Wind River.

Monitoring

The project area has weathered the first two winters extremely well. No significant erosion was observed on de-compacted road surfaces, cross drains or culvert removal sites. The log and rock toes installed on the large culvert removal site is working as designed in preventing bank scour and erosion. Slash placed on the face of the slope is also working as designed and have prevented rills from developing on rehabilitated banks. Native vegetation is re-colonizing the de-compacted road surface.

2. Riparian Rehabilitation Efforts

Objective 6: Rehabilitate riparian corridors, flood plains, and channel morphology to reduce maximum water temperatures to less than 61°F, to increase bank stability to greater than 90%, to reduce bankfull width to depth ratios to less than 30, and to provide natural levels of pools and cover for fish. [**USFS, UCD**]

Task 6.a: Place key pieces of large woody debris and implement soil bioengineering techniques along degraded stream segments (**UCD**, USFS)

Task 6.b: Plant and thin riparian vegetation at select sites. (**USFS**)

At the end of the 1999 contract period, NEPA and survey and manage species surveys were complete and contracts had been secured for 4.01 river miles of the Upper Wind River and Trout Creek. Physical habitat surveys were conducted on three river miles of Dry Creek and two river miles of Paradise Creek for a paired watershed analysis. Approximately 60 riparian acres have been marked for thinning and will provide an estimated 1,500 trees for flood plain and channel treatment. Project results for the budget period of 1999 are reported below.

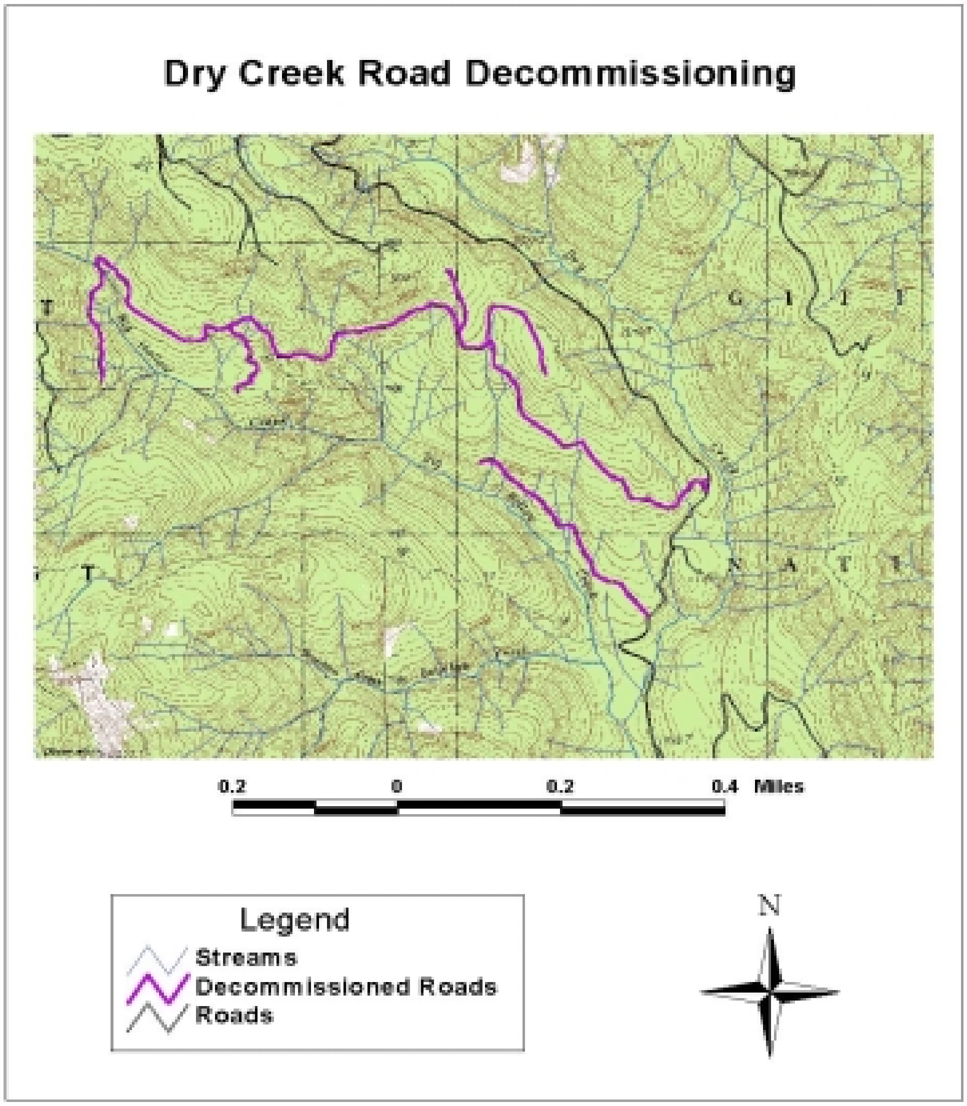


Figure 2. Dry Creek road decommissioning, Skamania County, Washington, T5N, R6E, Sect. 1, 2; T5N, R7E, Sect. 5, 6, 7, 8.

3. Dry and Paradise Creek Channel Surveys

<u>Project Lead</u>: US Forest Service
<u>Cooperators</u>: Bonneville Power Administration.
<u>Project Location</u>: T5N. R7E. Sections 20, 29 and 32; T6N, R7E, Sections 29 and 33

Introduction

Dry and Paradise Creek were surveyed to evaluate the differences in disturbed and undisturbed habitat with the intent on using data to develop quantitative objectives and a restoration prescription. Dry Creek was railroad logged from late 1920s to the mid 1930s. The entire riparian area was denuded of its old growth. Riparian areas and channels have not recovered due to the lack of in-stream wood needed for velocity modification that protects young riparian stands from floods. Paradise Creek is not logged and contains intact riparian areas from river mile 1.1 to 2.8 and will be used as a relic analog for developing quantitative objectives and a template restoration design.

Methods

Stream survey protocols used for channel evaluation incorporated various methodologies to collect quantitative data. The survey protocol includes measuring thalweg profiles, low water and bank-full stage channel cross sections, pieces of LWD per mile, percent stream shade, and bank stability.

Thalweg profile and cross-sections are measured using a methodology derived from the Forest Service's manual "Stream Channel Reference Sites". With the use of a surveyor's class 1 laser level, water surface elevation, stream bottom (along the thalweg), maximum depth and habitat units are mapped. Thalweg profiles typically begin at the mouth of the stream and work upstream. Measurements are taken at the pool tail crest (including both water surface and channel elevations), maximum depth and again at the pool head. The riffle length is measured and then channel elevation measurements resume at the next pool tail crest. Linear distances are also measured between each measured point with a laser range finder. Cross-sections are taken at each pool's maximum depth and midway through the length of each riffle. Cross-sections measure from the channel's left bank bank-full stage and cross perpendicular to flow to the right bank bank-full stage. Again low flow water level and water surface elevation are recorded. The resulting data can be plotted on a graph to display channel slope, pool area and bank-full area. Permanent markers are installed in areas of particular interest so that the measurement can be duplicated in the exact same place in the future.

Pieces of LWD per mile are derived by counting all pieces within the bank full channel that are: 1) 12"-24" in diameter and 2) more than 24" in diameter and more than 50 feet in length.

Stream shade is measured using a Solar Pathfinder® brand instrument. Measurements are taken at random locations. The instrument measures the percentage of solar radiation at a given site by month.

Bank stability monitoring was adapted from Rosgen (1996) methodology. Bank height relative to root density is evaluated and linear measurements are taken.

Results

Data have been collected and will be evaluated and used to design riparian and channel restoration in Dry Creek.

4. Stabler Reach Bank Stabilization

<u>Project Lead</u>: Underwood Conservation District
<u>Cooperators</u>: Land Owner John Sandberg, US Fish and Wildlife Service, Longview Fibre, Bonneville Power Administration Wind River Watershed Council and the US Forest Service.
<u>Project Location</u>: T4N, R7E, Section 23

Introduction

The Stabler Bank Stabilization Project began as a cooperative stream restoration effort between private landowners, the Underwood Conservation District, the USDA Forest Service, and the U.S. Fish and Wildlife Service. The project area is in the Middle Wind River (Figure 3) and contains the highest spawner densities within the watershed. The project area was cleared of trees for agriculture in the mid 1940s. After removing riparian vegetation, the southern bank of the project area eroded over 500 feet in a 50-year period, which resulted in more than 223,000 cubic yards of coarse and fine sediment delivered to the stream. The Stabler site was selected by the Wind River Watershed Action Committee (now Wind River Watershed Council) as a demonstration project for community watershed restoration (Powers et al. 1998).

Project Goals and Objectives

The goals of this project are to reduce water temperature maximums below lethal salmonid levels, restore riparian conifers, and reestablish bank and channel stability to recover viable populations of wild steelhead.

The objectives for the Stabler Bank Stabilization Project are: reduce bank-full width to depth ratios within stream reach to less than 30:1. Increase bank stability to greater than 80%. Increase frequency of LWD in Middle Wind to greater than 120 pieces per mile to store sediment, scour pools and provide cover for fish (USFS 1995). Increase stream shade to greater than 60%. Reduce maximum water temperatures to below 70 degrees F (21.1°C). Monitor for project effectiveness. Educate public and school students about watershed issues and current efforts to restore water quality and fish habitat.

Methods

Four log/boulder complexes were installed along 500 feet of degraded stream segment. Forty-seven logs were installed, 22 with attached root wads (Figure 4). They were obtained from various stakeholders and near by landowners and Long View Fibre Corp. The logs were hauled to the site and placed with a tracked excavator. Thirty feet of bank was sloped to a 2:1 slope, seeded with a grass/forb mix, and planted with willow and cottonwood cuttings. Conifers were planted in the spring of 1999. The plantings and structures will be maintained and monitored with help from and for the education of local students throughout the coming years.

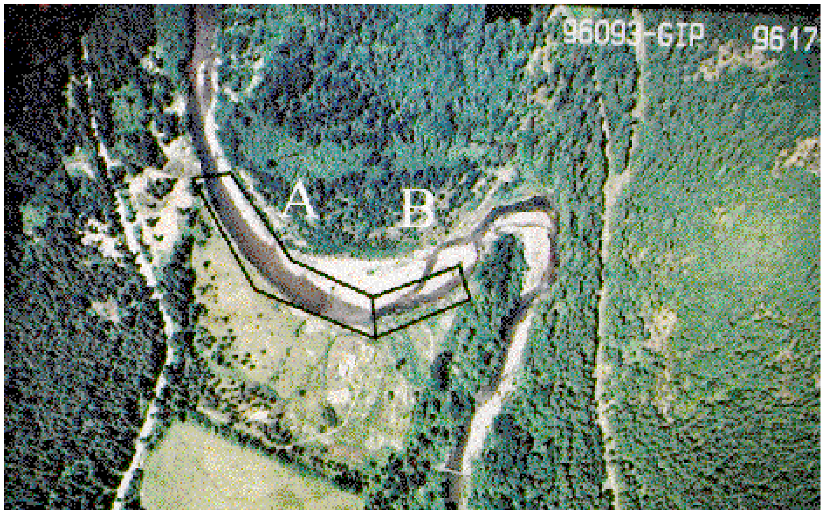


Figure 3. Aerial photograph of the Wind River Stabler Bank Stabilization Project sites (A & B), T4N, R7E, Section 23, Skamania County, Washington.

Figure 4. Construction of log revetment on the Wind River Stabler Bank Stabilization Project, T4N, R7E, Section 23, Skamania County, Washington.

5. Trout Creek Flats Channel Rehabilitation, Phase IV

<u>Project Lead</u>: US Forest Service
<u>Cooperators</u>: US Fish and Wildlife Service and Bonneville Power Administration.
<u>Project Location</u>: T4N, R6E, Section 13

Introduction

Trout Creek is a major tributary of the Wind River and is vital for the recovery of wild summer run steelhead within the basin (Figures 5 and 6). The Trout Creek watershed has historically supported up to 50% of the entire Wind Rivers run of wild steelhead yet composes 1/16th of the watershed area. Trout Creek Flats (river mile 6.5 to 9.0) was tractor logged in 1948. Re-vegetation efforts after logging failed apparently due to compacted soils. In the late 1960s the entire flats area was "ripped" with heavy equipment to de-compact the soils and restore percolation. In the 1970s, log jams were thought to be migration barriers to steelhead. Log jams and other wood was removed or "cleaned" from stream channels. The removal of LWD eliminated the natural water velocity modification and sediment storage that the stream needed to function properly. The removal of wood from within the channel instigated serious channel degradation (Figure 7). The cumulative effect of removing streamside vegetation and in-stream LWD produced maximum water temperatures > 75°F. Bank full channel width to depth ratios exceeded 60 on average with undisturbed reaches within the basin containing similar morphology possessed width to depth ratios of 25 on average (Figure 8). Stream shade was reduced to < 27%, bank erosion rates were > 40% and in-stream LWD levels were < 40 pieces per river mile while undisturbed channels averaged 120 pieces per river mile within the watershed and loss of flood plains and side channel habitat.

Project Goals and Objectives

The goals of this project are to reduce water temperature maximums below lethal salmonid levels, restore riparian conifers, and reestablish bank and channel stability to recover viable populations of wild steelhead.

The objectives to meet these goals are: (1) reduce the width to depth ratios within identified reaches to less than 25 (2 years), (2) increase shade to greater than 80% (60 years) (3) increase bank stability above 80% (10 years), (4) restore the conifer component along these reaches to eight trees per acre greater than 31" in diameter (200 years), (5) increase in-stream LWD > 100 pieces per river mile (1 year), and (6) maintain 0.8 river miles of old growth channel and historic flood plains.

Methods

One hundred and twenty blown down logs (half with attached root-wads) will be salvaged and stockpiled in Trout Creek Flats. A heavy helicopter will fly the material to project areas. A tracked excavator shall construct logjams and bank revetments with the wood to meet the previously mentioned objectives. Site-specific placement of revetments and jams will be based on templates derived from empirical data and analysis of undisturbed channels with similar characteristics (Figure 5). The head-gate sediment control structure that was placed to aggrade the channel in 1996 will be removed to allow natural channel processes to occur.

Results

U.S. Fish and Wildlife Service, Bonneville Power Administration and the USDA Forest Service have cooperatively funded this project. NEPA was completed in the winter of 1998. Materials were stockpiled in fall 1998, implementation was begun by mid July 1999, and the project was completed late August 1999.

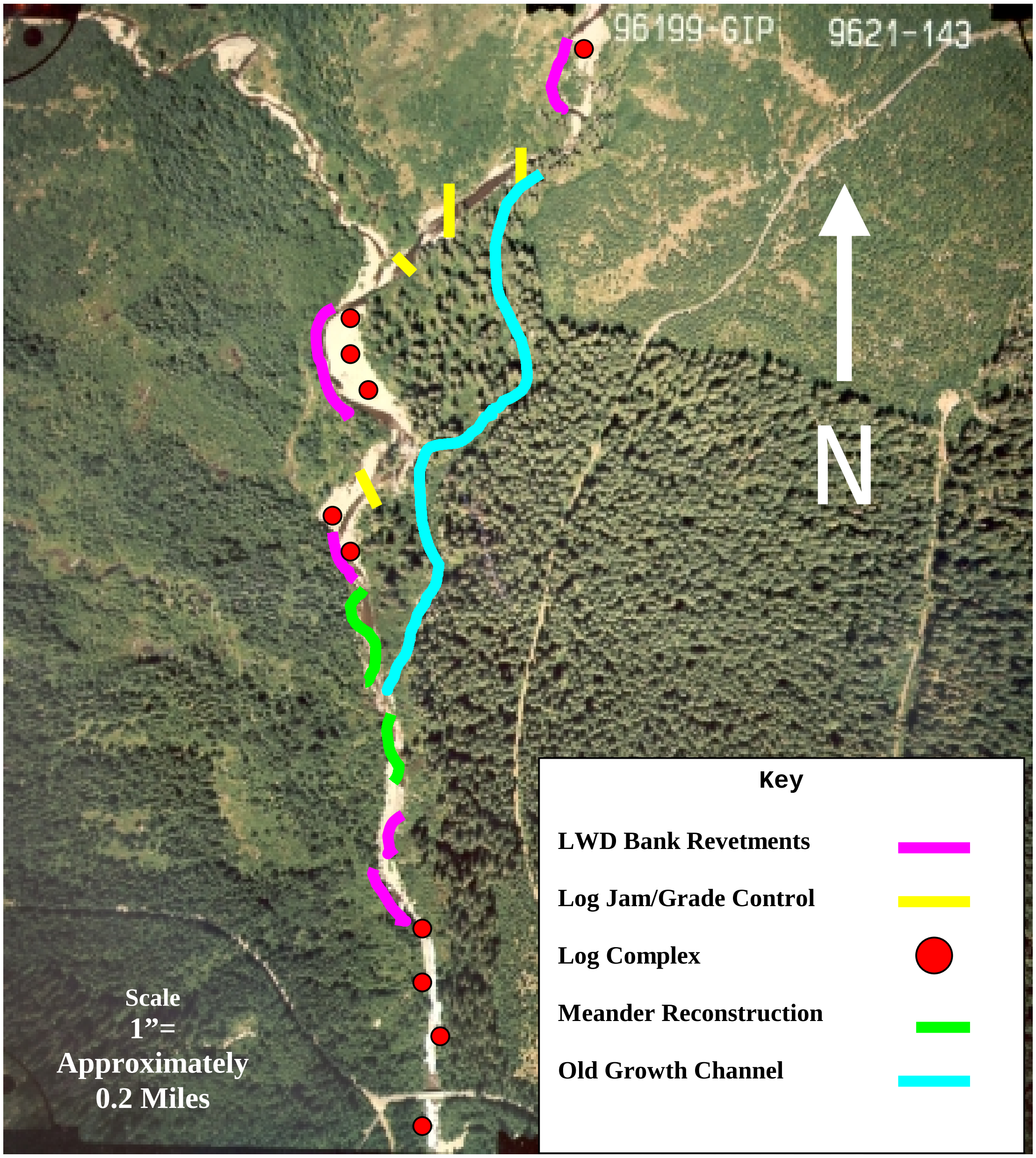


Figure 5. 1999 Trout Creek Restoration Project Plan, T.4N., R.6E. Section 13, Skamania County Washington. (Photo Bair)

Figure 6. A 1995 photo of the entrance to the Trout Creek old growth channel, Skamania County, WA. A logjam that was thought to be a migration barrier was removed in 1981. The removal of the logjam initiated the channel to “down-cut” or degrade approximately five feet below the original bed elevation. As the channel degraded the connectivity with the flood plain and the last remaining old growth reach in Trout Creek. Log jams will be replaced to reactivate flood plain and old-growth channel. (Photo Bair)

Figure 7. Photo of severe bank erosion on Trout Creek (river mile ~ 7.3), Skamania County, WA. Removal of riparian vegetation and removal of in-stream LWD instigated severe channel degradation and bank erosion within the watershed. Large woody bank revetments will be installed to rehabilitate reaches such as this. (Photo Bair)

Figure 8. Large width to depth ratios and low stream shade depicted in the above photo increase maximum water temperature and provide poor quality rearing habitat for steelhead. Width to depth ratios will be rehabilitated by reconstructing meanders and increasing LWD. Trout Creek, about river mile 7.1, Skamania County, WA. (Photo Bair)

6. The Mining Reach of the Wind River Riparian and Channel Rehabilitation.

Project Lead: USFS
Cooperators: Bonneville Power Administration.
Project Location: T6N, R7E, Sections 4,9,16 & 21

Introduction

The project area was railroad logged from late 1920s to the mid 1930s. The entire riparian area was denuded of its old growth. Riparian areas and channels have not recovered due to 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. Stream survey data and aerial photo analysis depict the problems found in the Mining Reach. Figures 9-12 show the existing channel conditions relative to the up-stream old growth reach and other similar undisturbed channels within the watershed. Large woody debris (diameter > 24 in, length > 50 ft) within undisturbed reaches averaged 120 pieces per river mile in the Wind River watershed. Within the Mining Reach average LWD was 73 pieces per river mile (Figure 9). Riparian areas within the Mining Reach are dominated with deciduous species such as alder, which will provide limited future LWD (Figure 10). Alder is an early successional species important to aquatic ecosystems. Alder typically reaches climax and die after 30 years. The dominance of alder within this reach 70 years after being logged indicates that channel disturbance has been frequent and the channel or riparian areas have not made significant progress in recovering. 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 11). 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. Downstream in the logged reach, bank-full width to depth ratios averaged 62 (Figure 12).

Project Goals and Objectives

The goal of this project is to restore riparian function, riparian conifers, and reestablish bank and channel stability to recover viable populations of wild steelhead.

The objectives to meet these goals are: (1) restore the riparian conifer component along these reaches to eight trees per acre greater than 31" in diameter (200 years), (2) increase shade to greater than 80% (60 years) (3) increase bank stability above 80% (10 years), (4) reduce bank-full width to depth ratios within identified reaches to less than 25 (2 years), (5) increase in-stream LWD > 100 pieces per river mile (70 years), and (6) Restore 32 acres of historic flood plains.

Methods

Riparian areas will be thinned and under planted with native conifers. Thinned trees will be yarded into project sites with a tracked dozer and placed on exposed gravel bars, flood plains and eroding banks with a tracked excavator.

Results

USDA Forest Service "Flood Restoration dollars" and Bonneville Power Administration fish and wildlife monies funded this project. The NEPA was completed in spring 1999, and implementation will begin mid August 1999. Three river miles will be treated with approximately 1,500 trees. Figures 13 & 14 show the site-specific areas and treatments proposed for restoration.

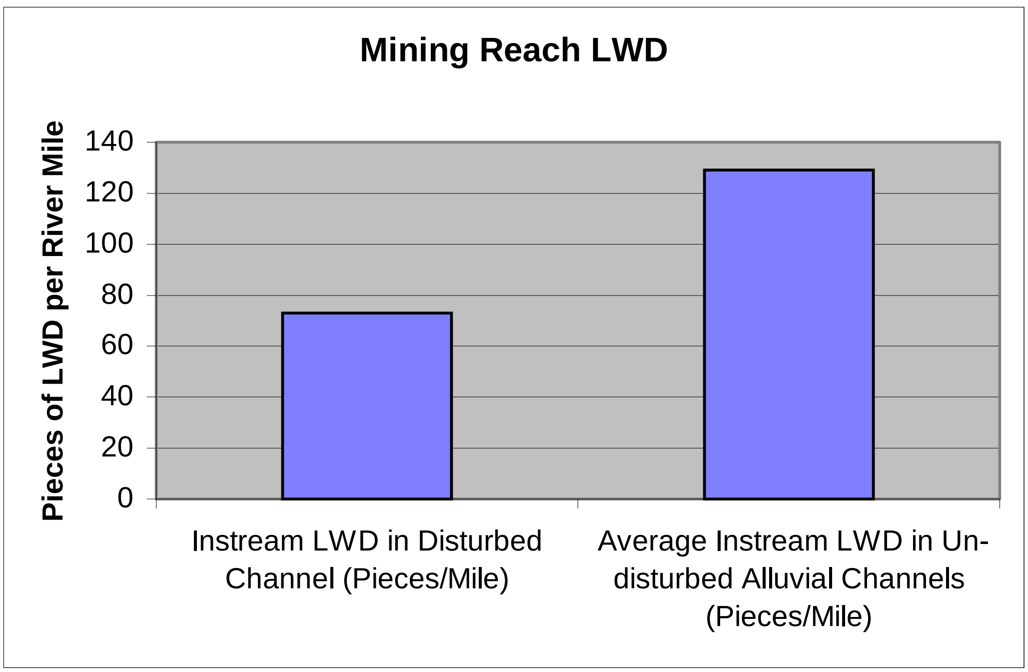


Figure 9. Comparison of existing large woody debris (LWD*) observed in the Mining Reach and average LWD per river mile observed in 13 alluvial reaches of stream within Wind River, Skamania County Washington.
**LWD is defined as pieces with diameter > 24 inches and length > 50 feet.*

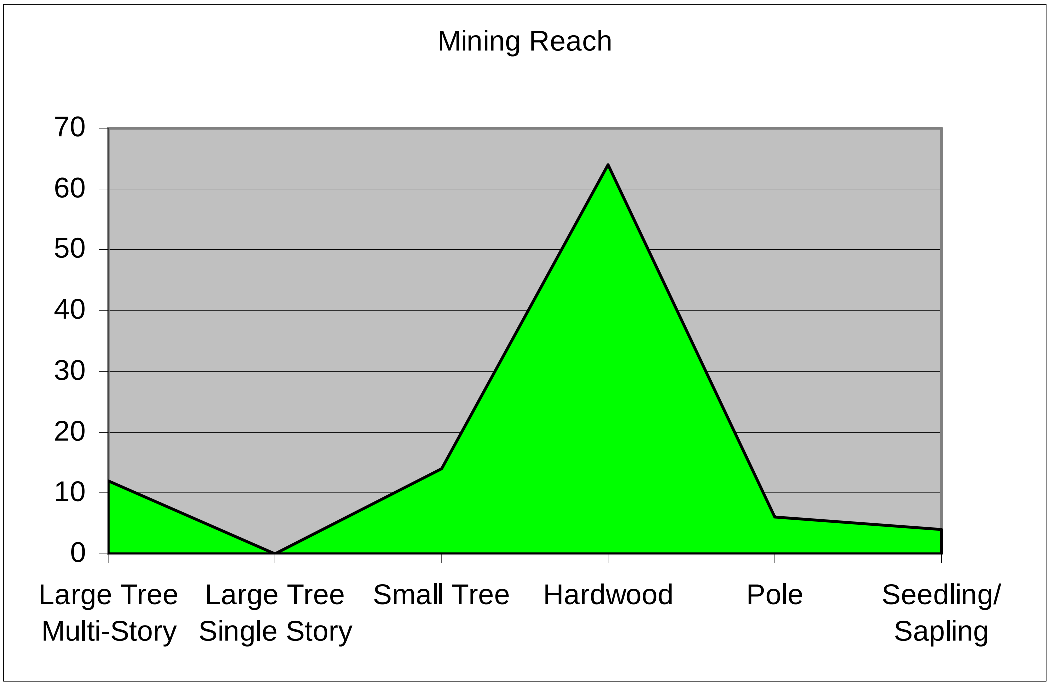


Figure 10. Percent composition of riparian stands* by seral class for the Mining Reach of the Wind River, Skamania County Washington.
** Riparian stands are delineated by the Aquatic Conservation Strategy standards; 360' from bank full channel. Seral class definitions: Large tree = 48"-32" in diameter, 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.*

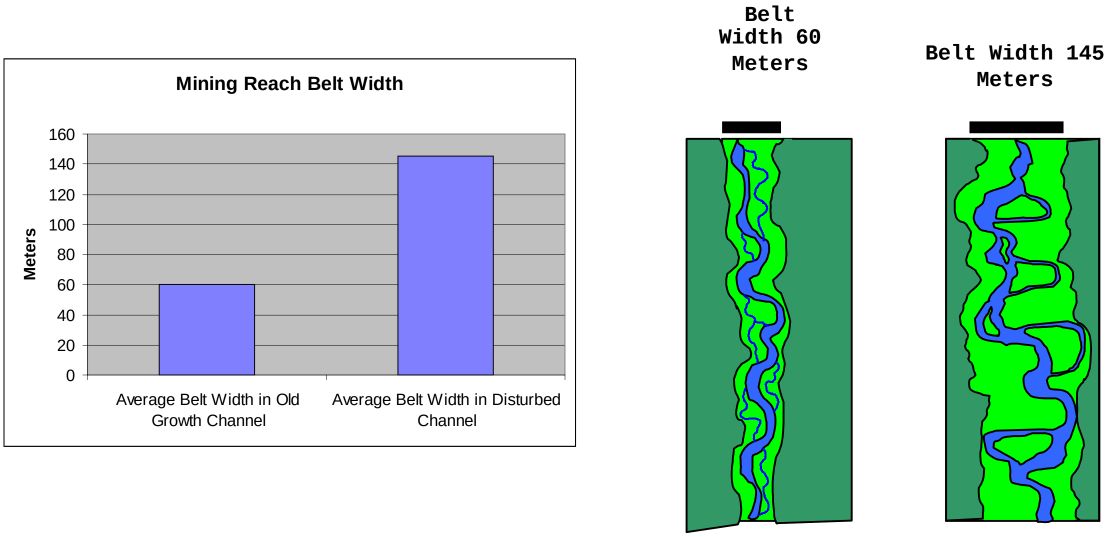


Figure 11. Comparison of belt widths in old growth and disturbed channels for the Mining Reach of the Wind River, Skamania County WA.

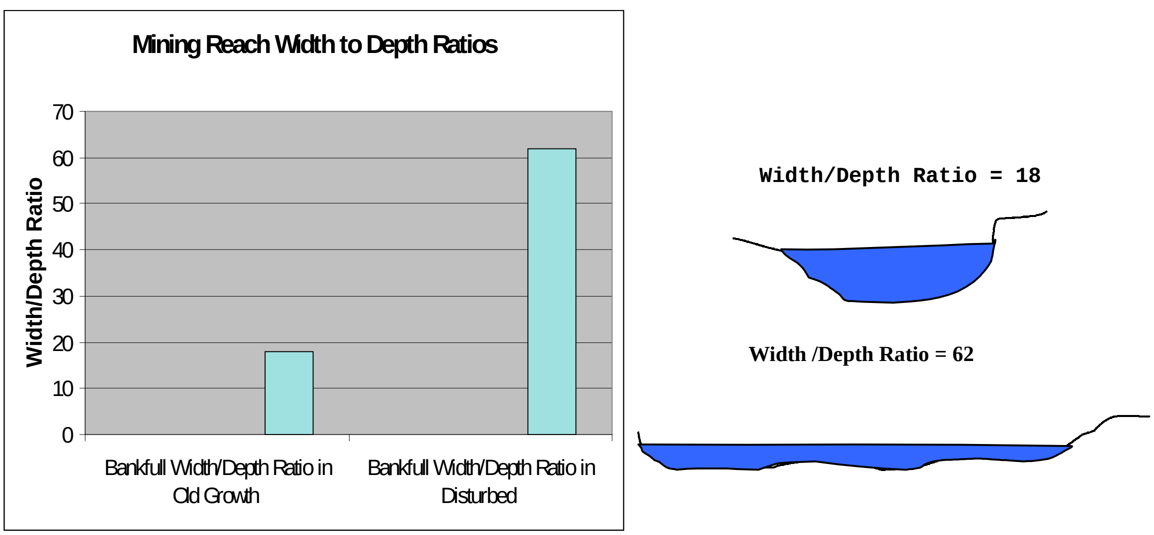


Figure 12. Comparison of the average width to depth ratios in old growth and disturbed channels for the Mining Reach of the Wind River, Skamania County WA.

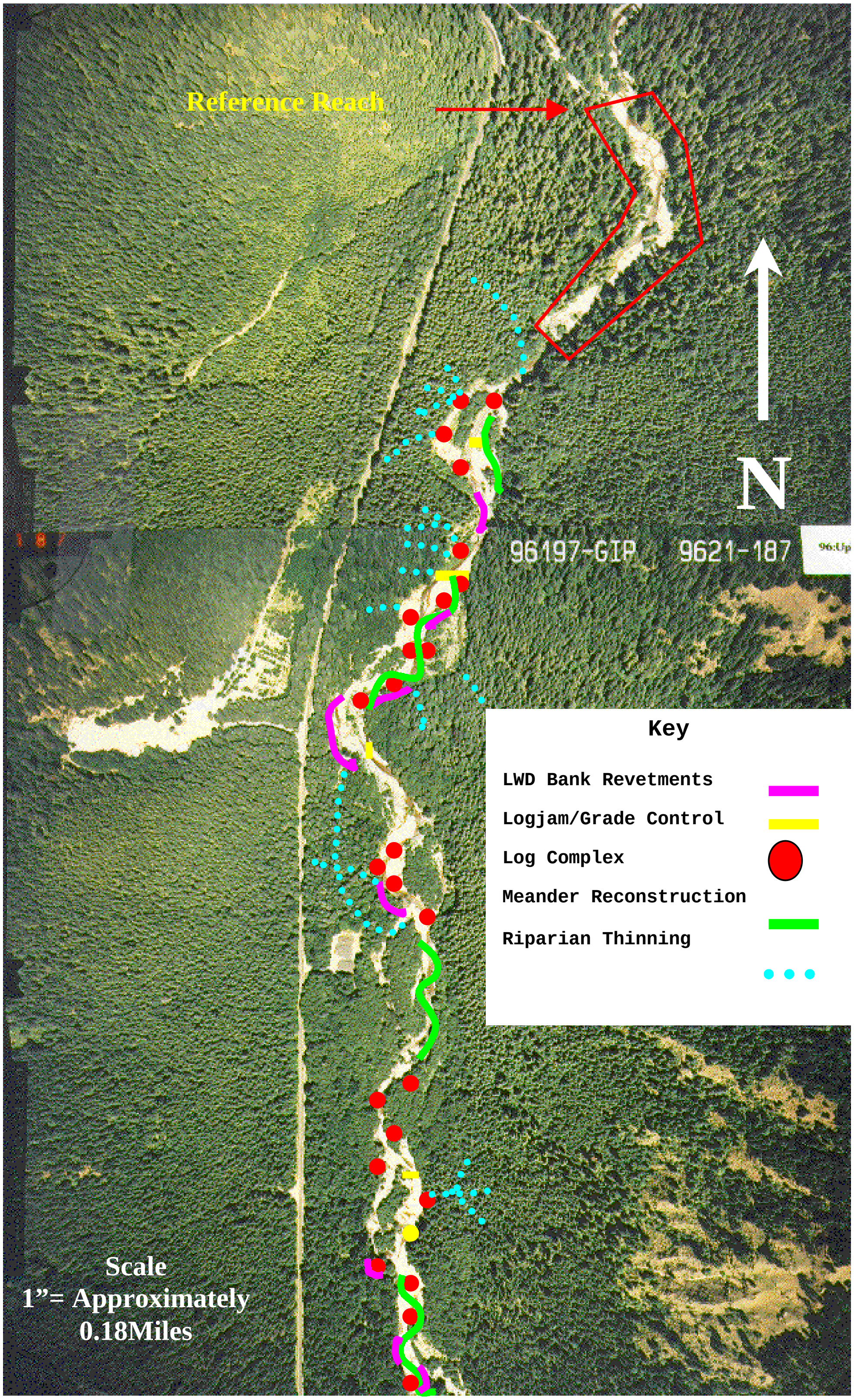


Figure 13. Upper project area and proposed treatments, river mile 25-23.5,of the Wind River, T6N, R7E, Sections 3,4,9 & 10, Skamania County WA.

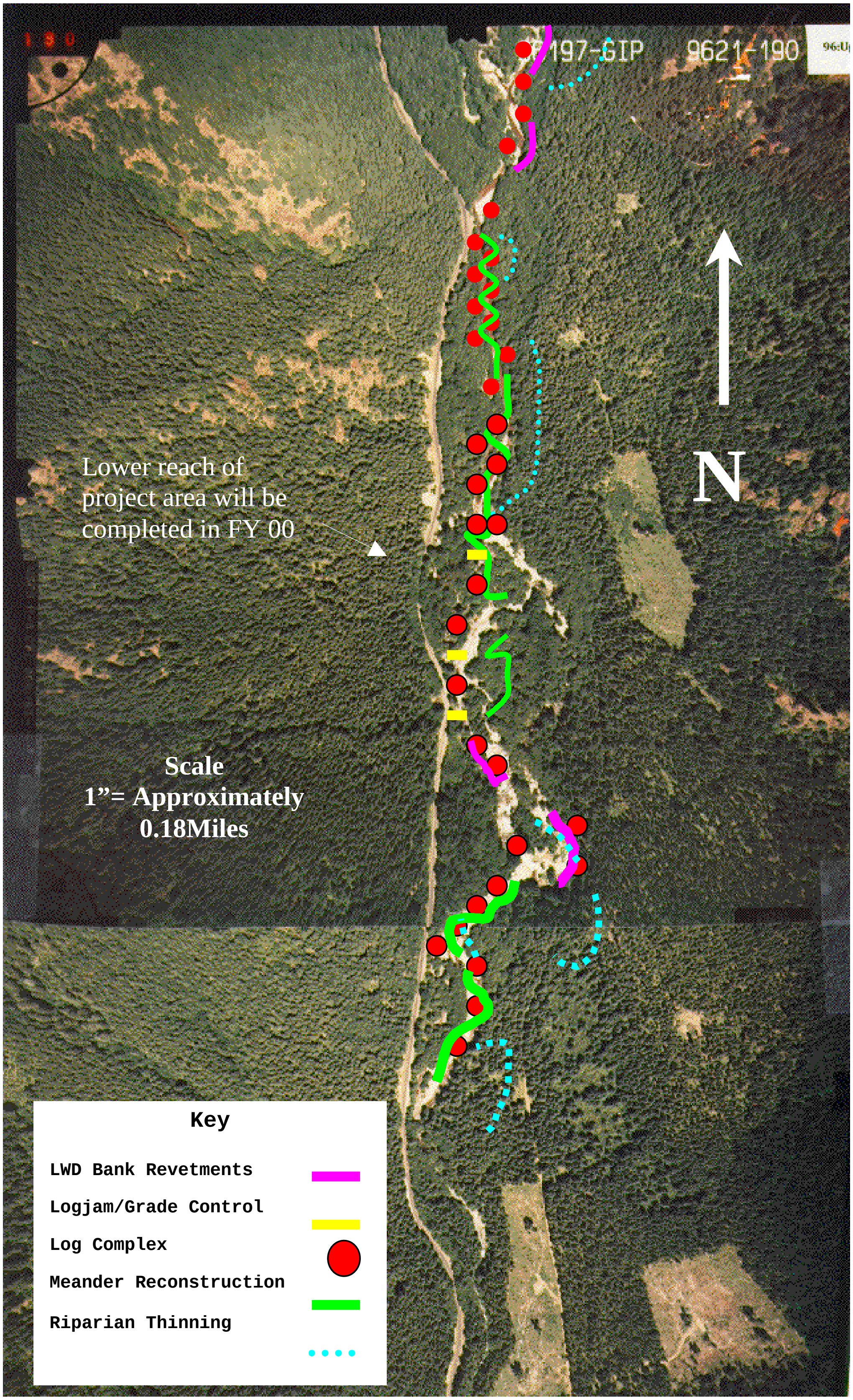


Figure 14. Lower project area and proposed treatments river mile 23.5-22 of the Wind River, T6N, R7E, Sections 9, 10, 16 & 21, Skamania County, WA.

7. Upper Wind River and Trout Creek Riparian Rehabilitation

Project Lead: US Forest Service
Cooperators: Bonneville Power Administration.
Project Location: T4N, R6E, Section 13 / T6N, R7E, Sections 4,9,16 & 21

Introduction

Stream-side vegetation was logged from late 1920s to the mid 1980s. Riparian areas have or are over-stocked with homogeneous stands of hard woods such as alder or Douglas fir conifers.

Methods

Densely stocked riparian stands will be thinned to increase stand vigor and diversity. Wind River silviculturists have selected climax species such as western hemlock and western red cedar that were present in the existing riparian stands. Trees surrounding the climax species will be thinned or girdled to accelerate growth by reducing competition for sunlight and nutrients. Felled and girdled trees will be left as down wood and snags to increase terrestrial, snag and roosting wildlife habitat.

Stands of alder and Douglas fir will also be under-planted with native conifers to increase stand diversity and provide a long-term source of LWD. Hand crews will plant coniferous seedlings on 5 to 10 foot spacing during spring months. Rooted willow stock is planted on the lower banks and within the bank-full channel to increase channel stability and increase stream shade.

Results and Discussion

At the end of the 1999 contract period, NEPA and survey and manage species surveys were complete and contracts had been secured for 3.6 river miles of the Upper Wind River and Trout Creek. Approximately 75 riparian acres have been marked to release native conifers such as cedar, hemlock and grand fir. In addition these stands will be under-planted with approximately 30,000 native conifers. Thinned trees will provide an estimated 1,500 trees for flood plain and channel treatment. Conifer seedlings intended for planting were removed from containers, pruned and trans-planted into nursery beds. Approximately 25 acres of rooted willow stock were planted on the lower banks and within the bank-full channel to increase channel stability and increase stream shade within Trout Creek and the Wind River.

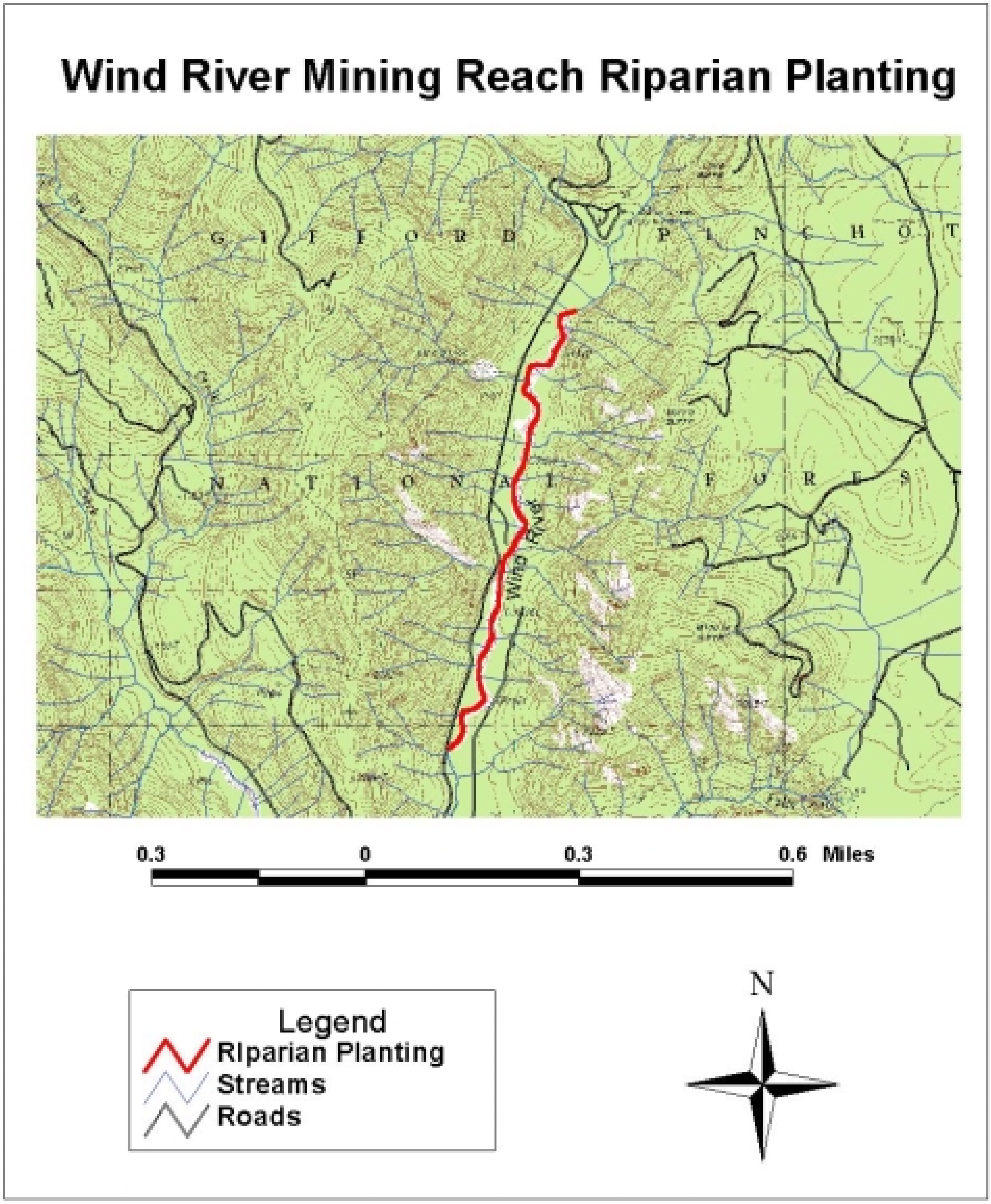


Figure 15. Upper Wind River thinning and conifer planting project area, T5N, R7E, Sect. 9, 16, Skamania County, Washington.

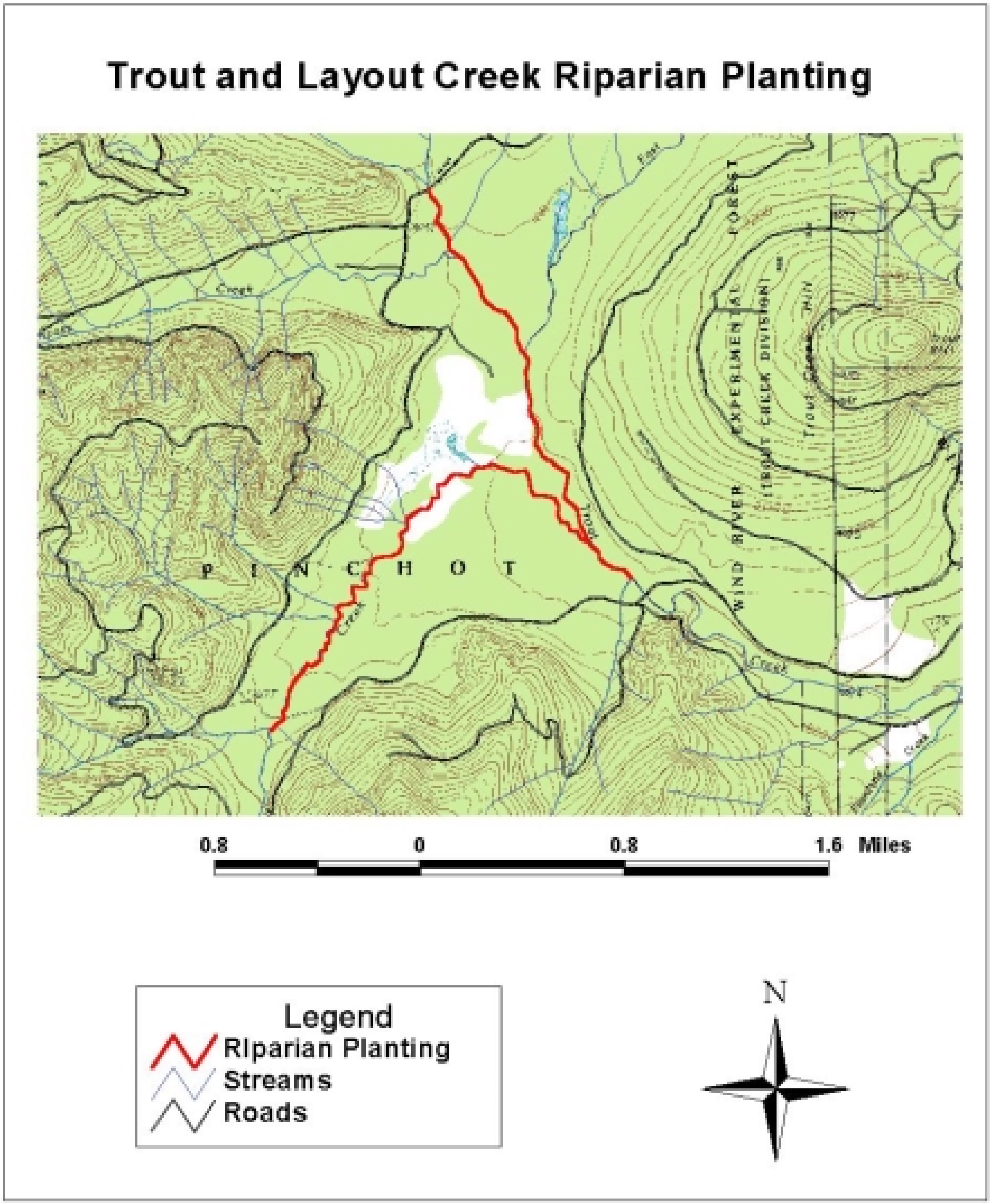


Figure 16. Hardwood planting sites for Trout and Layout creeks, T4N, R6E, Section 13, Wind River watershed, Skamania County, Washington, 1999.

Monitoring

Fourteen survival and growth plots were established for riparian plantings. Survival and growth will be evaluated on an annual basis for the next five years.

Acknowledgements

I would like to pay a special thanks to all of the U.S. Forest Service employees at both Mt. Adams Ranger District and Wind River Work and Information Center who have contributed to the restoration of the Wind River watershed. In particular and in no particular order: Seth Defoe, Aletta Wilson, Anthony Olegario, Greg Robertson, Betty Hebert, Paul Powers, Eric Plimmer, Cathy Flick, James Umtuch, Pete Nelson, Jim Nielsen, Steve Ohnemus, Bruce Burke, Gail Bouchard, and John Forsberg. I would also like to thank and acknowledge Pat Connolly and crews of the USGS Biological Resource Division's Columbia River Research Laboratory for their hard work and efforts toward biological monitoring of restoration projects.

References

Bair, B. 1997. Trout Creek restoration. USDA Forest Service, Wind River Ranger District, Carson, Washington.

Bair, B. 1999. Wind River Watershed restoration completion report. Internal Report, USDA Forest Service, Wind River Ranger District, Carson, Washington.

USFS (U.S. Forest Service) and BLM (Bureau of Land Management). 1994. Record of Decision for amendments to Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl, standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. April 13, 1994.

USFS (U.S. Forest Service). 1993. 1992 basin assessment. Wind River Ranger District. Draft report. Carson, Washington.

USFS (U.S. Forest Service). 1996. Wind River basin watershed analysis. Wind River Ranger District, Carson, Washington.

Harrelson, C. C., C. L. Rawlins, and J. P. Potyondy. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rp. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61.p.

Rosgen, D. L. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO.

Johnston, G. 1998. Restoration - Part I. Annual report to BPA. Report F *In*: P. J. Connolly, editor. 1999. Wind River watershed project. 1998 Annual Report. Project number 9801900. Prepared for: Bonneville Power Administration, Portland, Oregon.

Powers, P., G. Johnston, and B. Bair. 1998. Wind River Stabler Reach, 1998 project completion report. Internal Report, USDA Forest Service, and Underwood Conservation District.

Wind River Watershed Restoration

Volume III: Monitoring Fish Populations

1999 Annual Report

September 2001

Edited by:

Patrick J. Connolly

U.S. Geological Survey
Columbia River Research Laboratory
5501-a Cook-Underwood Road
Cook, WA 98605

Prepared for:

Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number: 1998-019-01
Contract Number 00004973
(previously 98-AI-09728-002)

Volume III: Monitoring Fish Populations

Contents

Report D: Juvenile Steelhead and Other Fish Rearing in the Wind River Watershed

Wind River Watershed Project

1999 Annual Report

September 2001

Prepared by:

Patrick J. Connolly and Ian G. Jezorek

U.S. Geological Survey
Western Fisheries Research Center
Columbia River Research Laboratory
5501-A Cook-Underwood Road
Cook, WA 98605

Introduction

In this report are results from efforts conducted by personnel from U.S. Geological Survey's Columbia River Research Laboratory (USGS-CRRL). This report covers work completed on two tasks that were delineated in a Statement of Work submitted to BPA in January 2000: Tasks 2a (*Conduct sampling and analyses to derive population estimates for steelhead parr and other salmonids*) and Task 2b (*Conduct sampling and analyses to derive annual estimates of production of steelhead smolts in the subbasin*). Task 2a was the primary focus of USGS-CRRL, while Task 2b was the primary focus of Washington Department of Fish and Wildlife. These tasks were undertaken to meet the objective of determining productivity and characterizing early life history of steelhead in the Wind River watershed.

Personnel from USGS-CRRL conducted field sampling in 1999 to derive population estimates for steelhead parr and other salmonids in several tributary streams throughout the Wind River watershed, especially those in Trout Creek and upper Wind River watersheds. Herein we report our findings on populations of juvenile steelhead and associated fish species based on data collected through December 1999.

Study Area

The Wind River watershed covers 582 km^2 and supports a fifth-order stream system with the largest tributary watersheds of Trout (88 km^2) and Panther (107 km^2) creeks supporting third-order systems (Figure 1). Elevations range from 25 m at the mouth of the Wind River at the watershed's southern edge to 1,190 m at ridge tops near its northern edge. The watershed is exposed to a temperate marine climate with most of the average annual precipitation of 280 cm occurring between November and April. Precipitation in the winter is largely delivered as rain in the lower elevations of the watershed and largely delivered as snow in the higher elevations.

Methods

To determine fish assemblage and obtain estimates of density and biomass, we first conducted habitat surveys of sampling reaches. We electrofished a systematic sample of habitat units (e.g., a single pool, glide, or riffle) within strata of habitat types (e.g., pools, glides, and riffles). Habitat units chosen for sampling were blocked off with nets to insure no movement into or out of the unit during sampling. A backpack electrofisher was used to conduct two or more passes under the removal-depletion methodology (Zippin 1956; Bohlin et al. 1982; White et al. 1982). The field guides of Connolly (1996) were used to insure that a controlled level of precision in the population estimate (CV < 25% for age-0 steelhead and CV < 12.5% for age-1 or older juvenile steelhead) was achieved within each sampling unit for each salmonid species (steelhead/rainbow trout, brook trout) and age group (two age groups). These methods were chosen specifically to minimize the number of units sampled by electrofishing and to minimize the number of electrofishing passes conducted. This approach serves to lessen the chance that individual fish will be exposed to potentially harmful effects of electroshocking while insuring a high degree of precision in our estimates.

Captured fish were anesthetized with the lightest possible dose of MS-222 before handling and released to their approximate point of capture after handling. The exception to this protocol was when a fish died before or during handling and/or the fish was "taken" for disease profiling by the U.S. Fish and Wildlife Service's Lower Columbia River Fish Health Center. All fish captured were measured for fork length to the nearest mm, weighed to the nearest 0.01 g, and inspected for external signs of disease. In order to track movements, growth, and survival of juvenile steelhead, we inserted PIT tags in some of the juvenile steelhead that exceeded 80 mm in length.

In addition to the stratified systematic sampling of tributaries described above, we snorkeled five ≥ 100-m sites within a 5 km segment of the mainstem Trout Creek. This 5-km reach was upstream of the free-flowing stream just above Hemlock Lake (rkm 6) and downstream of the Road 43 bridge (rkm 11). Four of the five sites were those sampled in 1998. An additional site, in the Trout Creek canyon area, was added in recognition of its unique habitat type. A single snorkeler identified and counted fish in individual habitat units (e.g., pools, glides, riffles) while proceeding upstream through the entire 100-m plus reach. Although some calibration efforts of snorkeler counts were conducted using electrofishing, the data presented in this report were not corrected for snorkeler bias because too few of these calibration efforts were completed. Extensive calibration efforts were conducted in 2000, and the results will be presented in the 2000 Annual Report.

The fish provided to the U.S. Fish and Wildlife Service's Lower Columbia Fish Health Center (Susan Gutenberger, Project Leader) were given a rigorous lab inspection for disease. Diseases screened at the Center by testing or microscopic observations included bacterial (bacterial kidney disease, coldwater disease, columnaris, emphysematous putrefactive disease, furunculosis, enteric redmouth), viral (infectious pancreatic necrosis, infectious hematopoietic necrosis, viral hemorrhagic septicemia), and parasitic (whirling disease, *Ceratomyxa*, digenetic trematodes, *Myxobolus kisutchi*, *Myxidium minteri*, *Hexamita*, *Gyrodactulus*, *Scyphidia*, *Heteropolaria*) agents. The budgeting for this effort was 100% supported by in-kind contributions from the USFWS.

Results

We found a total of four fish species in our sampling areas in 1996-1999 (Table 1): steelhead/rainbow trout *Oncorhynchus mykiss* (hereafter referred to as "steelhead"), shorthead sculpin *Cottus confusus*, brook trout *Salvelinus fontinalis*, and chinook salmon *O. tshawytscha* (Table 2). Whereas juvenile steelhead were present in all areas sampled, shorthead sculpin and brook trout were much more limited in their distribution (Table 2). No sculpin were, or ever have been over the last five years, found upstream of the canyon reach (about rkm 9) in Trout Creek, which suggests that one or more of the numerous small falls in this reach is a barrier to sculpin. Brook trout were a prevalent part of the fish assemblage in the mainstem and tributaries of Trout Creek above the canyon reach, but were much less frequent in the lower mainstem Trout Creek and the upper Wind River watershed, and have never been observed during our extensive surveys in Panther Creek. Observations of juvenile chinook in 1999 were limited to a few individuals in Paradise and Trapper creeks of the upper Wind River watershed. Chinook were not found in the portions of Trout Creek and Panther Creek watersheds that we sampled in 1996-1999.

A total of eight stream reaches were surveyed by electrofishing or snorkeling for juvenile steelhead in summer 1999. These surveys are an extension of an existing matrix of comparative surveys (Table 1) conducted in 1984 (Crawford et al. 1985), 1985-1988 (USFS, unpublished data), 1996 (Connolly 1997), 1997 (Connolly et al. 1997), and 1998 (Connolly 1999). For analysis of population trends, I grouped these surveys into two, 5-yr time periods: 1984-1988 and 1996-1999. The resulting mean values and standard errors for population (fish/m) and biomass (g/m, g/m^2) estimates of juvenile steelhead and brook trout are given in Appendix Tables 1 and 2, respectively.

In most stream reaches where comparable data exist, estimates of juvenile steelhead population and biomass in 1996-1999 were less than those in 1984-1988 in Trout Creek (Figure 2), Panther Creek (Figure 3), and upper Wind River (Figure 3) watersheds. The only population increases of juvenile steelhead noted between 1984-88 and 1996-99 were in age-1 and older fish in Layout Creek and in age-0 fish in Martha Creek (Figure 4). Layout and Big Hollow creeks were the only sites that did not show at least one of the two age groups of juvenile steelhead having a decrease in population over 25%. Percentage decreases of 25% or more in juvenile steelhead populations from 1984-88 to 1996-99 were common.

We had a limited number of PIT tags to use in 1999, and all were the "older" 400-kHz type. We inserted a total of 285 in juvenile steelhead (> 80 mm) that were collected during our fish surveys in the upper Wind River and Trout Creek watersheds (Table 3). All appropriate data on PIT-tagged fish were entered in the PTAGIS database following protocol set by the Columbia Basin Fish and Wildlife Authority PIT Tag Steering Committee (1999).

We completed our second year of snorkeling at sites in the 5-km portion of mainstem Trout Creek downstream of the Road 43 Bridge but upstream of Hemlock Lake. Uncalibrated snorkel counts in this area have been as high as 2.0/m for age-0 steelhead and 1.4/m for age-1 and older steelhead (Figure 5). These results indicate that sections of this 5-km portion of the Trout Creek mainstem held juvenile steelhead in numbers comparable to the best areas of the mainstem and tributary areas upstream (Figure 2). All four sites sampled in both 1998 and 1999 showed a large decrease (as much as 100%) in the number of juvenile steelhead in 1999 relative to that in 1998, but the site with the most juvenile steelhead in 1999 ("D") was not sampled in 1998. It can not be determined from our data whether the total population in the total 5-km portion of

Trout Creek decreased in 1999 relative to that of 1998 because the fish may have simply expressed a more contagious distribution in 1998 that our sampling could not detect.

Brook trout are a persistent part of the fish fauna in the mainstem and tributaries of Trout Creek in the Cedar Flats area (upstream of rkm 11). In the two stream reaches that were sampled in 1984 and in each year during 1996-1999, brook trout biomass has remained low and have not exceeded the 1984 biomass reported by Crawford et al. (1985), whereas juvenile steelhead biomass showed a decreasing trend (Figure 6; Appendix Table 2).

A low number of diseases screened for were actually found in wild steelhead and brook trout in the Wind River watershed (Tables 4 and 5). Diseases screened for (see above in Methods), but not listed in the tables, have not been detected in Wind River fish as of 1999. In addition to the sites tested within the three focus watersheds (upper Wind River, Trout Creek, and Panther Creek), a sample of five resident rainbow trout was taken from Bear Creek above an impassible falls. These fish from Bear Creek tested positive for bacterial kidney disease, as well as having *Myxidium minter*i and *Heteropolaria*. In water accessible to anadromous fish species, no fish with viral diseases were found, and fish with bacterial diseases (bacterial kidney disease, coldwater disease) were limited to tributaries of Trout Creek.

A large number of juvenile steelhead observed during 1996-1999 were infested with *Heteropolaria* (formerly *Epistylis*), a ciliated protozoan. Brook trout infested with *Heteropolaria* have been limited to two streams: mainstem Trout (at Road 33 bridge) and Compass Creek. Although the distribution of fish infested with *Heteropolaria* is essentially system-wide, juvenile steelhead in the Trout Creek watershed, especially in Planting Creek, Crater Creek, and Trout Creek above the 33 Road Bridge, have had a high rate of, and severe cases of, infestation relative to areas sampled in upper Wind River and Panther Creek watersheds.

Discussion

Shipherd Falls has had a strong influence in limiting the number of fish species present in the Wind River system, and human intervention has resulted in an increase in the number of fish species. Of the four species found in our sampling area, only steelhead and shorthead sculpin are considered to be native to the Wind River subbasin above Shipherd Falls (Connolly 1995). In addition to the steelhead, shorthead sculpin, brook trout, and chinook that we found in our study areas, a limited number of other fish species exist in the Wind River above Shipherd Falls. Mountain whitefish *Prosopium williamsoni* are prevalent in the mainstem Wind River, as observed by snorkelers participating in the annual adult fish survey (pers. com. with Dan Rawding, WDFW), and are possibly the only other native fish species that persists above Shipherd Falls. Isolated and rare sightings of sockeye *O. nerka* (probably never occurred above Shipherd Falls before ladder construction), brown trout *Salmo trutta* (non-native, from hatchery introductions), and cutthroat trout *O. clarki* (perhaps native, but could also be from hatchery introductions) have been reported by seasoned snorkelers (pers. com. with Dan Rawding, WDFW; Tim King, WDFW; and K. Wieman, USFS; respectively). Human interventions, especially the laddering of Shipherd Falls in the 1950s and introduction of exotic fish species or stocks, with varying degrees of success, by WDFW and USFWS (including steelhead, chinook, coho, rainbow trout, brook trout, brown trout, and cutthroat trout) has increased the number of fish species and stocks in the system (Connolly 1995; USFS 1996).

Populations of age-0 and age-1 and older juvenile steelhead were generally lower during 1996-99 than in 1984-88 in all streams surveyed. The decreases in populations were especially evident in the upper reaches of the Trout Creek watershed and its tributaries. These findings correspond to decreases in adult returns and in frequency of redd counts, which indicate that few adult steelhead returned to the upper Trout system for spawning during the mid 1990s (see separate report on adult returns in this document).

The biomass of brook trout in mainstem Trout Creek and Crater Creek was generally lower during 1996-1999 than in 1984, but the percent of total salmonid biomass represented by brook trout during 1996-1999 often exceeded that in 1984. A primary objective for tracking brook trout populations is to see if the decline in numbers of rearing steelhead has resulted in an increase in brook trout. Because the biomass of brook trout has remained relatively stable, the general trend of increases in percent of total salmonid biomass represented by brook trout is more attributable to decreased juvenile steelhead biomass rather than increased brook trout biomass.

The first chance to recapture PIT-tagged fish was during the spring 2000 smolt out-migration and these results will be reported in our 2000 Annual Report. The PIT-tagging effort was greatly expanded in 2000 using “newer” tags (134.2 kHz) that were acquired through the Pacific States Marine Fisheries Commission.

A large number of juvenile steelhead continue to be infested with *Heteropolaria*, with especially heavy infestations of age-1 steelhead in the Trout Creek system. Trout Creek and two of its tributaries (Crater and Layout creeks) were the only sites to harbor fish with Bacterial Cold Water Disease and with *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease. The monitoring of *Heteropolaria* infestation and other disease agents will continue in future sampling.

Acknowledgements

A number of people helped with this body of work. Many fellow staff members at USGS-CRRL helped with the project. Jim Petersen served as Project Leader and handled much of the administrated needs for the project. Julie Parsons provided valuable field help performed much of the data entry. Other USGS-CRRL personnel who contributed help in the field include: Brady Allen, Craig Barfoot, Cari Clemets, Adam Daniel, Reed Fee, Ken Gates, Glen Holmberg, Pete Kofoot, Amanda McKinney, Teresa

Nation, Angie Powers, Craig Robinson, Sally Sauter, Eric Shoudel, and Matt Wilcox. Dan Rawding of Washington Department of Fish and Wildlife helped by providing personnel for field assistance; in particular the much appreciated efforts of P. Charlie Cochran and Tim King. The cooperative efforts of Ken Wieman and Brian Bair of the U.S. Forest Service were much appreciated. Help provided by Susan Gutenberger and Ken Lujan of the U.S. Fish and Wildlife Service's Lower Columbia Fish Health Center much benefited the project by their providing field assistance and fish health profiles. A large thanks goes to John Baugher of BPA for his diligence as Contracting Officer for the project.

References

Bohlin, T. 1982. The validity of the removal method for small populations -- consequences for electrofishing practice. Institute of Freshwater Research Drottningholm Report 60:15-18.

Connolly, P. J. 1995. Wind River steelhead restoration project: With special emphasis on the Trout Creek Basin. Prepared for: Columbia River Research Laboratory, Cook, WA.

Connolly, P. J. 1996. Resident cutthroat trout in the central Coast Range of Oregon: logging effects, habitat associations, and sampling protocols. Doctoral dissertation. Oregon State University, Corvallis.

Connolly, P. J. 1997. Status of juvenile steelhead rearing in Trout and Panther creeks of the Wind River basin. Prepared for: Washington Trout, Duvall, WA.

Connolly, P. J. 1999. Editor. Wind River watershed project. 1998 Annual Report. Project number 9801900. Prepared for: Bonneville Power Administration, Portland, Oregon.

Connolly, P. J., R. P. Hanten, and J. H. Petersen. 1997. Juvenile steelhead in Trout and Panther creeks of the Wind River basin sampled in August-September 1997. Prepared for: Washington Trout, Duvall, WA.

Crawford, B. A., R. Pettit, and R. Claflin. 1985. Study of juvenile steelhead densities and biomass in the Wind and E.F. Lewis rivers. Washington Department of Game, Olympia.

Columbia Basin Fish and Wildlife Authority PIT Tag Steering Committee. 1999. PIT tag marking procedures manual. Version 2.0. Pacific States Marine Fisheries Commission, Gladstone, OR.

USFS (U.S. Forest Service). 1996. Wind River basin watershed analysis. Gifford Pinchot National Forest, Wind River Ranger District. Carson, Washington.

White, G. C., D. R. Anderson, K. P. Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. No. LA-8787-NERP, UC-11. Los Alamos National Laboratory, Los Alamos, New Mexico.

Zippin, C. 1956. An evaluation of the removal method of estimating animal populations. Biometrics 12:163-189.

Table 1. Locations and timing of population surveys using snorkeling or the removal method with electrofishing within the Wind River watershed, 1996-1999. Coordinates obtained from a hand-held Global Positioning System using North American Datum 1927. Sites are listed from upstream to downstream within a watershed relative to the mainstem.

Watershed Subwatershed Subdrainage	Start point distance from mouth (km)	Length of reach (km)	Coordinates at start point North	Coordinates at start point West	Coordinates at end point North	Coordinates at end point West	Year sampled[a] 1996	1997	1998	1999
Upper Wind										
Paradise Cr.[b]	0 (at mouth)	0.5	45 56.816'	121 55.978'	45 56.986'	121 56.213'	No	No	Yes	Yes
Big Hollow Cr.[b]	0 (at mouth)	0.5	RNO[c]		45 55.275'	121 58.719'	No	No	Yes	No
Trapper Cr.[b]	0 (at mouth)	1.0	45 52.778'	121 58.784'	45 53.380'	122 00.435'	No	No	Yes	No
Trout Creek										
Trout Cr. - above Crater Cr.	0 (at mouth)	0.5	45 50.759'	122 01.960'	45 50.979'	122 01.943'	Yes	Yes	No	No
Crater Cr.[b]	0 (at mouth)	0.5	45 50.759'	122 01.960'	45 50.847'	122 02.275'	Yes	Yes	Yes	Yes
Trout Cr. - A (33 bridge)[b]	14.0	0.1	45 50.589'	122 01.909'	45 50.646'	122 01.943'	Yes	Yes	Yes	Yes
Compass Cr.[b]	0 (at mouth)	0.5	45 50.524'	122 01.870'	45 50.432'	122 02.133'	Yes	No	No	No
East Fork Trout Cr.	0 (at mouth)	0.4	45 50.187'	122 01.489'	45 50.452'	122 01.345'	Yes	No	No	No
Layout Cr.[b]	0 (at mouth)	1.0	45 49.749'	122 01.478'	45 49.643'	122 01.989'	Yes	No	No	Yes
Trout Cr. - B (43 bridge)	11.0	0.1	45 49.332'	122 00.679'	45 49.353'	122 00.754'	Yes	No	Yes	No
Planting Cr.[b]	0 (at mouth)	0.5	45 49.018'	121 59.400'	45 48.814'	121 59.584'	Yes	Yes	No	No
Trout Cr. - C (nr Planting Cr.)	9.4	0.1	RNO		RNO		No	No	Yes	Yes
Trout Cr. - D (canyon reach)	9.0	0.1	RNO		RNO		No	No	No	Yes
Trout Cr. - E (PCT bridge)	8.0	0.1	45 48.694'	121 57.376'	45 48.739'	121 57.376'	No	No	Yes	Yes
Trout Cr. - F (smolt trap site)	6.0	0.1	45 48.241'	121 56.330'	45 48.235'	121 56.432'	No	No	Yes	Yes
Martha Cr.[b]	0.9	0.4	45 47.772'	121 55.248'	45 47.691'	121 55.255'	No	Yes	Yes	No
Panther Creek										
Mouse Cr.[b]	0 (at mouth)	0.5	45 50.574'	121 51.522'	45 50.383'	121 51.332'	Yes	No	No	No
Eightmile Cr. - upper	0.7	0.5	45 50.529'	121 52.367'	45 50.597'	121 52.710'	Yes	No	Yes	No
Eightmile Cr. - lower	0 (at mouth)	0.6	45 50.364'	121 52.100'	45 50.529'	121 52.360'	Yes	Yes	Yes	No
Cedar Cr.	1.0	0.6	45 48.097'	121 51.512'	RNO		Yes	No	No	No

[a] Fish sampling conducted during August through mid-October. Results from 1996, 1997, and 1998 were reported in Connolly (1997), Connolly et al. (1997), and Connolly (1999), respectively.
[b] Locations sampled in 1984 by Crawford et al. (1985) or by the U.S. Forest Service in 1985-1988 (unpublished data).
[c] RNO = Reading not obtained, largely because of topography of basin.

Table 2. Presence and absence of the primary fish species found in tributaries of the Wind River. The list of streams represent those sampled during 1996-1999, but declaration of presence or absence is based on latest data available (through December 2000). Watersheds and streams are listed in an upstream to downstream pattern. P = present, A = absent.

Watershed Stream	Steelhead trout[a]	Shorthead sculpin	Brook trout[b]
Upper Wind River			
Paradise Creek	P	P	P
Ninemile Creek	P	P	A
Dry Creek	P	P	A[c]
Big Hollow Creek	P	P	A
Trapper Creek	P	P	P
Trout Creek			
Trout Creek - upper	P	A	P
Crater Creek	P	A	P
Trout Creek - A (33 bridge)	P	A	P
Compass Creek	P	A	P
East Fork Trout Creek	P	A	P
Layout Creek	P	A	P
Trout Creek - B (43 bridge)	P	A	P
Planting Creek	P	A	A
Trout Creek - C (nr Planting Cr.)	P	A	A[c]
Trout Creek - D (canyon reach)	P	A	A[c]
Trout Creek - E (PCT bridge)	P	P	A[c]
Trout Creek - F (smolt trap site)	P	P	P
Hemlock Lake	P	P	A[c]
Martha Creek	P	A	A
Panther Creek			
Mouse Creek	P	P	A
Eightmile Creek - upper	P	P	A
Eightmile Creek - lower	P	P	A
Cedar Creek	P	P	A

[a] It was not determined what portion, if any, of these fish were resident rainbow trout, but anadromous steelhead had access to all stream sections sampled.
[b] Brook trout are not native to the Wind River watershed.
[c] Although never observed, this species has a high likelihood of being present during some years or parts of a single year.

Table 3. Number and location of PIT tags placed in juvenile steelhead (fork length > 80 mm) in the Wind River watershed during 1999. Watersheds and streams are listed in an upstream to downstream pattern.

Watershed Stream reach or section		Number of 400 kHz PIT tags deployed
Upper Wind River		
Paradise Creek		68
Wind River – mining reach		59
Dry Creek		44
	Subtotal	**171**
Trout Creek		
Crater Creek		27
Trout Creek – A (33 bridge)		18
Layout Creek		69
	Subtotal	**114**
		Total 285

Table 4. Detected disease agents in wild juvenile steelhead from three focus watersheds in the Wind River subbasin, 1996-1999. Results are from laboratory examinations by the U.S. Fish and Wildlife Service's Lower Columbia River Fish Health Center (LCRFHC; Underwood, WA) unless noted with an "*", which indicates the disease factor was identified by USGS personnel in the field. YES = detected; S = suspected; nd = not detected. Streams not listed did not have fish analyzed by LCRFHC.

Watershed Stream or reach	Number of fish examined by LCRFHC	Disease agent[a]								
		RS	BCD	MK	MM	HEX	GYR	TRE	SCY	EPI
Upper Wind River										
Paradise Creek	11	nd	nd	nd	nd	nd	nd	nd	nd	YES*
Wind River (mining reach)	6	nd	nd	nd	nd	nd	YES	nd	YES	YES*
Ninemile Creek	4	nd	nd	nd	nd	nd	YES	YES	nd	YES
Dry Creek	2	nd	nd	nd	nd	nd	nd	nd	nd	YES
Big Hollow Creek	8	nd	nd	nd	nd	nd	nd	nd	YES	YES
Trout Creek										
Trout Creek - upper	7	S	YES	nd	nd	nd	nd	YES	YES	YES
Crater Creek	9	S	nd	nd	YES	nd	YES	nd	YES	YES
Trout Creek - A (33 bridge)	13	nd	nd	nd	nd	nd	YES	nd	nd	YES
Compass Creek	4	nd	nd	nd	YES	YES	YES	nd	nd	YES
Layout Creek	5	nd	nd	nd	nd	nd	nd	nd	YES	YES
Trout Creek - B (43 bridge)	6	nd	nd	nd	nd	nd	nd	nd	nd	YES
Planting Creek	2	nd	YES	nd	nd	nd	nd	nd	nd	YES
Martha Creek	3	nd	nd	nd	nd	nd	YES	nd	nd	YES*
Panther Creek										
Eightmile Creek	13	nd	nd	YES	nd	nd	nd	YES	YES	YES
Cedar Creek	5	nd	nd	nd	nd	nd	YES	YES	nd	nd

[a] Bacteria: RS = *Renibacterium salmoninarum* (causative agent of Bacterial Kidney Disease), BCD = Bacterial Coldwater Disease (*Flavobacterium psychrophilum*); Parasites: MK = *Myxobolus kisutchi*, MM = *Myxidium minteri*, HEX = *Hexamita*, GYR = *Gyrodactylus*, TRE = digenetic trematodes, SCY = *Scyphidia*, EPI = *Epistylis* (newer name: *Heteropolaria*).

Table 5. Detected disease agents in wild brook trout from the Trout Creek watershed in the Wind River subbasin, 1996-1999. Results are from laboratory examinations by the U.S. Fish and Wildlife Service's Lower Columbia River Fish Health Center (LCRFHC; Underwood, WA) unless noted with an "*", which indicates the disease factor was identified by USGS personnel in the field. YES = detected; S = suspected; nd = not detected. Streams not listed did not have fish analyzed by LCRFHC.

Watershed Stream or reach	Number of fish examined by LCRFHC	Disease agent[a]								
		RS	BCD	MK	MM	HEX	GYR	TRE	SCY	EPI
Trout Creek										
Trout Creek - upper	10	S	nd	nd	nd	nd	nd	nd	nd	nd
Crater Creek	16	S	nd	nd	YES	nd	nd	nd	YES	nd
Trout Creek - A (33 bridge)	4	nd	nd	nd	nd	nd	nd	nd	nd	YES
Compass Creek	2	nd	nd	nd	nd	nd	nd	nd	nd	YES
East Fork Trout Creek	5	nd	nd	nd	nd	nd	nd	nd	YES	nd
Layout Creek	47	YES	nd	nd	nd	nd	nd	nd	nd	nd
Trout Creek - B (43 bridge)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd

[a] Bacteria: RS = *Renibacterium salmoninarum* (causative agent of Bacterial Kidney Disease), BCD = Bacterial Coldwater Disease (*Flavobacterium psychrophilum*); Parasites: MK = *Myxobolus kisutchi*, MM = *Myxidium minteri*, HEX = *Hexamita*, GYR = *Gyrodactylus*, TRE = digenetic trematodes, SCY = *Scyphidia*, EPI = *Epistylis* (newer name: *Heteropolaria*).

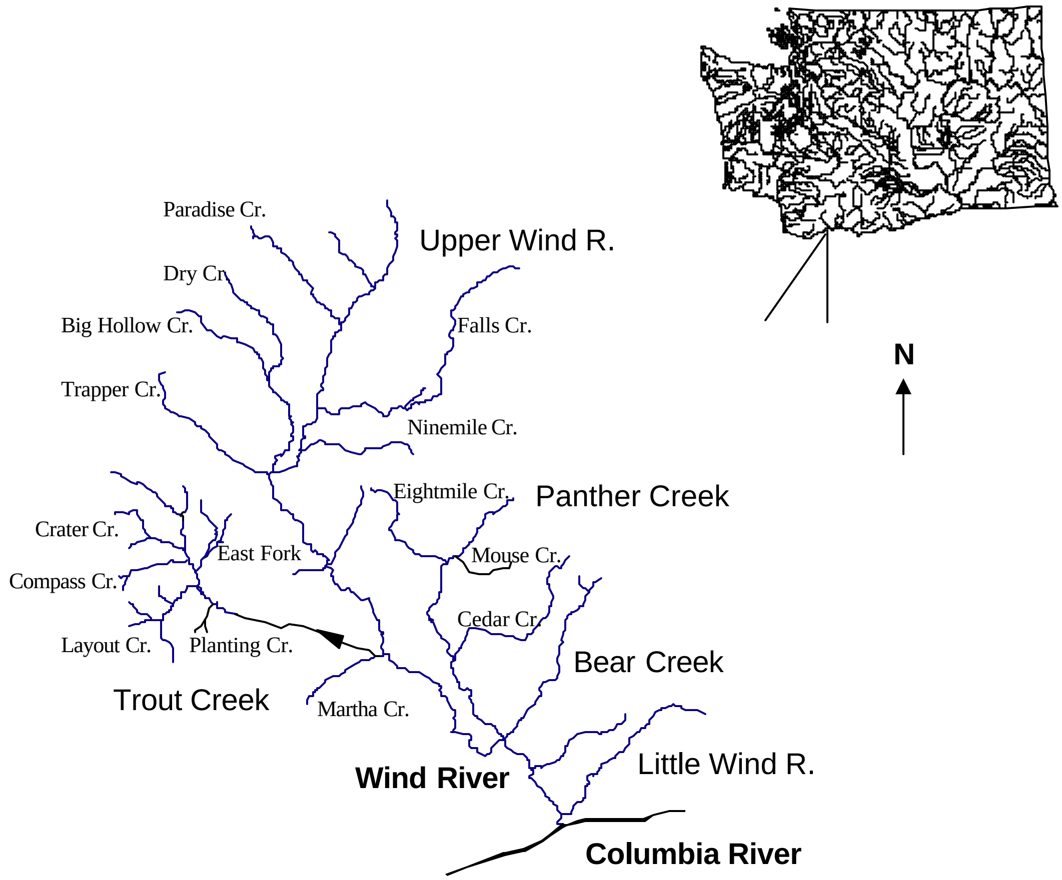


Figure 1. Wind River watershed with the major streams labeled.

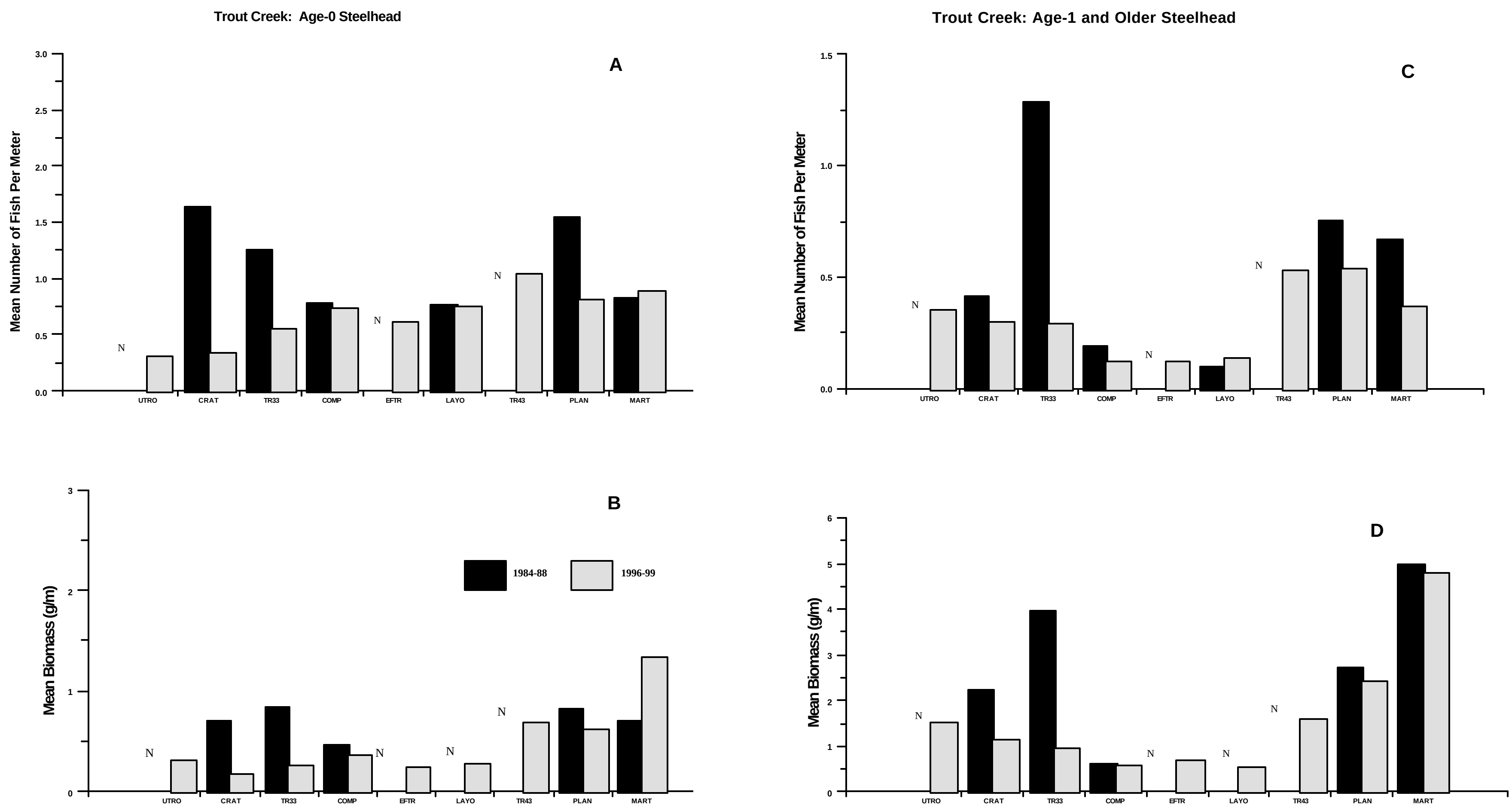


Figure 2. Mean population and biomass estimates of age-0 (A and B, respectively) and age-1 and older (C and D, respectively) steelhead for index sites in Trout Creek watershed, 1984-88 and 1996-99. The 1984 estimate is revised from Crawford et al. (1985), the 1985-88 estimates were derived from USFS unpublished data, and the 1996-99 estimates were derived from USGS data. N = No data. Streams read from left to right go from upstream to downstream. Stream codes are: UTRO = upper Trout Cr., CRAT = Crater Cr., TR33 = Trout Cr. near 33 Bridge, COMP = Compass Cr., EFTR = East Fork Trout Cr., LAYO = Layout Cr., TR43 = Trout Cr. near 43 Bridge, PLAN = Planting Cr., and MART = Martha Cr.

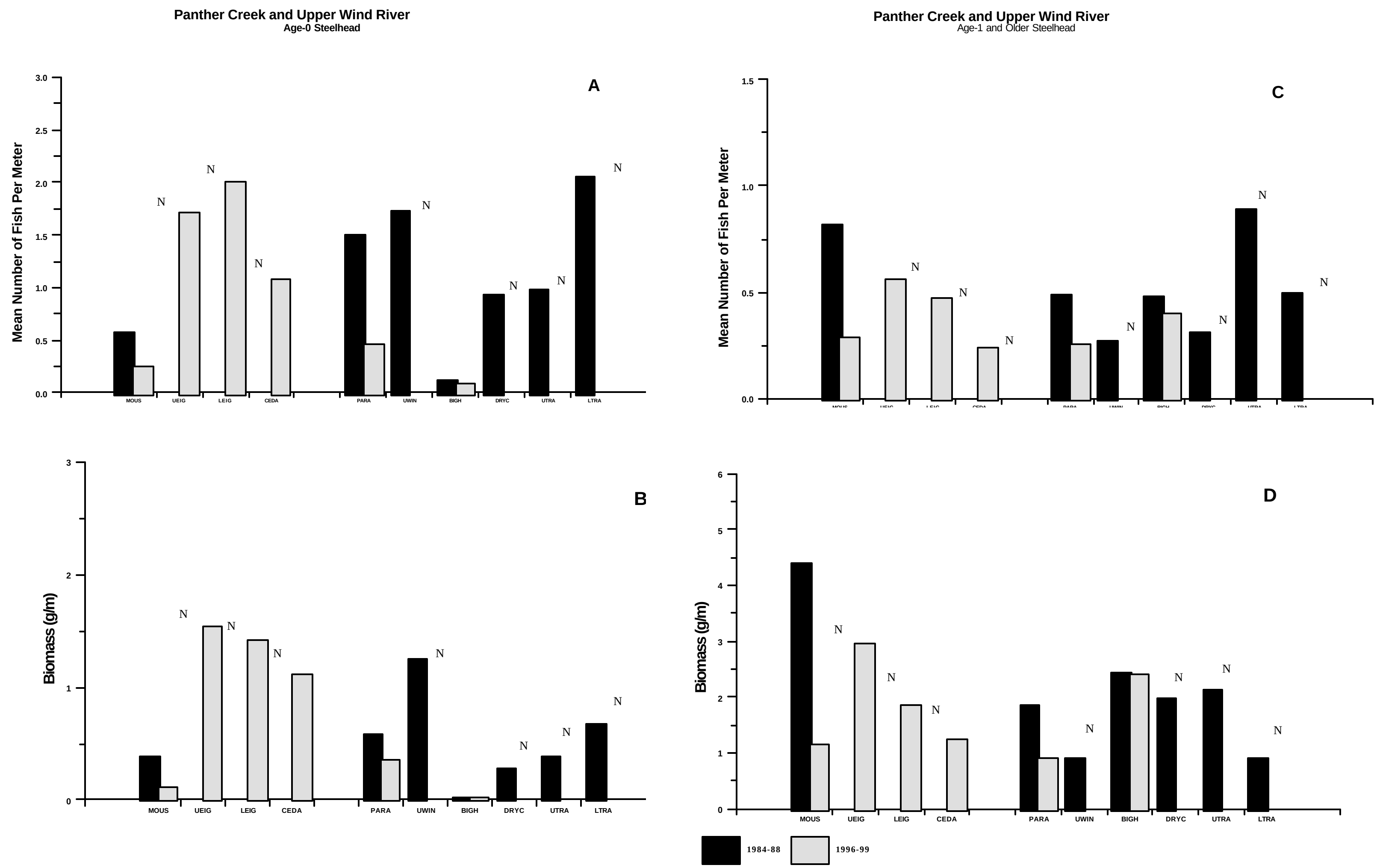


Figure 3. Mean population and biomass estimates of age-0 (A and B, respectively) and age-1 and older (C and D, respectively) steelhead for index sites in Panther Creek and upper Wind River watersheds, 1984-88 and 1996-99. The 1984 estimate is revised from Crawford et al. (1985), the 1985-88 estimates were derived from USFS unpublished data, and the 1996-99 estimates were derived from USGS data. N=No data. Streams read from left to right go from upstream to downstream. Stream codes are: MOUS = Mouse Cr., UEIG = upper Eightmile Cr., LEIH = lower Eightmile Cr., CEDA = Cedar Cr., PARA = Paradise Cr., UWIN = upper Wind R., BIGH = Big Hollow Cr., DRYC = Dry Cr., UTRA = upper Trapper Cr., LTRA = lower Trapper Cr.

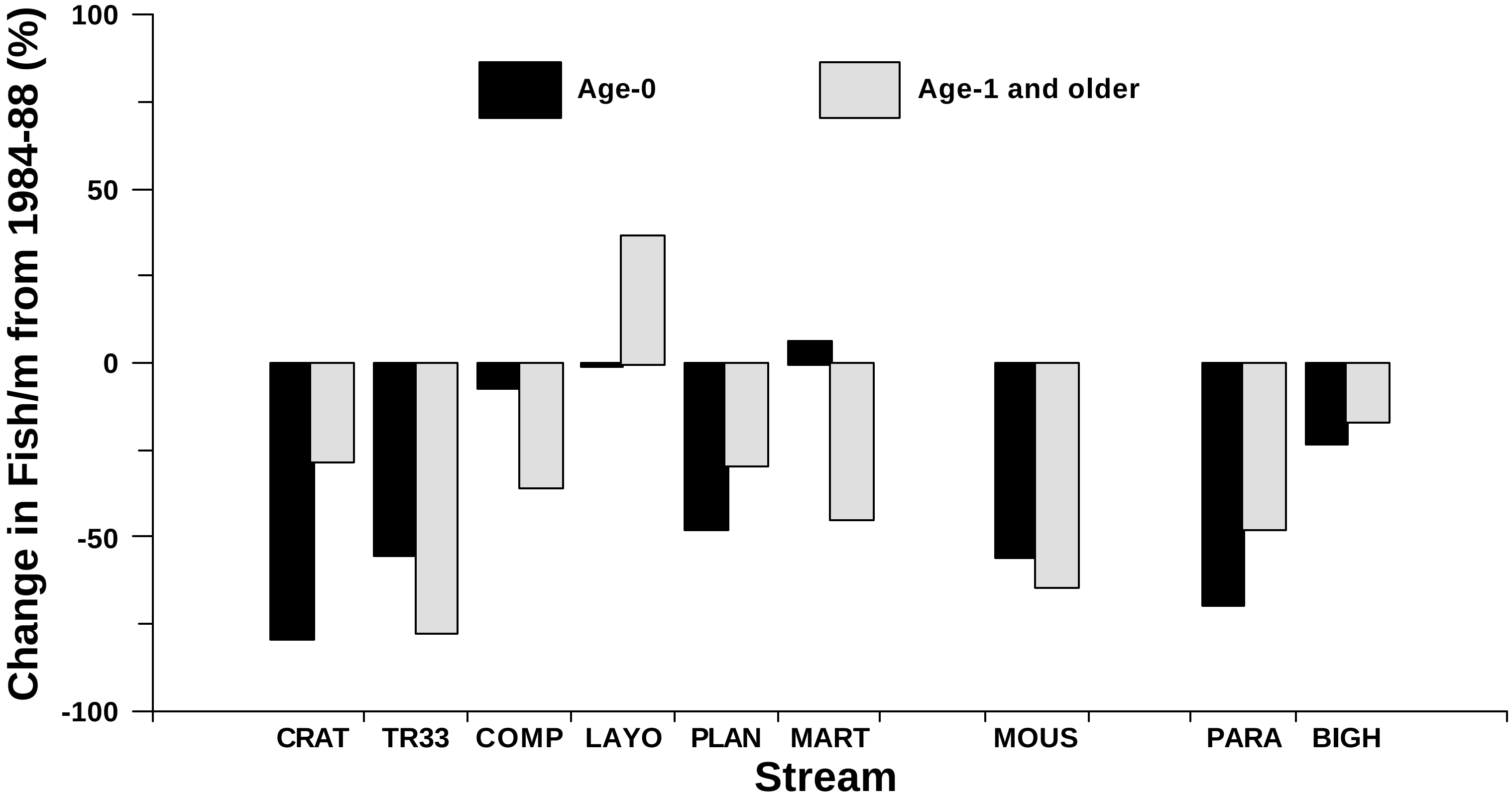


Figure 4. Percentage change in juvenile steelhead per meter from 1984-88 to 1996-99. Stream codes are: CRAT = Crater Cr., TR33 = Trout Cr. near 33 Bridge, COMP = Compass Cr., LAYO = Layout Cr., PLAN = Planting Cr., and MART = Martha Cr. of the Trout Creek watershed; MOUS =Mouse Cr. of the Panther Creek watershed; PARA = Paradise Cr., and BIGH = Big Hollow Cr. of the upper Wind River watershed. See Appendix Table 1 of this report for population estimates.

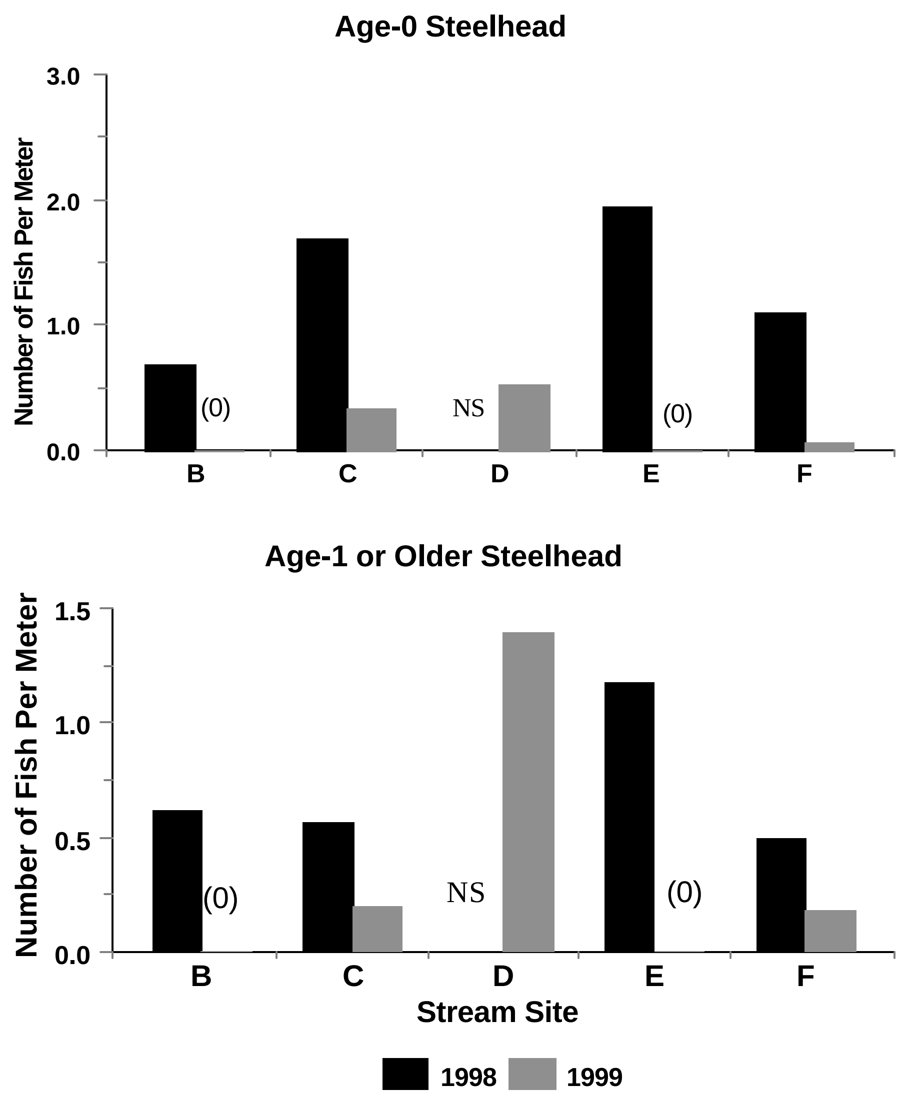


Figure 5. Snorkel counts (uncalibrated) of age-0 and age-1 and older juvenile steelhead at five 100-m sites in mainstem Trout Creek during summer, 1998 and 1999. Sites read from left to right go upstream to downstream with the most upstream site located near the Road 43 bridge and the most downstream site located just above Hemlock Lake. Stream kilometers above the Trout Creek mouth for mid-point of the 100-m sites are 11.0 (B), 9.4 (C), 9.0 (D), 8.0 (E), and 6.0 (F). NS = not sampled.

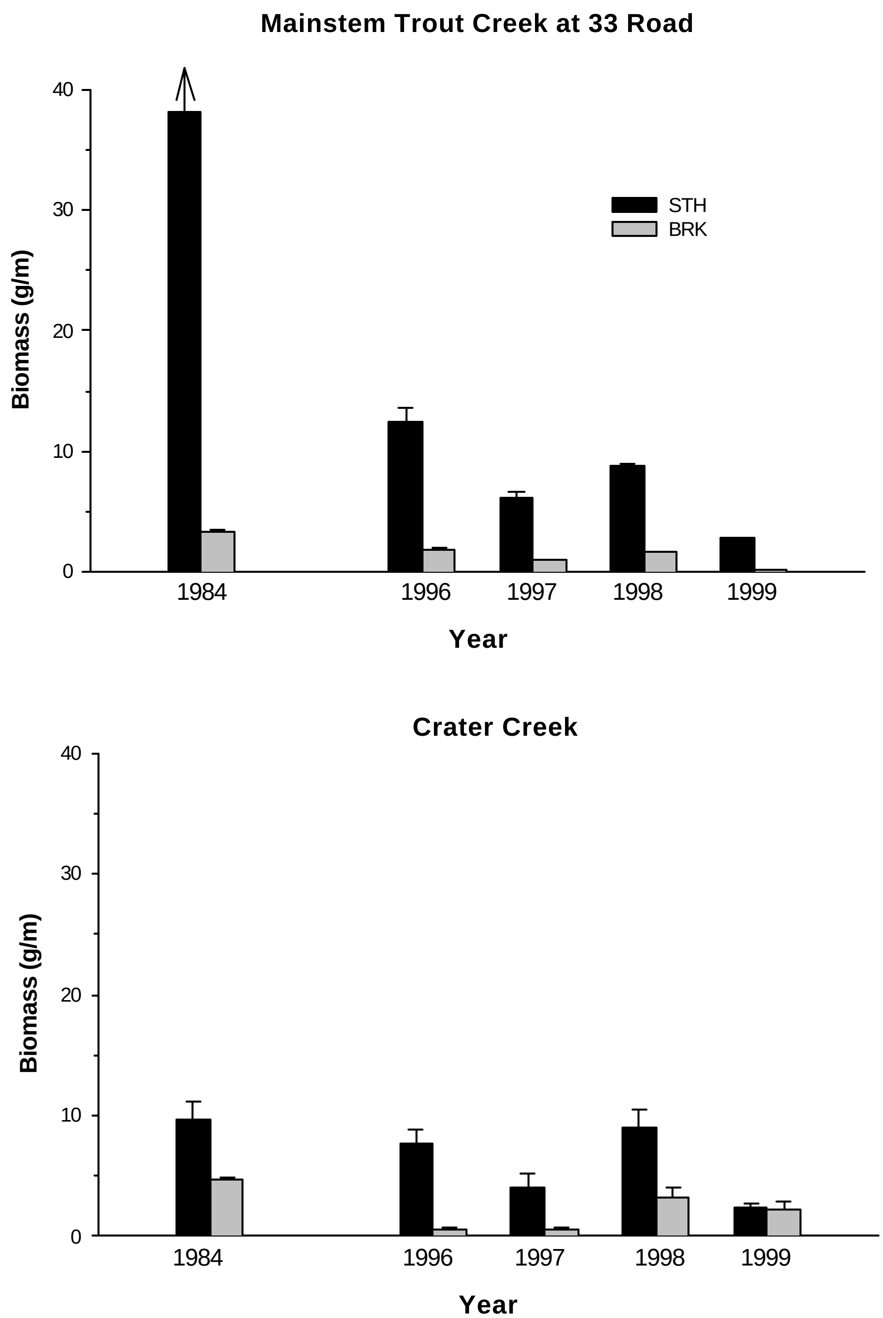


Figure 6. Annual estimates of biomass of juvenile steelhead and brook trout in two stream reaches of Trout Creek watershed, 1984, 1996-1999. The 1984 estimates are revised from raw data provided in Crawford et al. (1985). Horizontal bars represent +1 SE.

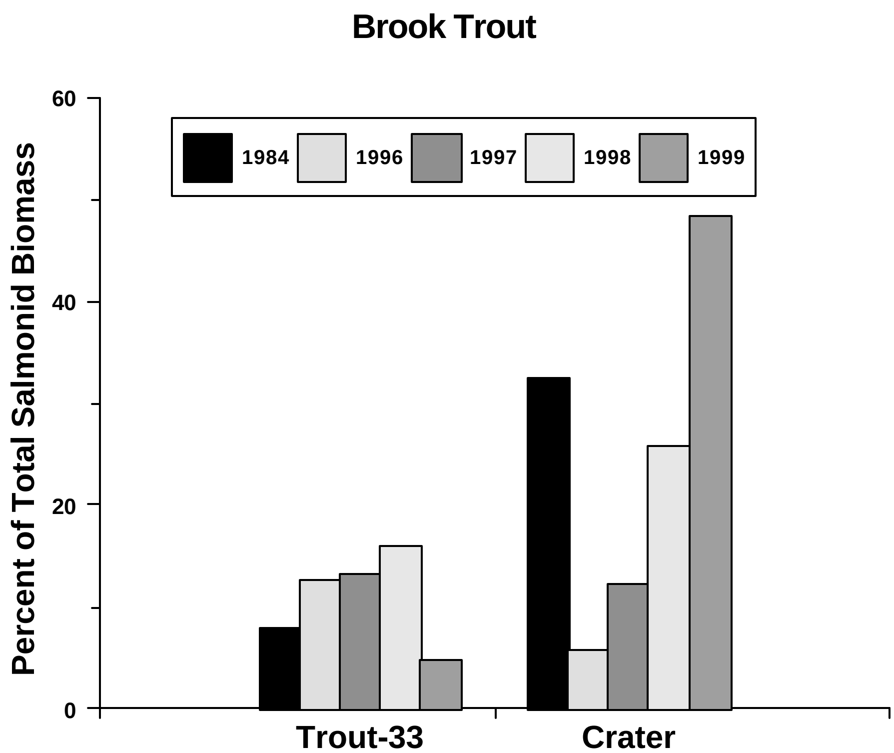


Figure 7. Annual estimates of the percent of total salmonid biomass that is brook trout in two stream reaches of Trout Creek watershed, 1984, 1996-1999. The 1984 estimates are revised from Crawford et al. (1985).

Appendix

Appendix Table 1. Density and biomass estimates of juvenile steelhead in stream reaches within the Wind River watershed. The 1984 estimate is revised from Crawford et al. (1985). The 1985-1988 estimates were derived from USFS unpublished data, and the 1996-1999 estimates were derived from USGS data. SE = standard error (when n > 1, it is the standard error of annual means); n = number of years sampled; NS = not sampled.

		Age 0 (fish/m)					
		1984-88			1996-99		
Watershed	Stream	Mean	SE	n	Mean	SE	n
Trout Cr.	Trout Cr. - upper	NS	NS	0	0.3022	0.2005	2
	Crater Cr.	1.6400	0.0000	2	0.3431	0.1355	4
	Trout Cr. - a (33 Bridge)	1.2500	0.0875	1	0.5601	0.1501	4
	Compass Cr.	0.7900	0.0869	1	0.7338	0.0748	1
	E. Fork Trout Cr.	NS	NS	0	0.6074	0.4130	1
	Layout Cr.	0.7600	0.0790	1	0.7556	0.2580	2
	Trout Cr. - b (43 Bridge)	NS	NS	0	1.0397	0.0492	2
	Planting Cr.	1.5450	0.5621	2	0.8074	0.4092	2
	Martha Cr.	0.8367	0.0597	3	0.8885	0.5907	2
Panther Cr.	Mouse Cr.	0.5750	0.0601	2	0.2539	0.0840	1
	Eightmile Cr. - upper	NS	NS	0	1.7099	0.3542	2
	Eightmile Cr. - lower	NS	NS	0	1.9991	0.3095	3
	Cedar Cr.	NS	NS	0	1.0870	0.4098	1
Upper Wind R.	Paradise Cr.	1.5100	0.4101	2	0.4690	0.0415	1
	Wind R. - mining reach	1.7300	0.0903	1	NS	NS	0
	Big Hollow Cr.	0.1200	0.0026	1	0.0926	0.0191	1
	Dry Cr.	0.9300	0.1599	1	NS	NS	0
	Trapper Cr. - upper	0.9900	0.4031	2	NS	NS	0
	Trapper Cr. - lower	2.0600	0.0428	1	NS	NS	0

Continued.

Appendix Table 1. Continued.

		Age 1 and older (fish/m)					
		1984-88			1996-99		
Watershed	Stream	Mean	SE	n	Mean	SE	n
Trout Cr.	Trout Cr. - upper	NS	NS	0	0.3539	0.0211	2
	Crater Cr.	0.4167	0.1018	3	0.2997	0.0334	4
	Trout Cr. - a (33 Bridge)	1.2900	4.5666	1	0.2903	0.0308	4
	Compass Cr.	0.1900	0.0212	2	0.1221	0.0424	1
	E. Fork Trout Cr.	NS	NS	0	0.1185	0.0352	1
	Layout Cr.	0.1000	0.0000	1	0.1366	0.0184	2
	Trout Cr. - b (43 Bridge)	NS	NS	0	0.5296	0.0116	2
	Planting Cr.	0.7550	0.2369	2	0.5345	0.1308	2
	Martha Cr.	0.6667	0.0883	3	0.3697	0.1496	2
Panther Cr.	Mouse Cr.	0.8150	0.1732	2	0.2911	0.0408	1
	Eightmile Cr. - upper	NS	NS	0	0.5605	0.2000	2
	Eightmile Cr. - lower	NS	NS	0	0.4709	0.1042	3
	Cedar Cr.	NS	NS	0	0.2400	0.0600	1
Upper Wind R.	Paradise Cr.	0.4850	0.0318	2	0.2533	0.0352	1
	Wind R. - mining reach	0.2700	0.1540	1	NS	NS	0
	Big Hollow Cr.	0.4833	0.0164	2	0.4029	0.0408	1
	Dry Cr.	0.3100	0.0205	1	NS	NS	0
	Trapper Cr. - upper	0.8900	0.0953	1	NS	NS	0
	Trapper Cr. - lower	0.5000	0.0269	1	NS	NS	0

Continued.

Appendix Table 1. Continued.

		Age 0 (g/m)					
		1984-88			1996-99		
Watershed	Stream	Mean	SE	n	Mean	SE	n
Trout Cr.	Trout Cr. - upper	NS	NS	0	1.3490	0.9264	2
	Crater Cr.	2.4928	0.5235	1	0.9052	0.3837	4
	Trout Cr. - a (33 Bridge)	6.0000	0.4200	1	1.6189	0.5341	4
	Compass Cr.	2.0540	0.2259	1	1.2176	0.1400	1
	E. Fork Trout Cr.	NS	NS	0	0.9366	0.6275	1
	Layout Cr.	NS	NS	0	1.6218	0.6654	2
	Trout Cr. - b (43 Bridge)	NS	NS	0	6.4913	0.6946	2
	Planting Cr.	2.9143	0.7559	2	1.9034	1.2124	2
	Martha Cr.	2.4190	0.3756	2	2.4880	1.6333	2
Panther Cr.	Mouse Cr.	1.5314	0.3032	2	0.4288	0.1338	1
	Eightmile Cr. - upper	NS	NS	0	4.6703	1.3727	2
	Eightmile Cr. - lower	NS	NS	0	4.8440	0.5378	3
	Cedar Cr.	NS	NS	0	4.9788	1.8222	1
Upper Wind R.	Paradise Cr.	2.5893	1.1338	2	1.6745	0.1480	1
	Wind R. - mining reach	7.3179	0.3820	1	NS	NS	0
	Big Hollow Cr.	0.1200	0.0026	1	0.0832	0.0172	1
	Dry Cr.	1.3764	0.2366	1	NS	NS	0
	Trapper Cr. - upper	2.7958	0.8359	2	NS	NS	0
	Trapper Cr. - lower	6.1800	0.1285	1	NS	NS	0

Continued.

Appendix Table 1. Continued.

		Age-1 and older (g/m)					
		1984-88			1996-99		
Watershed	Stream	Mean	SE	n	Mean	SE	n
Trout Cr.	Trout Cr. - upper	NS	NS	0	6.7461	0.1611	2
	Crater Cr.	8.4845	1.4724	2	4.8367	0.6816	4
	Trout Cr. - a (33 Bridge)	28.6301	101.35	1	5.9552	0.5852	4
	Compass Cr.	2.8012	0.6417	2	2.0020	0.5986	1
	E. Fork Trout Cr.	NS	NS	0	2.6692	1.0490	1
	Layout Cr.	NS	NS	0	3.0551	0.2433	2
	Trout Cr. - b (43 Bridge)	NS	NS	0	14.9043	0.2409	2
	Planting Cr.	10.4015	1.9016	2	5.0771	2.4412	2
	Martha Cr.	18.1306	3.4149	2	10.2716	3.2419	2
Panther Cr.	Mouse Cr.	16.7762	3.4494	2	4.4205	0.6763	1
	Eightmile Cr. - upper	NS	NS	0	8.9573	2.7820	2
	Eightmile Cr. - lower	NS	NS	0	6.5867	1.4436	3
	Cedar Cr.	NS	NS	0	5.6391	1.5677	1
Upper Wind R.	Paradise Cr.	8.4496	2.1712	2	4.2831	0.5946	1
	Wind R. - mining reach	5.4101	3.0854	1	NS	NS	0
	Big Hollow Cr.	13.9036	1.1622	1	10.3224	1.0454	1
	Dry Cr.	9.6663	0.6380	1	NS	NS	0
	Trapper Cr. - upper	15.0650	1.6135	1	NS	NS	0
	Trapper Cr. - lower	8.3300	0.4482	1	NS	NS	0

Continued.

Appendix Table 1. Continued.

		Age 0 (g/m^2)					
		1984-88			1996-99		
Watershed	Stream	Mean	SE	n	Mean	SE	n
Trout Cr.	Trout Cr. - upper	NS	NS	0	0.3181	0.2192	2
	Crater Cr.	0.7102	0.1491	1	0.1760	0.0711	4
	Trout Cr. - a (33 Bridge)	0.8333	0.0583	1	0.2526	0.0848	4
	Compass Cr.	0.4689	0.0516	1	0.3623	0.0417	1
	E. Fork Trout Cr.	NS	NS	0	0.2477	0.1660	1
	Layout Cr.	NS	NS	0	0.2693	0.1023	2
	Trout Cr. - b (43 Bridge)	NS	NS	0	0.6956	0.0775	2
	Planting Cr.	0.8196	0.2688	2	0.6270	0.4044	2
	Martha Cr.	0.7076	0.1683	2	1.3339	0.9100	2
Panther Cr.	Mouse Cr.	0.3854	0.0559	2	0.1127	0.0352	1
	Eightmile Cr. - upper	NS	NS	0	1.5360	0.4524	2
	Eightmile Cr. - lower	NS	NS	0	1.4196	0.1092	3
	Cedar Cr.	NS	NS	0	1.1067	0.4051	1
Upper Wind R.	Paradise Cr.	0.5781	0.2650	2	0.3535	0.0312	1
	Wind R. - mining reach	1.2488	0.0652	1	NS	NS	0
	Big Hollow Cr.	0.0211	0.0005	1	0.0196	0.0040	1
	Dry Cr.	0.2803	0.0482	1	NS	NS	0
	Trapper Cr. - upper	0.3851	0.1278	2	NS	NS	0
	Trapper Cr. - lower	0.6674	0.0139	1	NS	NS	0

Continued.

Appendix Table 1. Continued.

		Age-1 and older (g/m^2)					
		1984-88			1996-99		
Watershed	Stream	Mean	SE	n	Mean	SE	n
Trout Cr.	Trout Cr. - upper	NS	NS	0	1.5043	0.0250	2
	Crater Cr.	2.2262	0.2845	2	1.1253	0.1751	4
	Trout Cr. - a (33 Bridge)	3.9764	14.0765	1	0.9497	0.0744	4
	Compass Cr.	0.6206	0.1599	2	0.5957	0.1781	1
	E. Fork Trout Cr.	NS	NS	0	0.7059	0.2774	1
	Layout Cr.	NS	NS	0	0.5226	0.0188	2
	Trout Cr. - b (43 Bridge)	NS	NS	0	1.6004	0.0223	2
	Planting Cr.	2.7199	0.2807	2	2.4336	0.2565	2
	Martha Cr.	4.9873	0.5120	2	4.8055	0.6232	2
Panther Cr.	Mouse Cr.	4.4173	1.1299	2	1.1616	0.1777	1
	Eightmile Cr. - upper	NS	NS	0	2.9460	0.9168	2
	Eightmile Cr. - lower	NS	NS	0	1.8713	0.3785	3
	Cedar Cr.	NS	NS	0	1.2534	0.3484	1
Upper Wind R.	Paradise Cr.	1.8637	0.5335	2	0.9042	0.1255	1
	Wind R. - mining reach	0.9232	0.5265	1	NS	NS	0
	Big Hollow Cr.	2.4478	0.2046	1	2.4250	0.2456	1
	Dry Cr.	1.9687	0.1299	1	NS	NS	0
	Trapper Cr. - upper	2.1430	0.2295	1	NS	NS	0
	Trapper Cr. - lower	0.8996	0.0484	1	NS	NS	0

Appendix Table 2. Density and biomass estimates of brook trout in stream reaches within the Trout Creek watershed. The 1984 estimate is revised from Crawford et al. (1985). The 1985-88 estimates were derived from USFS unpublished data, and the 1996-99 estimates were derived from USGS data. SE = standard error (when n > 1, it is the standard error of annual means); n = number of years sampled; NS = not sampled.

	All ages (fish/m)					
	1984-88			1996-99		
Stream	Mean	SE	n	Mean	SE	n
Upper Trout Cr.	NS	NS	0	0.1121	0.0362	2
Crater Cr.	0.0700	0.0265	3	0.0747	0.0173	4
Trout Cr. - a (33 Bridge)	0.0800	0.0024	1	0.0456	0.0154	4
Compass Cr.	0.0600	0.0250	2	0.0269	0.0096	1
E. Fork Trout Cr.	NS	NS	0	0.2364	0.0477	1
Layout Cr.	NS	NS	0	0.0530	0.0448	2
Trout Cr. - b (43 Bridge)	NS	NS	0	0.0107	0.0024	2

	All ages (g/m)					
	1984-88			1996-99		
Stream	Mean	SE	n	Mean	SE	n
Upper Trout Cr.	NS	NS	0	1.5362	0.4240	2
Crater Cr.	3.0800	1.5600	2	1.5810	0.6503	4
Trout Cr. - a (33 Bridge)	3.2800	0.0984	1	1.1412	0.3840	4
Compass Cr.	0.6000	0.2750	2	0.7937	0.4311	1
E. Fork Trout Cr.	NS	NS	0	2.5831	0.8810	1
Layout Cr.	NS	NS	0	1.8901	1.1008	2
Trout Cr. - b (43 Bridge)	NS	NS	0	0.4279	0.1663	2

	All ages (g/m^2)					
	1984-88			1996-99		
Stream	Mean	SE	n	Mean	SE	n
Upper Trout Cr.	NS	NS	0	1.8187	0.4791	2
Crater Cr.	0.8500	0.4719	2	0.3740	0.1602	4
Trout Cr. - a (33 Bridge)	0.4556	0.0024	1	0.1769	0.0577	4
Compass Cr.	0.4901	0.0697	2	0.2361	0.1282	1
E. Fork Trout Cr.	NS	NS	0	0.6831	0.2330	1
Layout Cr.	NS	NS	0	0.3374	0.2098	2
Trout Cr. - b (43 Bridge)	NS	NS	0	0.0456	0.0174	2

Report E: Wind River Steelhead Smolt and Parr Production Monitoring during the 1999 Spring Outmigration Wind River Watershed Project

Wind River Watershed Project

1999 Annual Report

September 2001

Prepared by:

Dan Rawding and Patrick Charles Cochran

Washington Department of Fish and Wildlife
Fish Management Program
600 Capitol Way
Olympia, WA 98195

Abstract

Four rotary screw traps were installed in the Wind River watershed to estimate natural steelhead (Oncorhynchus mykiss) smolt and parr production from key reaches in 1999. A trap efficiency method from a Petersen estimator was used to develop smolt yield and spring parr production estimates for sub-watersheds. This was the fifth consecutive year that smolt production has been estimated. During the period the smolt production for the entire basin has improved from a low of 8,330 in 1995 to high of 24,316 in 1998. The 1999 smolt population estimate of 21,899 was the second highest on record. The trap data indicate that a substantial number of Wind River steelhead have adopted a transient life history pattern, in which steelhead juveniles rear near the spawning areas in the tributaries or the upper mainstem for one year, after which they migrate into the higher gradient mainstem sections before outmigrating from the lower mainstem as age 2 or 3 smolts. These movements suggest that all anadromous river reaches are used by Wind River wild steelhead for part of their freshwater residence and that high quality habitat, from the headwaters to the mouth, is needed for a healthy and diverse steelhead population. WDFW fishing regulations, which include delaying the trout opener until June 1 and an 8-inch minimum size limit, protected at least 99% of the steelhead juveniles from direct harvest by anglers.

Introduction

The abundance of wild steelhead populations in the Wind River declined to sufficiently low levels that these fish were listed under the Endangered Species Act in March 1998 along with other steelhead populations in the Lower Columbia River ESU. Significant coordinated efforts to recover wild steelhead populations in the Wind River basin were initiated in 1993, when an interagency group represented by the United States Fish and Wildlife Service (USFWS), United States Forest Service (USFS), Yakama Nation (YN), and Washington Department of Fish and Wildlife (WDFW) was formed. Since then, the work group has expanded to include the U.S. Geological Survey-Columbia River Research Laboratory (USGS-CRRL), the Underwood Conservation District (UCD), and Washington Trout (WT). The group's goal is to protect, restore, and enhance the productivity of Wind River wild salmonids and their ecosystem. In addition, the group adopted a short-term goal of restoring the wild summer steelhead population size to at least 500 spawners while maintaining the genetic diversity and long-term productivity of these fish. Funding to assist with the recovery of steelhead and steelhead habitat was provided from the Bonneville Power Administration (BPA) beginning in 1998. The objectives for 1999 were to develop annual estimates of smolt production for the Wind River and key production areas within the basin, and to collect juvenile steelhead life history information during the outmigration. This data will be used to help determine factors for decline within key production areas, develop a steelhead and watershed recovery plan based on a science-based assessment, and to determine if watershed restoration activities are effective at recovering steelhead. This year marked the fifth consecutive spring in which juvenile steelhead outmigration was monitored.

Study Area

The Wind River is located near Carson, Washington. This fifth order stream drains 225 square miles and enters the Columbia River in the Bonneville Pool at River Mile (RM) 155. The watershed provides habitat for summer and winter steelhead, rainbow trout, spring and fall chinook (*Oncorhynchus tshawytscha*), and coho salmon (*Oncorhynchus kisutch*), mountain whitefish (*Prosopium williamsoni*), lamprey (*Lampetra spp*) suckers (*Catastomas spp*), sculpins (*Cottus spp*) stickleback (*Gasterosteus aculeatus*), peamouth (*Mylocheils caurins*), reside shiner (*Richardsontius balteatus*) and leopard dace (*Rhinichthys falcatus*). Prior to the construction of the Shipherd Falls fish ladder at RM 2 in 1956, the only anadromous salmonid accessing the upper watershed were steelhead. The primary purpose of the fishway is to provide passage for spring chinook, which return to Carson National Fish Hatchery at RM 18. The upper portion of the watershed lies within the Gifford Pinchot National Forest. The President's Forest Plan categorizes this basin as a "Tier 1, key watershed" that provides habitat for anadromous salmonids. The USFS manages 77% of the watershed for multi-use benefits. The lower portion the Wind River basin consists of non-federal lands primarily managed for timber harvest.

Methods

Four rotary screw traps were installed in early April 1999 and were fished until mid-June, which coincides with the smolt migration time for wild steelhead. Trap locations were the same as 1998 (Figure 1). The 5-foot traps were located in the upper Wind River (RM 18.8), in lower Trout Creek (RM 2), and in lower Panther Creek (RM 2). The eight-foot trap was located in the lower Wind River (RM 1). Trap sites were developed in conjunction with monitoring objectives. The upper Wind River and lower Trout Creek sites are located near the downstream boundary of USFS property, where stream restoration projects are ongoing or proposed. Data collected from these traps will be used to determine if restoration projects increase the carrying capacity for juvenile steelhead. WDFW has identified genetic differences in the Wind River steelhead population in the mainstem Wind River, Panther Creek and Trout Creek. Juvenile monitoring in lower Trout Creek, lower Panther Creek, and lower Wind River, will provide status information on these subpopulations. Finally, adult traps are located near the lower Wind and lower Trout Creek juvenile traps. This combination of adult and smolt sampling allows for estimates of freshwater and ocean productivity. Measures of freshwater productivity are used to evaluate habitat restoration projects.

Traps were fished 24 hours per day throughout the smolt migration period. The lower Wind River trap was not operated on April 21 and 23 during the release of 2 million hatchery spring chinook smolts from Carson National Fish Hatchery. The trap was also not operational on May 8 and 25 due to debris. The Panther Creek trap was not operational April 15 due to debris. The Trout Creek trap was not operational due to debris on May 20, 25, and 26. Traps were checked daily and all fish were enumerated. Steelhead were classified as smolts, pre-smolts or parr based on life history stage. Steelhead juveniles in good condition were marked and released upstream of the trap. Recaptured juveniles were released below the trap site. Fish classification and handling procedures were the same as described in Rawding et al. (1999).

The number of juvenile outmigrants was estimated by using a trap efficiency method of releasing marked fish upstream of the trap (Thedinga et al. 1994). Captured juvenile steelhead were marked with a Panjet inoculator (Hart and Pitcher 1969, Thedinga and Johnson 1995). Our marking schedule rotated every week and used different fin combinations to distinguish between traps. This allowed us to identify fish based on trap site and marking period. Trap efficiency is estimated using a modification (Chapman 1951) to the Petersen estimate from the equation:

$$e = (R+1) / (M+1) \qquad (1)$$

where *e* is the estimated trap efficiency, *M* is the number of marked fish released upstream of the trap, and *R* is the number of marked fish recaptured. The number of migrants at each trap was determined from the equation:

$$N = U / e \qquad (2)$$

where *N* is the estimated number of outmigrants, *U* is the total unmarked catch, and e is the trap efficiency. The variance for each *N* was determined by a bootstrapping method (Efron and Tibshirani 1986) with 1,000 iterations from a Fortran program (Murphy et al. 1996). Confidence limits were calculated from the equation:

$$95\%\ CL = 1.96 * \sqrt{V} \qquad (3)$$

where *V* is the variance determined from bootstrapping.

When trap efficiencies are low, the population studied is small, and/or during the early or late portion of the migration, the recapture of marked fish is low. When recaptures during a marking period are expected to be less than five, the addition or deletion of even one fish can make significant change in the estimates of trap efficiency and ultimately population size. Bailey (1951) demonstrated this relatively high bias at low sample sizes and Schwarz and Taylor (1998) indicated there should be at least five recaptured fish per strata. Therefore, mark weeks are pooled to obtain a minimum sample size of five recaptures in every trapping interval. After this preliminary pooling, a series of Chi Square tests were performed to determine if there was a statistical difference between mark groups. When significant differences between adjacent mark periods were noted, then samples taken in that period could not be pooled and trap efficiency estimates, population estimates, and variances were individually calculated for the mark period. If no difference was noted between adjacent mark periods, groups were further pooled, resulting in more precise estimates.

At the lower Wind River trap we had marks available from that trap and the three upriver traps. First, we performed a Chi-Square test to detect seasonal efficiency differences between mark groups from each of the traps. If there were no significant differences then marks from all traps would be pooled. Next, weekly mark groups from all traps were pooled to ensure the number of recaptures was greater than or equal to five fish. A further Chi-Square test on mark groups was conducted. When the differences were significant, trap efficiency estimates, population estimates, and variances were calculated for the mark period by trap. If there was no difference between adjacent mark periods, groups were pooled to tighten the confidence limits.

Murphy et al. (1996) listed the standard assumptions of the Petersen method (Seber 1982) that apply in trap-efficiency experiments: (1) the population is closed; (2) all fish have the same probability of capture in the first sample; (3) marking does not affect catchability; (4) the second sample is either a simple random sample, or if the second sample is systematic, marked and unmarked fish mix randomly; (5) fish do not lose their marks; and (6) all recaptured marks are recognized. During the smolt-trapping season, we took steps to reduce the possibility that these assumptions were violated. When possible we conducted experiments to determine the bias caused by violations of these assumptions and develop correction factors.

Results

Since trap catches were low (1 to 2 smolts) for the first few days the traps were operated, it was assumed that smolt migration prior to the period of trap installation was insignificant. Smolt migration began in early April in the upper watershed and smolts continued through mid-June. Smolt outmigrations peaked on April 25 in Panther Creek, May 18 in the upper Wind River and Trout Creek, and on May 24 in the lower Wind River. Figure 2 shows the date at which 25%, 50%, and 75% of the smolts passed each trap and Figure 3 displays the daily smolt migration past each trap site.

Steelhead smolt lengths ranged from 119 – 236 mm. However, most smolts were between 130 –190 mm. The mean smolt lengths from Trout Creek, Panther Creek, and upper Wind River were 160, 156, and 153, respectively. The mean smolt length in the lower Wind River was larger at 165 mm. The length frequency distribution by key production area is shown in Figure 4. Length statistics for recaptured smolts were analyzed to determine if fish size had a significant effect on trap efficiency (Table 1). The recapture sample size was small, but there were no obvious discrepancies between the sizes of new or recaptured smolts, which is consistent with previous seasons.

A total of 303 readable scale samples were collected from wild steelhead smolts. Smolt age frequencies by trap are shown in Figure 5. The majority of smolts at all four sites were age two in 1999. This is consistent with previous seasons except at Panther Creek and the upper Wind River, where the majority were age three in previous seasons. Age four smolts were sampled in small abundance at all of the sites except Trout Creek, and were generally those individuals at 200 mm fork length or above. Trout Creek produced very few smolts in excess of 190 mm, despite having a larger average smolt length than Panther Creek or the upper Wind. Smolt length frequency distributions by age class are in Figure 6.

Table 1. Summary of steelhead smolt fork length (in mm) data by trap site in the Wind River Basin, Spring 1998.

Site	New smolts (mean)	New smolts (S.D.)	New smolts (range)	Recaptured smolts (mean)	Recaptured smolts (S.D.)	Recaptured smolts (range)
Trout Ck	160	14.91	120-205	158	11.68	120-182
Panther Ck	156	15.86	124-209	157	15.81	137-183
U. Wind	153	15.00	122-230	151	12.80	130-194
L. Wind	165	15.21	119-236	163	14.14	137-198

The 1998 spring parr migration exhibited variable distributions. In general parr migration increased through the season peaking in mid June when the traps were removed. Parr lengths ranged from 60 to 232 mm. Since the maximum parr length exceeded the maximum smolt length, it is likely the largest parr are adult resident rainbow trout. Mean parr length ranged from 88 mm on Panther Creek to 111 mm in the lower Wind River (Table 2). Although, no scales were taken from these fish, it is likely they were age 1 to 3. Parr migration timing for the spring of 1999 is shown in Figure 7.

Table 2. Summary of steelhead parr fork length (in mm) data by trap site in the Wind River basin, Spring 1998.

Trap site	Mean	Standard deviation	Range
Trout Creek	102	23.07	60-232
Panther Creek	88	18.27	61-199
U. Wind	97	15.98	69-163
L. Wind	111	11.11	81-132

A total of 1,800 wild steelhead smolts were trapped in 1999. We marked 1731 smolts with alcian blue dye for trap efficiency tests and of these 1713 fish were cheek tagged with blank wire. Trap efficiencies were less in 1999 compared to 1998 and this is due to higher flow, more missed days of fishing, and physical change in sites. In the upper Wind River mark group estimates were pooled to create a total of 8 groups with at least 5 recaptures, and a Chi-Square test indicated that there was no difference between the groups and a seasonal estimate was produced. Similarly on the lower Wind River, the Chi-Square test indicates no difference between seven groups and all marks were pooled to create a seasonal estimate. In Panther Creek only one of eleven mark groups produced five recaptures. Similarly in Trout Creek only in two of twelve mark groups did we obtain more than five recaptures. Due to the low population size and efficiency at these sites only seasonal estimates were developed. Estimated smolt yields with 95% confidence limits by trap are listed in the Table 3.

Table 3. Summary of mark and recapture data for marked groups of Wind River wild steelhead smolts, 1999.

Trap Site	Sample Period	Smolts Captured	Smolts Marked	Smolts Recaptured	Trap Efficiency	Population Estimate	+/- 95% Con. Lim.
L. Wind R.	4/5-6/26	1,100	1,731	86	5.0%	21,899	4,760
U. Wind R.	4/3-6/26	267	267	57	21.6%	1,238	325
Panther Cr.	4/3-6/20	126	120	19	9.9%	1,271	756
Trout Cr.	4/5-6/26	307	305	35	11.8%	2,610	902

Parr production estimates are available only during the spring outmigration, even though parr may migrate at other times of the year. In 1999, we estimated that 4,304, 2,244, and 1,261 parr migrated past the Panther Creek, upper Wind River, and Trout Creek, respectively. Trap efficiency for parr was not tested at the lower Wind River site. However, trap efficiencies for parr and smolts were similar at the other three sites. If we assume the lower Wind River smolt trap efficiency for parr and smolts was the same, then the lower Wind River parr production estimate is 458. Parr outmigrants accounted for 2% of the total spring migrants passing the lower Wind River trap and they accounted for 77% in Panther Creek, 65% in the upper Wind River, and 33% in Trout Creek. This is consistent with data from previous seasons.

Discussion

Data accuracy and precision

It is important to develop unbiased, accurate, and precise estimates of smolt production in the Wind River. Robust wild steelhead smolt estimates are needed by management agencies to assess the status steelhead in the Wind River and to evaluate the effectiveness of habitat restoration projects. Robson and Regier (1964) identified that investigators should target 95% confidence limits for the population estimate at 25% for management and 10% for research applications. Rawding (1997) indicated that a 95% confidence limit +/- 20% for Wind River steelhead smolt population estimates was the maximum that could be achieved on a regular basis due to the low population size, and expected range of trap efficiencies for wild steelhead smolts. The approximate equivalent statistical expression for 95% confidence limits that are +/- 20% is that the coefficient of variation should be less than 10% calculated from the equation: CV = SD/N, where CV is the coefficient of variation, SD is the standard deviation, and N is the population estimate. The precision estimates since 1995 are found in Table 4. In 1999 we did not achieve our goals primarily due to a few nights of mechanical problems at traps and heavy debris.

Table 4. Precision of smolt yield estimates in the Wind River, 1995 -1999.

Trap site	1999 Population estimate	1999 +/-95% Confidence limit	1999 Coefficient of variation	1998 Coefficient of variation	1997 Coefficient of variation	1996 Coefficient of variation	1995 Coefficient of variation
L Wind	21,899	4,760	11%	9%	18%	18%	30%
Trout	2,610	902	18%	7%	15%	19%	21%
Panther	1,271	756	30%	22%	~50%	~50%	~50%
U Wind	1,234	325	13%	8%	Not Available	Not Available	Not Available

The Petersen estimator can provide accurate and precise population estimates if the following conditions are met: (1) the population is closed; (2) no mark loss; (3) all marked fish are properly recognized; (4) marking has no effect on catchability; and (5) all fish have the same probability of being tagged in the first sample or all fish have the same probability of being captured in the second sample. Rawding et al. (1999) reviewed the possible violation of these assumptions for the Wind River smolt-trapping program and the specific experiments used to test these assumptions. In 1999 similar experiments were conducted to determine if these assumptions were likely to be violated. As in 1998 we could not detect that any of these assumptions were violated and the estimates are likely unbiased and accurate.

In 1998 we wired tagged over 3,000 wild steelhead smolts in the right cheek. These fish have returned in 1999 and 2000. At the Shipherd Falls and Hemlock dam trap, all adult steelhead are scanned for the presence of a cheek tag. To date, 40 ocean age one steelhead were examined for tags in 1999 and 78 ocean age two steelhead in 2000. We have found 13 tagged steelhead. A Petersen estimate is calculated using the same formula as above with equation:

$$N = C * (M+1) / (R+1)$$

where M is the number of wire tagged smolts in 1998, C is the number of wild adult steelhead trapped at Shipherd Falls or Trout Creek trap from the 1998 smolt outmigration year scanned for wire, and R is the number of tagged adult steelhead from the 1998 smolt release recaptured at Shipherd Falls or Trout Creek adult steelhead trap. Sieler et al. (1997) termed this method “back calculation”.

The 1998 smolt migration estimate based on the trap efficiency methods is 24,316, with a 95% confidence interval of 20,204 to 28,427. The 1998 smolt migration estimate based on “back calculation” is 25,581 with a 95% confidence interval of 10,953 to 40,209. Ocean age three fish that return in 2001 will be included and the estimate revised. These data strengthen our previous conclusions that the trap efficiency method does not appear to violate the assumptions of the Petersen estimator, and is a valid method for estimating juvenile steelhead production in the Wind River. A more detailed description of the "back calculation method" and the estimates from this are found in Appendix A.

Trend in smolt abundance

Smolt production in the Wind River has been monitored since 1995. Estimates of smolt production for Trout Creek above Hemlock Dam and the Wind River above RM 1 are available for five years. Production estimates from Panther Creek above RM 2 were calculated in 1995-1997 but have little statistical power due to poor trap efficiencies and extremely small sample sizes. Smolt production in the upper Wind River just above Carson National Fish Hatchery is available for the last two years. These are presented in Table 5 and Figure 8.

Smolt production in Panther Creek is low and stable averaging just over 1,000 smolts per year. Smolt yield in the upper Wind River is also low but more variable and averaged 1,900 smolts. Trout Creek production is slightly larger than either the upper Wind River or Panther Creeks but variable, ranging from about 1,111 to 4,030. The Wind River smolt production has increased from 8,669 in 1995 to 24,316 in 1998 and dropped to 21,899 in 1999. By subtracting the three smolt trap estimates from the lower Wind River estimate the smolt production from the Wind River canyon, Stabler Flats, and lower portions of Trout and Panther creeks can be estimated. In 1998 and 1999, this area produced over 16,000 wild steelhead smolts, which accounts for 67% and 77% of the production, respectively. The Wind River Canyon (RM 11 to RM 1) accounts for the largest portion of this area and most of the production is believed to originate from this area.

It should be noted that over 2/3 of the juveniles migrating past the Panther Creek and Upper Wind River traps are parr and over 1/3 of the juvenile migrating past the Trout Creek are parr. Their peak migration past the traps occurs just after the peak in smolt migration in late May. We believe this downstream parr migration into the Wind River canyon is to take advantage of habitat recently vacated by smolts. This suggests that a transient life history pattern is important for Wind River steelhead. This pattern includes fish spawning in the mainstem Wind River or its tributaries above Stabler (RM 11), in Trout Creek, and in Panther Creek. These juveniles rear one year near the spawning site and migrate as age 1 parr into the high gradient sections of lower Trout Creek and lower Wind River. These movements suggest that all anadromous river reaches in the Wind River are used by wild steelhead for part of their freshwater residence and that high quality habitat, from the headwaters to the mouth, is needed for a healthy and diverse steelhead population.

Table 5. Smolt production estimates (95% Confidence Limits) for the Wind River and key production areas.

Basin	1999	1998	1997	1996	1995
Trout	2610 (+/-26%)	4030 (+/-16%)	2171 (+/-29%)	1111 (+/-37%)	1951 (+/-42%)
Panther	1271 (+/-60%)	1394 (+/-44%)	Not available	Not available	Not available
U Wind	1238 (+/-36%)	2580 (+/-16%)	Not available	Not available	Not available
L Wind	21899(+/22%)	24316(+/18%)	15619 (+/-36%)	11326 (+/-36%)	8330 (+/-58%)

Fishing Regulations to protect juvenile steelhead

WDFW has developed statewide and specific regulations for individual rivers to protect juvenile steelhead from direct harvest. The intent of these regulations is to close the stream during the smolt outmigration to protect smolts from harvest, or if the stream is open during the smolt outmigration for spring chinook or summer steelhead establish a minimum size that will protect all wild steelhead smolts from harvest. Finally, the trout season open from June 1 to October 31, with an 8-inch minimum size to protect juvenile steelhead from harvest.

Most tributaries to the lower Columbia River are closed from March 15 to May 31, in part to protect yearling smolts including steelhead. On the Wind River the wild steelhead smolt migration commences in early April peaks in mid-May and is finished by mid-June (Figure 3). Based on timing alone a March 15 to June 1 fishing closure in 1998, protected over 98% of the smolts in headwaters and tributaries from harvest, and 95% of the smolts in the entire basin from harvest (Table 6). In 1999, the smolt outmigration was the latest we have observed and may be viewed as a worse case scenario. In this year over 86% of the smolts in the basin were protected from harvest. In the headwaters of the Wind River and Panther Creek, the protection from harvest was high 90% and 100%, respectively. In Trout Creek, the protection was less at 74%.

WDFW has established a minimum size of 8 inches in part to protect steelhead smolts and parr from harvest in all rivers. This is in addition to the closure of trout fishing in the spring. In mainstem rivers where anadromous cutthroat trout are present, the minimum size is increased to 12 inches or greater affording additional protection to steelhead juvenile. To evaluate the effectiveness of these regulation, we estimated the percentage of steelhead smolts that we above 12 inches (305 mm) and 8 inches (203 mm). These data suggest that a 12-inch minimum size in the mainstem protects 100% of all steelhead smolts and parr from harvest because no steelhead smolts above 12 inches have been captured in the Wind River (Table 7). The 8-inch minimum size is also very effective on average 99% of the steelhead smolts in the headwaters and sampled tributaries are less than 8 inches. Smolts captures in the lower Wind River trap are larger (Rawding et al. 1999 and Table 1). However, the 8-inch minimum size still protects over 98% of the steelhead smolts from harvest.

To evaluate the effectiveness of both a spring closure and an 8-inch minimum size on the direct harvest of juvenile steelhead, we multiplied the proportion of steelhead available after May 31 by the proportion of steelhead over 8 inches. In 1998 and 1999 for the entire Wind River, a total of 5% and 14 % of the run passed after May 31. For these same years the percentage of the steelhead exceeding 8 inches, was 5.97% and 1.43%, respectively. These estimates indicate that between 0.2% and 0.3% of the entire steelhead smolt yield was potentially available for direct harvest.

Table 6. The percentage of steelhead smolts by production area migrating prior to and after June 1, which is the opening day of trout fishing season.

Year	Basin	% < June 1	% > May 31
1998	Panther	99%	1%
	Upper Wind	99%	1%
	Trout	98%	2%
	Entire Wind	95%	5%
1999	Panther	100%	0%
	Upper Wind	90%	10%
	Trout	74%	26%
	Entire Wind	86%	14%

Table 7. The percentage of steelhead smolts by production area that exceed the 8- and 12-inch minimum size limits.

Site	Year	% smolts over 8" (203mm)	% smolts over 12" (305mm)
Lower Wind	1995	1.04%	0.00%
	1996	2.03%	0.00%
	1997	0.87%	0.00%
	1998	5.74%	0.00%
	1999	1.43%	0.00%
	Avg	2.22%	
Trout Creek	1995	1.40%	0.00%
	1996	0.00%	0.00%
	1997	0.33%	0.00%
	1998	1.03%	0.00%
	1999	0.33%	0.00%
	Avg	0.62%	
Panther Creek	1995	2.22%	0.00%
	1996	0.00%	0.00%
	1997	0.00%	0.00%
	1998	1.78%	0.00%
	1999	0.82%	0.00%
	Avg	0.96%	
Upper Wind	1998	2.32%	0.00%
	1999	0.37%	0.00%
	Avg	1.35%	

Conclusions and Recommendations

Smolt production on the Wind River has increased since monitoring was initiated in 1995. Smolt production was estimated to be 21,899 in 1999. A total of 73%, 23%, and 1% of the smolts were age 2, 3, and 4 in 1999, respectively. Production has been variable over the monitoring period ranging from 8,330 in 1995 to 24,316 in 1998.

The habitat below the Trout Creek, Panther Creek, and upper Wind River traps, but above the lower Wind River trap, is composed of a moderate gradient reach from the RM 19 to 11 called the Wind River flats and a high gradient reach from RM 11 to 1 called the Wind River canyon. In 1998 and 1999, a total of 67% and 77% of the smolt production originated from the Wind River flats and canyon. Maintaining the high quality habitat in this area is essential to maintaining this wild steelhead production in the Wind River.

A transient life history pattern is important for Wind River steelhead. This pattern includes fish spawning in the mainstem Wind River or its tributaries above Stabler (RM 11), in Trout Creek, and/or in Panther Creek. These juveniles rear for one year near the spawning site and migrate as age 1 parr into the high gradient sections of lower Trout Creek and lower Wind River. These movements suggest that all anadromous river reaches used by wild steelhead for part of their freshwater residence and that high quality habitat, from the headwaters to the mouth, is needed for a healthy and diverse steelhead population.

WDFW general trout fishing regulations, which delay opening day to June 1, and have 8-inch minimum size in the tributaries and a 12-inch minimum size in the mainstem are very effective at eliminating the harvest of juvenile steelhead. The June 1 opener protected 95% and 86% of the steelhead smolts from harvest in 1998 and 1999. The tributary and mainstem minimum size limits protected 100% of the smolts from harvest. The combination of these timing and minimum size limits protects over 99% of the juvenile wild steelhead from direct harvest.

Smolt production is influenced by the number and composition of adult spawners, along with habitat quality and quantity. Smolt production over the five years of this study was improving but variable. These variations in smolt production make it difficult to discern short-term effects of habitat restoration. Long-term smolt, adult, and environmental monitoring are necessary to determine the effects of restoration activities. Since these steelhead are also listed under the Endangered Species Act, continued smolt and adult monitoring are needed to assess extinction risk and determine if and when the steelhead populations in the Wind River should be delisted from the Endangered Species Act.

Acknowledgments

We would like to thank the following people who assisted with this project. We would especially like to recognize Tim King (WDFW), who assisted with all parts of this study including trap installation and repair, data collection, and entry. The USFS - Wind River Ranger District staff including Ken Wieman, Brian Bair, and James Umtuch provided assistance in data collection, and smolt trap installation and removal. Tim Cummings and Travis Coley (USFWS) provided the four screw traps, trap anchoring systems, and fish sampling equipment that were used in this study. Bill Thorson and Jeff Blaisdell at Carson National Fish Hatchery (USFWS) assisted with trap installation and repairs. Pat Connolly and his staff at USGS-CRRL provided assistance in trap installation and computer database management. Gary Schurman (WDFW) provided materials and technical assistance in cheek tagging steelhead smolts. Cameron Sharpe (WDFW) provided assistance with statistical analysis. Michael Murphy (NMFS-Auke Bay) provided the Fortran program for the calculation of trap efficiencies, population estimates, and variances. We would like to thank the private landowners, who allowed us to anchor traps on their property and access the traps through their property including: Tim and Alice Meyers on Panther Creek, and Jordan Kim, manager of Carson Hot Springs Resort, on lower Wind River trap. Part of this study was funded by BPA and we would like to thank John Baugher for his support of this project.

References

Bailey, N. T. J. 1951. On estimating the size of mobile populations from recapture data. Biometrika 38:293-306.

Chapman, D. G. 1951. Some properties of the hypergeometric distribution with applications to zoological sample censuses. University of California Publications in Statistics 1:131-160.

Efron, B., and R. Tibshirani. 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Statistical Science 1:54-77.

Hart, P. J., and T. J. Pitcher. 1969. Field trials of fish marking using a jet inoculator. Journal of Fish Biology 1: 383-386.

Murphy, M. L., J. F. Thedinga, and J. J. Pella. 1996. Bootstrap confidence intervals for trap efficiency estimates of migrating fish. National Marine Fisheries Service, Juneau, AK.

Rawding, D. 1997. Wind River smolt monitoring program. Washington Department of Fish and Wildlife, Vancouver, WA. Unpublished draft.

Rawding, D., P. C. Cochran, and T. King. 1999. Wind River Steelhead Smolt and Parr Production Monitoring during the 1998 spring outmigration. Washington Department of Fish and Wildlife, Vancouver, WA. 30pp.

Robson, D. S., and H. A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society 93:215-226.

Schwarz, C. J., and C. G. Taylor. 1998. Use of the stratified- Petersen estimator in fisheries management: estimating the number of pink salmon (Oncorhynchus gorbuscha) spawners in the Fraser River. Canadian Journal of Fisheries and Aquatic Sciences 55:281-296.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, 2nd edition. Charles Briffin and Company, London.

Seiler, D., and five co-authors. 1997. Wild salmon production and survival evaluation. Annual Report No. RAD97-03. Washington Department of Fish and Wildlife, Olympia.

Thedinga, J. F., S. W. Johnson, K V. Koski, J. M. Lorenz, and M. L. Murphy. 1994. Determination of salmonid smolt yield with rotary screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14:837-851.

Thedinga, J. F., and S. W. Johnson. 1995. Retention of jet-injected marks on juvenile coho and sockeye salmon. Transactions of the American Fisheries Society 124:782-785.

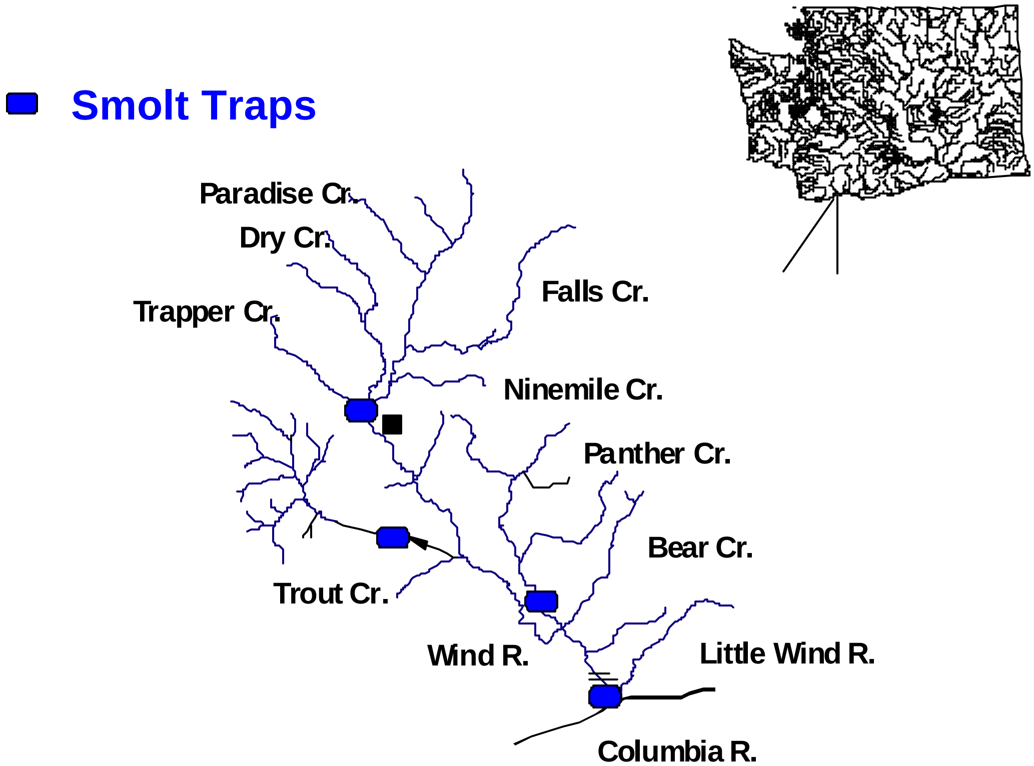


Figure 1. Location of downstream migrant traps in 1999.

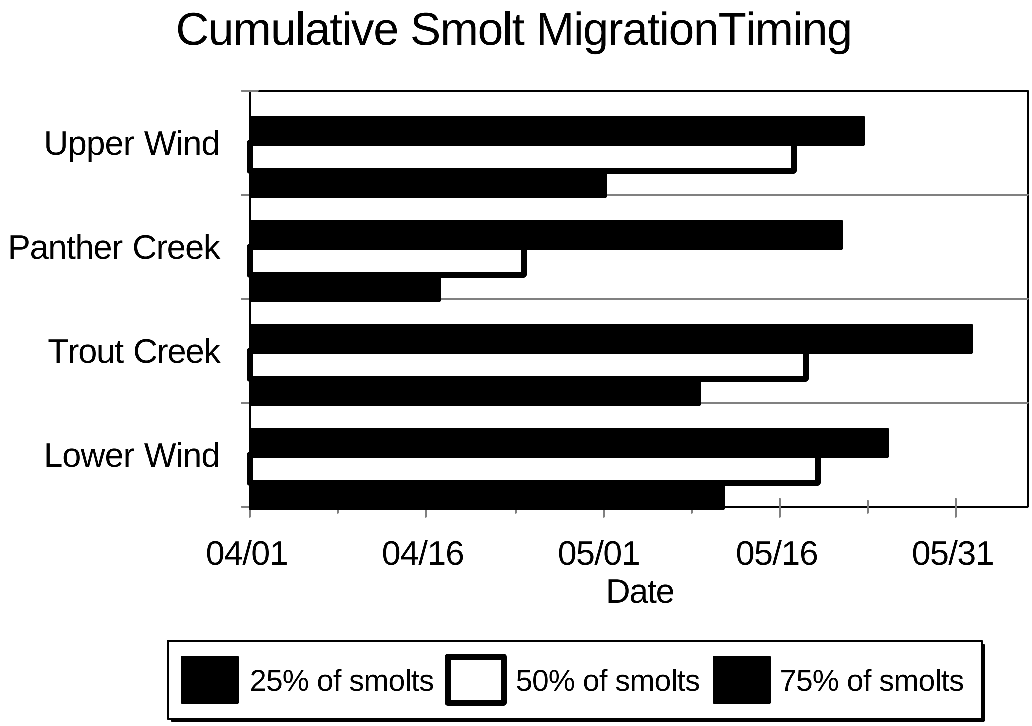


Figure 2. Cumulative steelhead smolt outmigration timing at four sites in the Wind River basin, Spring 1999.

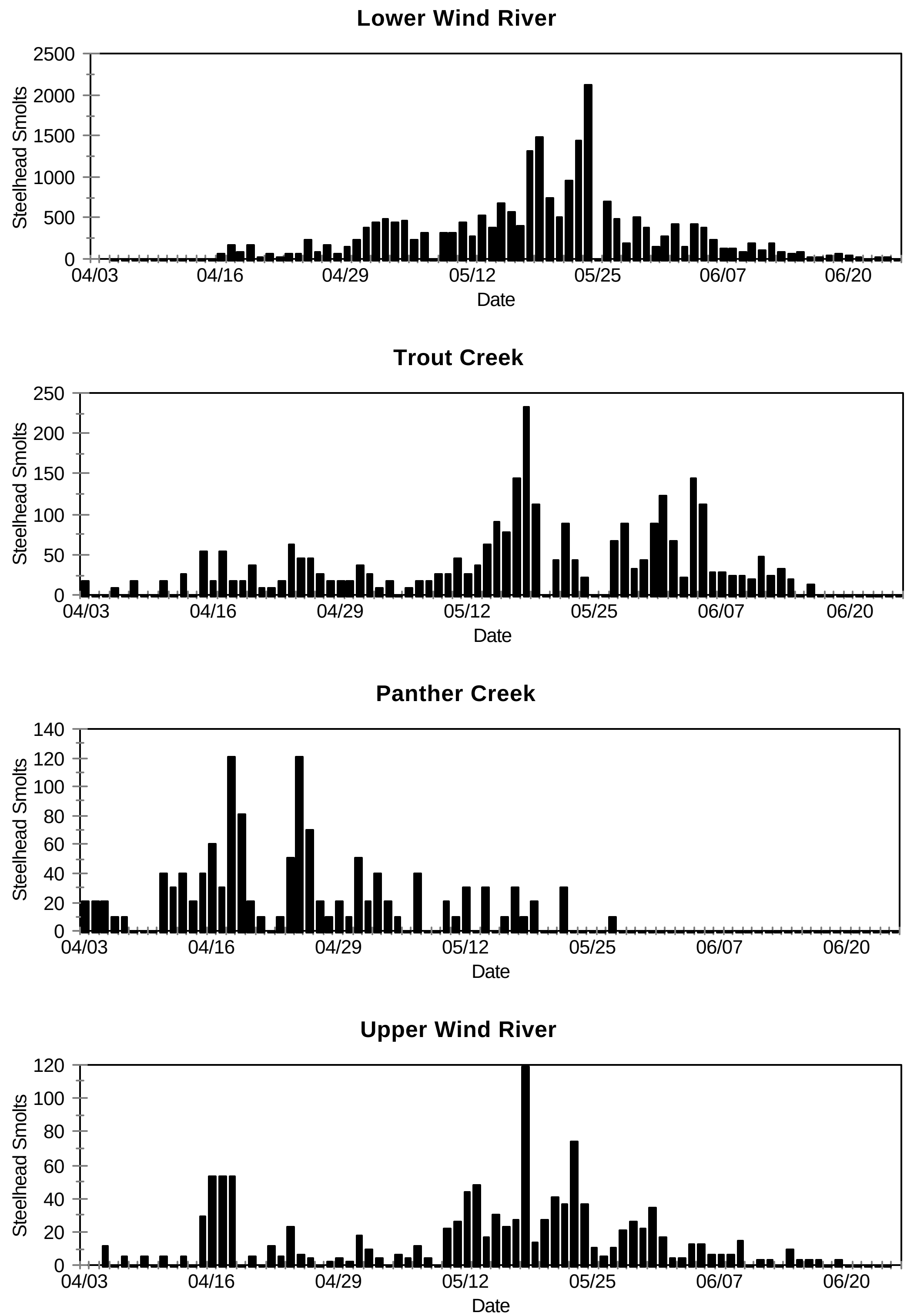


Figure 3. Expanded daily steelhead smolt outmigration by trap site in the Wind River basin, Spring 1999.

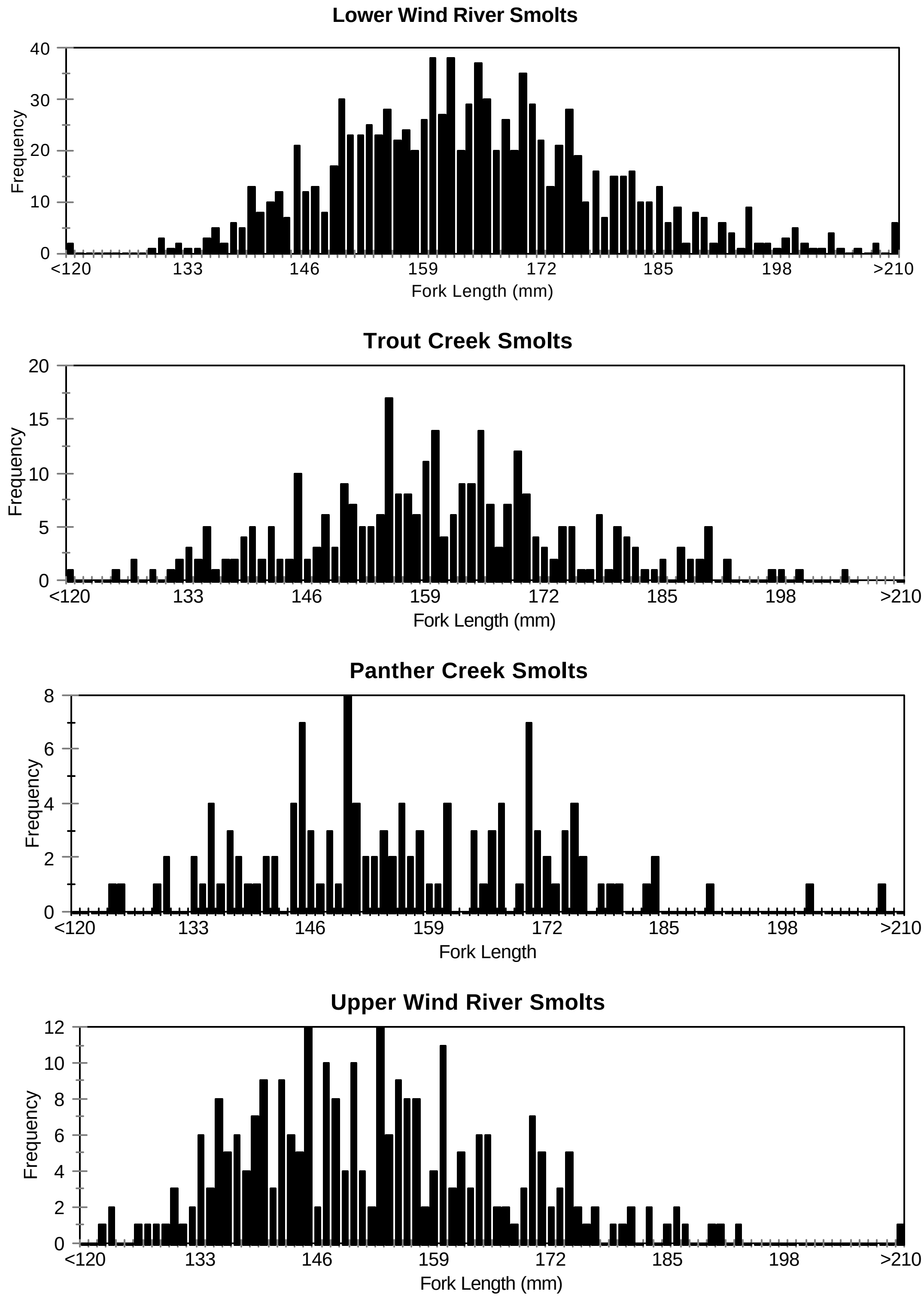


Figure 4. Steelhead smolt length frequency distributions at four sites in the Wind River basin, Spring 1999.

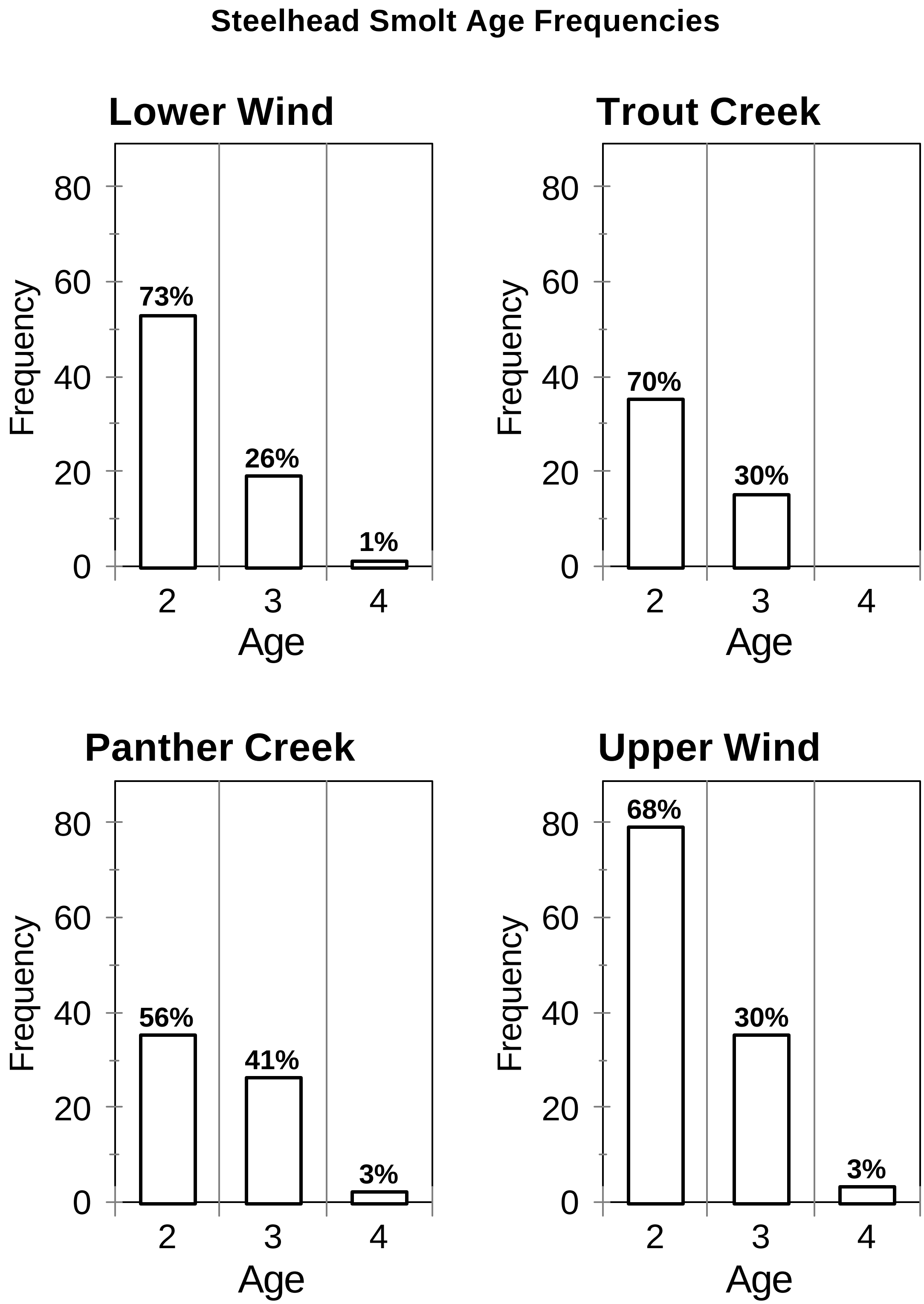


Figure 5. Steelhead smolt age frequencies and age composition at four sites in the Wind River basin, Spring 1999.

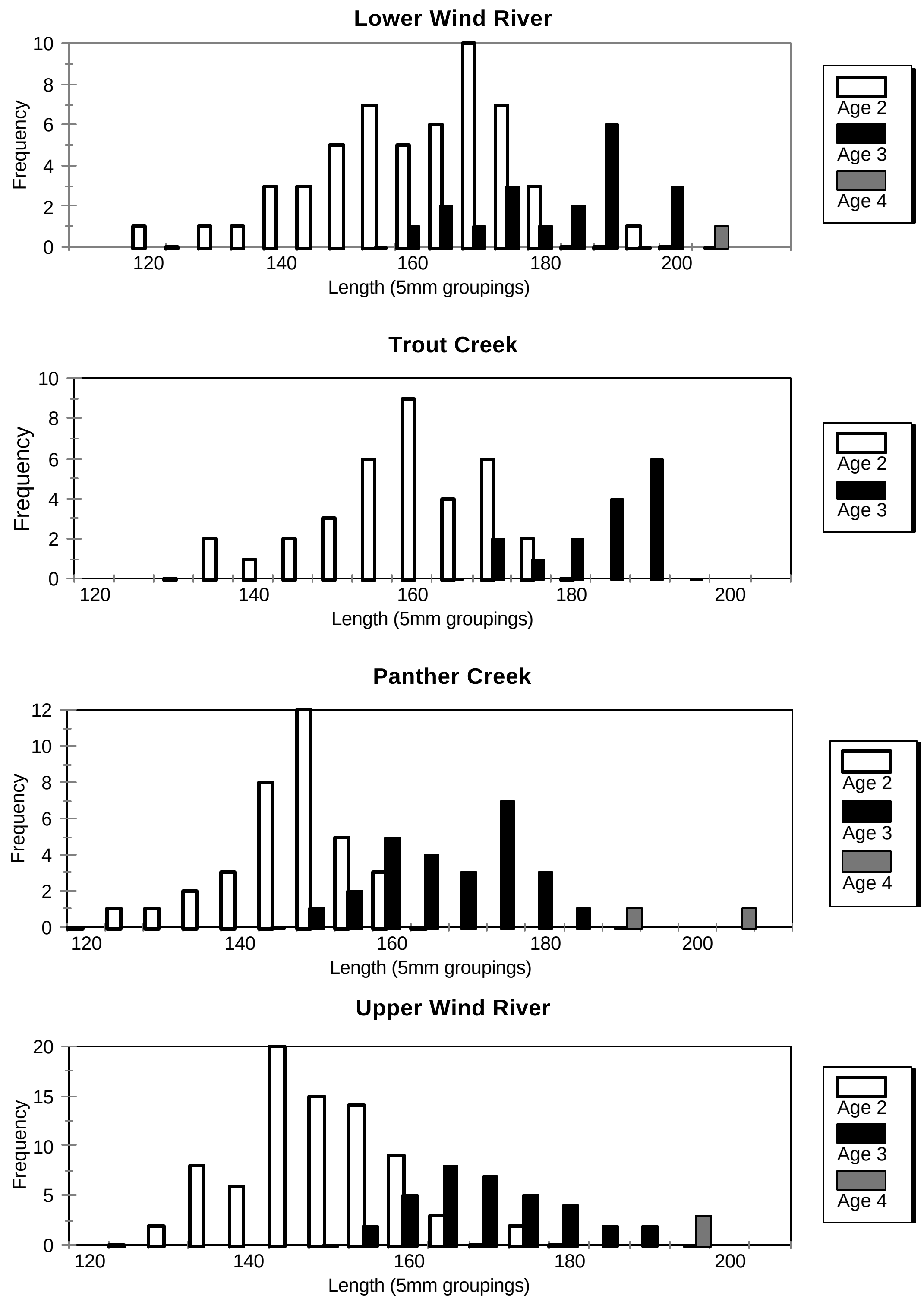


Figure 6. Steelhead smolt length frequency distributions by age class in the Wind River basin, Spring 1999.

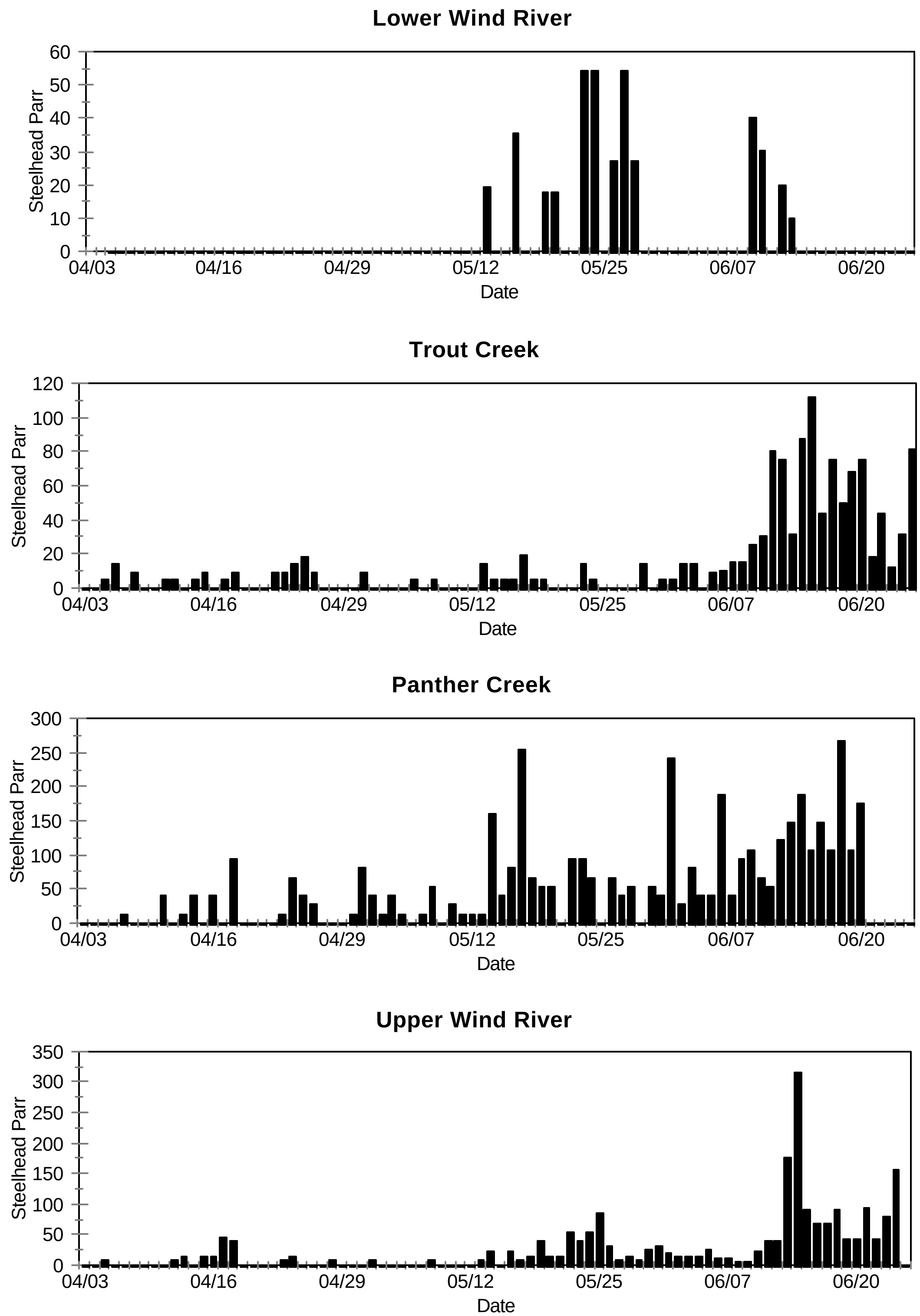


Figure 7. Expanded daily steelhead parr migration by trap site in the Wind River basin, Spring 1999.

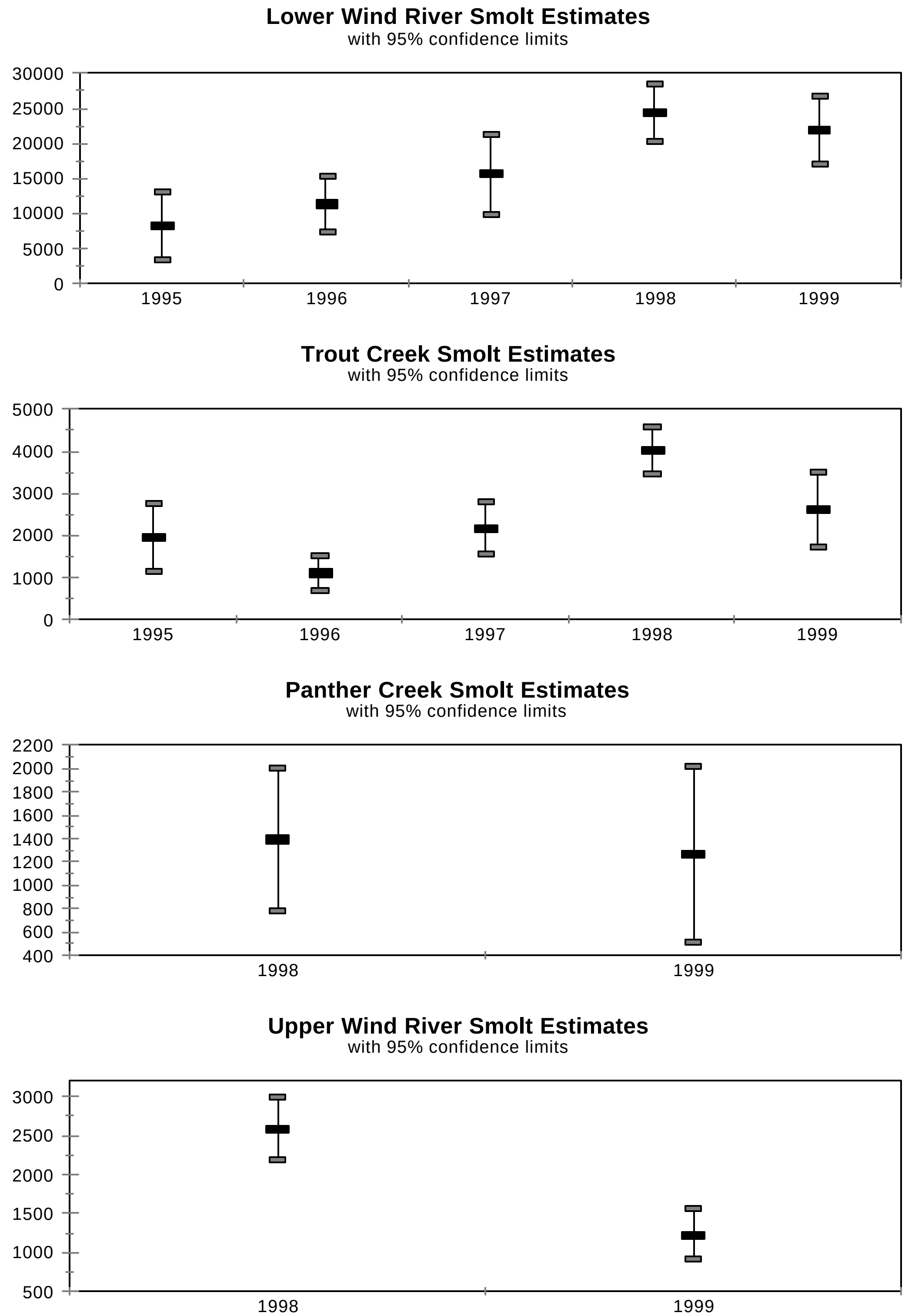


Figure 8. Annual smolt production estimates and 95% confidence limits by trap site in the Wind River basin, 1995-1999.

Appendix A of Report E

Testing and Evaluation of Marking and Tagging Protocols to Estimate Wild Steelhead Smolt Production in the Wind River Basin

April 2001

Prepared by:

Patrick Charles Cochran and Dan Rawding

Washington Department of Fish and Wildlife
Fish Management Program
600 Capitol Way
Olympia, WA 98195

Introduction

Smolt production in the Wind River basin has been monitored since 1995 using rotary screw traps. Total production from the basin and from major subbasins have been estimated using mark-recapture data fitted to a modified Peterson estimator. Smolts are collected from the traps are given a tattoo mark using a Panjet medical instrument (Hart and Pitcher 1969, Thedinga et al. 1994), and released above the traps. The unmarked catch is then expanded by the mark recovery rate (trap efficiency) to produce a population estimate.

Continual protocol refinements, and lessons learned about trap placement, have steadily improved the precision of the Wind River smolt production estimates. There are numerous assumptions of the Petersen estimator that cannot be tested using the trap data alone. Environmental conditions, especially changes in flow, may produce both instantaneous and long-term changes in trap efficiency and reduce the statistical confidence in estimates. Although long-term changes in trap efficiency can be accounted for, significant problems arise when high flows or heavy debris loads disable the traps during crucial periods, such as following the release of large numbers of marks. Lost opportunity to recover marks is difficult to account for with any accuracy because fish may move downstream at different rates, limiting our ability to estimate the number of marked and unmarked fish missed when the trap is not fished. Migration patterns in response to major freshets have not been assessed on the Wind River because attempts to fish through them have resulted in inoperable or damaged traps. Data gaps caused by unsampled freshets are probably the single biggest factor affecting the apparent validity of our smolt production estimates since 1995 because they can violate the assumption that all marked and unmarked smolts have the same probability of capture in the trap.

Another concern about the validity of the data is that mark retention had only been tested on a limited basis, and other studies indicate that samplers can fail to recognize marks on smolts (Thedinga et al. 1994). Two crucial assumptions that are imposed by the Peterson estimator are known rate of mark loss, and proper mark recognition. Failure to meet either of these assumptions would invalidate the resulting population estimates.

Seiler et al. (1997) developed an alternative method for estimating smolt production termed "back calculation" that is unaffected by short-term changes in trap efficiency or missed sampling days. This method consists of inserting smolts with magnetized, coded wire or blank wire tags, and sampling for the presence of tags in returning adults. The percentage of adults from a given smolt year that scan positive for wire tags should approximately equal the percentage of the smolt population that was tagged. Although a higher number of smolts tagged and adults checked for tags will maximize statistical confidence in this method, it does not necessarily require equal or uniform sampling effort during the smolt migration period or that every fish have an opportunity to be sampled. The frequent disruptions to screw trapping don't affect the back calculation method because it assumes that all smolts from the basin will mix randomly over the course of their 1-3 years in saltwater.

Wild steelhead smolts captured in the traps were first wire tagged during the 1998 migration. A number of measures have been taken to evaluate retention of marks and wire tags on this and similar projects. In order to validate assumptions of both methods used to calculate smolt production, we found it necessary to document mark and tag retention rates and marking/handling mortality using our established methods. Similar studies on juvenile salmon and steelhead have shown that wire tag and Panjet mark retention can be very high. Thedinga et al. (1994) experienced 98-99% mark retention in a study using the Panjet with a variety of ink and dye colors. Coded wire tag retention studies using automated tag injectors have been conducted primarily on chinook and coho salmon, which average much smaller than the steelhead smolts encountered in the Wind River. However, retention rates have been shown to be very high, ranging from 94-98% (Blankenship 1990), with most of the variation correlated to fish size, tag size and the experience of the crew in tagging smolts. Another study found survival rates for trapped and coded wire tagged coho salmon to be only 84% relative to untrapped and untagged individuals (Blankenship and Hanratty 1990). Given the implications but limited applicability of these studies to steelhead, we have made an effort to evaluate our sampling methods and quantify mark and tag retention and short-term survival rates for steelhead.

Methods

Routine Operations

Trap design, installation and placement are fully described in previous documents (Rawding et al. 1999, Rawding 1997). Four traps are in constant operation, three below different production zones in the upper watershed, and one trap near the mouth of the mainstem Wind that captures fish originating from each of the three upper production areas as well as the area below the other traps. Fish are collected from the traps and transported to the shore in covered buckets. Fish are either held in five gallon buckets or in an aerated, 90 quart cooler. A catch of 20 or more fish usually dictates use of an aerated cooler.

Fish are anesthetized in a separate bucket with 1.5-2 gallons of water using MS-222 at a concentration of 105 mg/liter. Fish are generally added to the anesthetic two at a time in intervals of 60 seconds, become disoriented in approximately 60 seconds, and after about 90 seconds fish have calmed enough to be measured, marked, and tagged. It takes approximately 30 seconds to examine, mark and tag each fish. Each time two fish are removed from the anesthetic, two more fish are added to the bucket. This system ensures that there are never more than six fish in the anesthetic, two fish in a fully anesthetized state, and fully sedated fish do not remain in the anesthetic for more than a minute. It also helps maintain a steady but unhurried pace so that care can be taken to ensure good quality control without holding the sample for longer than necessary. Tremendous care is taken to ensure adequate oxygenation, minimize stress from overcrowding and prevent warming of holding or recovery water by keeping buckets and coolers full and frequently changing the water.

Anesthetized fish are examined over a white background for previous marks, scanned for the presence of tags, measured, given a tattoo mark according to a weekly rotating mark scheme, and fitted with a blank wire tag. The wire tags we use are 1.5 length (approximately 1.7mm). Panjet marks are applied to the anal, pectoral and ventral fins in various combinations with additional marks on either of the two lobes of the caudal fin. This allows us to identify recaptures by the site and time frame of original capture. Wire tags are inserted immediately behind the eye, between the skin layer and opercular muscle, with a manually loaded hand injector manufactured by Northwest Marine Technologies. Tag location is rotated annually between right and left opercle to distinguish adult recoveries by smolt year. After tagging, each fish is again scanned, or wanded, with a magnetic field detector manufactured by Northwest Marine Technologies and visually examined to ensure that the tag was inserted and not simply stuck to the exterior of the fish. Fish are recovered in another five-gallon bucket or aerated cooler with fresh water and transported to the release site where they are again visually examined to ensure full recovery prior to release.

Mark and Wire Tag Retention Testing

We tested retention of Panjet marks on a small scale several times. Rawding (1997) marked and held spring chinook smolts at Carson National Fish Hatchery prior to initial use of the Panjet as a marking tool on the Wind River. An additional thirty spring chinook (average fork length, 115 mm) smolts were marked on various fins in 1996 and held in a hatchery raceway for 30 days. Further short-term mark retention tests were conducted in 1998 consisting of marking 33 steelhead smolts sampled in the traps and holding them for 24 hours in live boxes. Short-term wire tag retention was tested along with Panjet marks in 1998, with fish sampled in the traps held for 24 hours.

A larger scale test was conducted in 1999 on hatchery steelhead smolts on the Washougal River. A total of 881 steelhead were tagged by two experienced samplers and held in a hatchery raceway. Each individual tagged only one cheek. The fish were checked for tag retention after 23 days and again 36 days following tagging. The tagging protocol was basically identical to that used for sampling from the traps, except that no lengths were collected prior to tagging and fish were not marked with the Panjet. The first time fish were checked for retention (after 23 days) they were processed rapidly and checked for tags with no other data collection. Fork lengths were recorded when the fish were checked again, 36 days after tagging.

Adult Tag Recovery

Two adult steelhead traps exist in the Wind River basin. A trap on Trout Creek Dam has been in operation since 1990 and a new trap was installed on the Shipherd Falls fishway in the spring 1999. Adult steelhead captured in the traps are scanned for the presence of wire tags in addition to collection of scale samples and basic biological data. Tag locations are determined simply by scanning first one then the other opercle. The 1.5 length tags can sometimes be detected from the opposite side of the fish's head. When the detector gives a positive signal (beep), it is sometimes necessary to experiment by passing it over each cheek again at varying distances to be sure of the tag location. All adult steelhead that give a positive signal are also examined for the presence of other metallic objects in their mouths or gills, especially fishing hooks, as these are detected by the wand and will give a false positive signal.

Saltwater age is determined from the scale samples so that each fish is assigned to the unmarked catch from the appropriate smolt outmigration year. When we are unable to age fish due to regenerated scales, or in rare instances when no scales were collected, they are assigned to the appropriate age group based on analysis of the length frequency distribution and length to age relationship.

Smolt Population Estimates

The number of juvenile outmigrants was estimated by using a trap efficiency method of releasing marked fish upstream of the trap (Thedinga et al. 1994). Captured juvenile steelhead were marked with a Panjet inoculator (Hart and Pitcher 1969, Thedinga and Johnson 1995). Our marking schedule rotated every week and used different fin combinations to distinguish between traps. This allowed us to identify fish based on trap site and marking period. Trap efficiency is estimated using a modification (Chapman 1951) to the Petersen estimate from the equation:

$$e = (R+1) / (M+1) \qquad (1)$$

where *e* is the estimated trap efficiency, *M* is the number of marked fish released upstream of the trap, and *R* is the number of marked fish recaptured. The number of migrants at each trap was determined from the equation:

$$N = U / e \qquad (2)$$

where *N* is the estimated number of outmigrants, *U* is the total unmarked catch, and *e* is the trap efficiency. To produce " back calculated" estimates, we can rewrite equation (2) as:

$$N = C * (M+1) / (R+1) \qquad (3)$$

where *C* is the total catch of adult steelhead scanned for wire tags, *M* is the total number of wire tagged smolts, and *R* is the number of wire tagged adult steelhead. The variance for each *N* was determined by a bootstrapping method (Efron and Tibshirani 1986) with 1,000 iterations from a Fortran program (Murphy et al. 1996). Confidence limits were calculated from the equation:

$$95\%\ CL = 1.96 * \sqrt{V} \qquad (4)$$

where *V* is the variance determined from bootstrapping.

Results

Trapping Operations

In 1998, a total of 3174 smolts were marked with alcian blue dye using the Panjet, and of these, 3076 were fitted with blank wire tags in the right opercle. Direct handling mortality in the marked sample was zero. We recaptured a total of 633 smolts with wire tags, and 100% of those had visible alcian blue marks. A total of 1731 smolts were marked and 1713 were wire tagged in the left opercle in 1999. Out of 179 recaptured smolts with wire tags, tattoo marks were not recognized on two fish prior to the positive location of the wire tag in 1999. Each of these occurred following the use of an experimental tool and ink color (pink) rather than the usual alcian blue mark. Further inspection following discovery of the wire tags revealed a scarcely visible mark on one of the fish and no visible mark on the other.

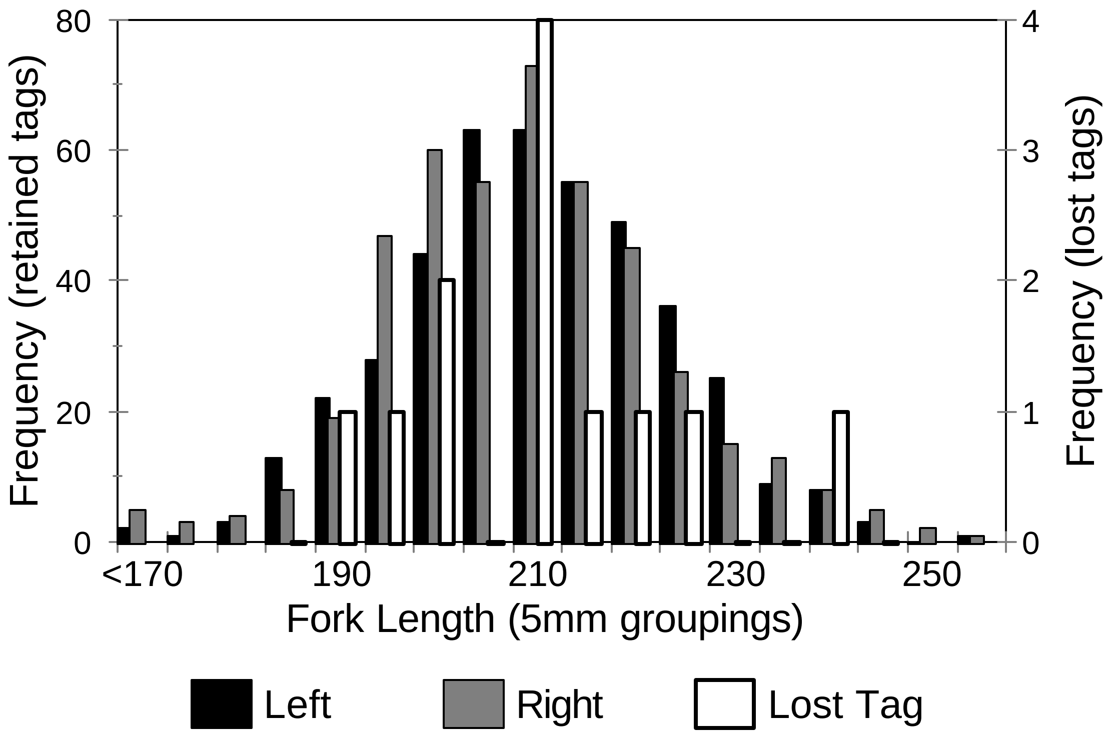
Mark Retention and Survival

In Panjet mark testing on spring chinook, mark retention on pectoral and anal fins was 100%, while two of 28 (7%) caudal fin marks were not visible (Rawding 1997). Further testing on spring chinook revealed that varying thickness of the caudal fin and spaces between fin rays affected how well the ink penetrated and dispersed in the fin. This observation was further refined through testing on hatchery steelhead smolts (average FL, 200 mm) captured in the trap in 1996. It was determined that marking the caudal fin too close to the thin, leading edge generally resulted in a tiny hole through the fin with little or no subcutaneous dispersal of the ink. Marking the fin too close to the caudal peduncle tended to deflect the ink with little or no penetration. It was also realized that in order to get an adequately visible and lasting mark, the main force of the ink jet had to hit a fin ray. This produces a clean line approximately 0.5 cm along the ray that is highly visible. All marking and testing after this realization was conducted with the requirement that fish would not be considered adequately marked until a fin ray was marked and a nice, linear streak produced. Of the 33 wild smolts marked and held for 24 hours in 1998, survival and alcian blue mark retention was 100%. One smolt, or 3% of the sample, lost its wire tag during the 24-hour period.

At the Washougal steelhead hatchery, 881 smolts were fitted with wire tags in 1999, 433 left cheek, and 448 right cheek. The first check after 23 days in the raceway revealed a total of 12 lost tags, or approximately 1.4%. One mortality (0.1%) was discovered by hatchery staff 2 days after initial tagging and there were no further mortalities during the study period. There was no additional tag loss after 23 days. Fork lengths were measured on all of the test fish 36 days after tagging to identify any correlations between tag retention and fish size. Appendix Table 1 displays the final numerical breakdown of length data, and length frequency distributions for each group are plotted in Appendix Figure 1.

Appendix Table 1. Final summary of fish length data from 881 hatchery steelhead smolts tested for wire tag retention.

	All Tags	Left Cheek	Right Cheek	Lost Tags
Number	869	425	444	12
Max Length (FL)	258	254	258	239
Min Length	153	157	153	186
Mean Length	208	209	208	209
Standard Dev	14.15	13.80	14.47	13.89



Appendix Figure 1. Length frequency distributions of hatchery steelhead smolts that retained (left or right cheek) or lost wire tags, 1999.

Adult Tag Recoveries and Smolt "Back Calculation"

The smolt production estimate for the Wind River basin in 1998 was 24,316 with a 95% confidence interval of 20,205-28,427 (+/- 17%) (Rawding et al. 1999). The total number of tagged smolts released during the 1998 outmigration was 3076. When corrected by the 1.4% tag loss rate from the hatchery test group, the expected number of tagged smolts leaving the basin is 3034. We began sampling adult steelhead for wire tags at Shipherd falls on June 16, 1999. Based on analysis of scale samples and length frequency distribution plots the size break for one-salt adults (those that outmigrated as smolts in 1998) was at 64 cm. A total of 33 ocean age 1 summer steelhead, or summer steelhead less than or equal to 64 cm, were scanned with the wire tag detector in 1999. Four were confirmed to have right cheek tags. Seven of eight ocean age 1+ winter steelhead were scanned and one right cheek tag was confirmed. The "back calculated" smolt production for 1998 is 20,223 steelhead determined by the equation (3), with 95% confidence limits of 1,351-39,095 (+/- 93%).

The majority of smolts from the 1998 outmigration will return during the 2000-01 run year as two-salt summers and two+-salt winter runs. Data from the 2000 summer run is preliminary because scale analysis of the entire sample has not been completed and the run is not over. By plotting length frequency distributions and some limited scale analysis the break points appear to be the same as during the 1999 summer run, with a sharp break between one and two salts at 64 cm and some overlap at 76-77 cm between two and three salts (Rawding et al. 2001). Analysis of a subsample of scales and the fact that one right cheek tag was discovered in a 77.5 cm fish confirms this overlap. Unfortunately for this exercise, there is no defensible way to split the large number of fish at 76-77 cm into two and three salts because all of the scales have not been read. For current purposes, all summer steelhead in 2000 between 65 and 77 cm will be considered to be two salts from the 1998 smolt outmigration. Using these guidelines, a total of 78 ocean age two, summer steelhead have been checked for wire tags during the 2000 summer run at Shipherd Falls as of February 12, 2001. There have been eight confirmed right cheek tags. By pooling the 1999-00 summer and winter run with the 2000 summer run, there are a total of 13 right cheek tags out of 118 adults. The "back calculated smolt" production using equation (3) is 25,581 with 95% confidence limits of 10,953-40,209 (+/- 57%).

Discussion

The low mortality rate of test fish (0.1%) indicates that our methods and the precautions taken to minimize stress to smolts are very effective. Thedinga et al. (1994) encountered similarly low mortality rates (0.7%) for steelhead trapped and marked during outmigration. Of the four sites used to release marked smolts on the Wind, three are one mile upstream of their respective trap and one is 4.5 miles upstream. These short distances combined with the high average gradient, typically high streamflow during the sampling period, relatively low abundance of predators in the basin, and the short delay between release and recapture of marked fish (1-2 days), we feel that increased predation on marked and released smolts is not a major factor.

Wire tag retention was high in the hatchery test (98.6%). Although there were no intensive statistical tests conducted, analysis of length frequency distributions indicate that there was no significant relationship between fish size and tag loss in these fish. There was some variability between two taggers with equal experience (1.8% to 0.9% tag loss), which could be a matter of natural variability or luck. Each of the individuals in the hatchery tagging experiment, tags approximately equal numbers of steelhead during normal trap operations, so we assume that the average retention of 98.6% is applicable to the entire sample.

Blankenship (1990) found a relatively high degree of variability between groups of different sized fish, and generally experienced higher tag loss rates than in our study on test groups implanted with full-length tags. Large groups of salmon are generally tagged using automated tag injectors that are adjustable according to the average size of the fish being tagged. Hatchery chinook and coho mark groups typically number in the hundreds of thousands, which precludes the use of manually loaded tag injectors. It is possible that strong correlations between fish size and tag loss would be more prevalent using a machine that is adjusted to the average size of a group rather than the specific size of each individual. Large variations of steelhead smolts size are found on the Wind River and in 1998 smolts ranged from 129mm to 254 mm, with a mean of 169 and a standard deviation of 17mm (Rawding et al. 1999). By contrast, taggers using hand injectors make adjustments to individual fish. Use of hand injectors puts the point of insertion in direct view as the needle is inserted and the tag expelled, ensuring that it is always precisely placed and any misfire or malfunction of the syringe will be seen readily. Tags that are properly placed in the opercle are usually visible as a tiny bulge under the skin. Risks of serious trauma and resulting mortality when placing cheek tags with hand injectors remain low as long as the fish are well anesthetized, because the angle of insertion is nearly parallel to the plane of the fish's cheek and not in the direction of any vital organ.

Given our improved understanding of the Panjet as a marking tool, and ongoing efforts to maintain quality control, we feel confident in a 100%, 30 day survival of alcian blue marks on pectoral, ventral and anal fins. These results are similar to those obtained by Thedinga and Johnson (1995) with coho salmon. Steelhead test results dictate that we not use caudal fin marks as a primary mark because it could violate this assumption. Caudal fin marks are used in combination with pectoral and anal fin marks to provide mark timing information only, and are never used alone on smolts. Therefore, in a worst case example, a smolt could be given an anal and lower caudal mark at the Trout Creek trap site, lose its caudal fin mark and then get recaptured at the lower Wind trap. The only information that would be lost is the time period that it was marked in Trout Creek, since that is the only place that anal fin marks are used. Since the maximum time between mark, release and recapture of steelhead smolts in the Wind River has been 21 days (Rawding et al. 1999), mark loss is assumed to be zero.

The third assumption of the Peterson estimator (mark recognition) becomes a concern primarily at the trap on the lower Wind River. Marked smolts from four different trap sites, or a total of 12 unique marks, could be included in the lower Wind trap catch on any given day. Thedinga et al. (1994) observed in a similar situation that samplers at a lower trap were three times more effective at recognizing marks made by themselves than different marks from another trap higher in the basin. In groups of fish that were marked at both traps according to their respective scheme, the samplers tended to recognize both marks on a consistent basis. The conclusion was that because the mark groups from the lower river trap were much larger and more recaptures were expected from those groups, the samplers were biased towards recognizing that specific mark. They then had more of a tendency to check fish more thoroughly for other marks once the expected mark was recognized.

Since the situation is similar on the Wind River, samplers at the lower Wind might be more effective at recognizing fish marked at that trap than those marked at the upper traps because their attention may be focused primarily on checking for marks from the lower Wind and marks from each trap are never used in combination with each other on the same fish. This potential for violating the third assumption and biasing the trap efficiency estimate is partially alleviated on the Wind because all four traps are operated by the same crew, and smolts are always checked for all possible Panjet marks and for wire tags prior to other data collection. If a Panjet mark is present but not recognized, a positive signal from the wire tag detector, which will occur on 98.6% of all recaptures, will force the sampler to carefully re-examine the smolt for dye marks that may have been overlooked. Careful examination of all smolts captured in the Wind is facilitated by relatively low numbers and the absence of other species in trap efficiency testing. Mark groups reported in Thedinga et al. (1994) included multiple species and numbered as high as 1000/day per species while an average daily catch at the lower Wind River trap is approximately 40-80 steelhead during peak migration.

Smolt "Back Calculation"

Blankenship and Hanratty (1990) designed a study to determine the effect of handling and tagging coho salmon at the smolt stage in Minter Creek, so that WDF could estimate the mortality wild coho trapping projects. They estimated that coho smolts that were trapped , CWT, and adipose clipped during the smolt migration had a 16% higher mortality than those not trapped and handled during the smolt outmigration. It is unclear if the Minter Creek coho data should be applied to trapped wild steelhead in the Wind River because of differences in species (steelhead vs. coho), trapping (screw traps vs. V-weirs), handling (daily vs. periodic), and trap densities (low vs. moderate to high). At juvenile migrant traps in the Lewis River basin in Southwest Washington, mortality rates for trapped smolts were observed to be higher for coho salmon than for steelhead (WDFW unpublished data) indicating these coho are more sensitive to handling than steelhead. The Minter Creek coho smolts were captured in a downstream V-weir trap and Wind River steelhead were captured in a rotary screw trap and the potential exist for different levels of injury because the of the different trap designs. Wind River steelhead traps are checked daily and coho at Minter Creek were checked daily or every other day (Pat Hanratty, pers. comm.). In addition, trap catches on the Wind River rarely exceed 50 individuals, where substantially more coho were caught at Minter Creek. The combination of higher densities of coho salmon smolts in Minter Creek and that some fish spent over 24-hours in the live box likely caused additional stress and ultimately more delayed mortality than for steelhead in the Wind River. Despite all the precautions taken during downstream trapping of smolts some level of delayed mortality is likely to occur. For the reasons mentioned above we believe for steelhead in the Wind River it is closer to 0% than the 16% estimated for coho salmon smolts by Hanratty and Blankenship (1990). Therefore, we will continue to use the 0.1% for delayed trap mortality for Wind River steelhead until additional data is available. The consequence of this assumption is that smolt production estimates from "back calculation" are more conservative, and the resulting calculation of freshwater productivity would be biased high and smolt to adult survival would be biased low if delayed mortality is higher.

The use of the "back calculation" method was primarily intended to be an independent verification of the smolt trap efficiency method. Smolt to adult survival rates in the Wind River are estimated to be less than 3% (WDFW unpublished) and more than 50% of the steelhead jump Shipherd Falls and are not trapped (Rawding and Cochran 2001). When a 3% smolt-to-adult survival is used along with a 50% trap rate, we expect that 3034 smolts (98.6% of 3074) left the basin with tags in 1998, and we would expect less than 90 tagged adults to return to the basin from this smolt population. This places the expected number of adult recaptures from the 1998 smolt year at less than 45. With such a low number of potential recaptures, the statistical confidence in the final "back calculated" estimate in 1998 (25,581 +/-57%) will be relatively low compared to the trap efficiency method (24,316 +/- 17%). So far the results are encouraging, suggesting that trap efficiency and "back calculated" smolt production estimates are similar. However, a more detailed statistical analysis is needed comparing both methods when all adult steelhead returns can be analyzed

Conclusions

1. **Trapping/Handling Mortality:** Appropriate fish handling methods enable us to conduct smolt mark-recapture testing without significant disruptions to outmigration or increased mortality. Direct mortalities can be eliminated from trap efficiency testing, so they will not effect production estimates. Marking and tagging fish that are otherwise trapped and sedated and handled does not increase overall or delayed mortality. Delayed handling mortality is difficult to quantify, but the 0.1% rate in the hatchery test indicates that it is not high enough to significantly effect production estimates.

2. **Mark and Tag Retention:** If fish are marked according to protocol, alcian blue mark retention is 100%. Use proper use of hand injectors may eliminate any relationship between fish size and wire tag retention and minimizes the mortality to individual fish. An overall wire tag loss factor of 1.4% may be applied, but will not significantly influence smolt production estimates.

3. **Proper Mark Recognition:** This assumption of the Peterson estimator is valid as long as we use alcian blue ink in the Panjet for marking, and samplers always check

smolts for all possible marks. Wire tagging smolts as a secondary mark is also effective at validating the assumption. We did not test wire tag detection rates in adults but they are believed to near 100%. We use 1.5 length tags to help maximize the tag detection rate.

4. **Smolt Production Estimates:** The "back calculated" smolt production estimate for 1998 effectively validates the trap efficiency estimate. "Back calculated" estimates can be expected to fluctuate substantially over the course of the three years that smolts from a given outmigrant year return as adults due to random mixing of tagged and untagged fish and run timing.

References

Blankenship, H. L. 1990. Effects of time and fish size on coded wire tag loss from chinook and coho salmon. American Fisheries Society Symposium 7:237-243.

Blankenship, H. L., and Hanratty, P. R. 1990. Effects on survival of trapping and coded wire tagging coho salmon smolts. American Fisheries Society Symposium 7:259-261.

Chapman, D. G. 1951. Some Properties of the Hypergeometric Distribution with Applications to Zoological Sample Censuses. University of California Publications in Statistics 1:131-160.

Hart, P. J., and T. J. Pitcher. 1969. Field trials of fish marking using a jet inoculator. Journal of Fish Biology 1:383-386.

Rawding, D. 1997. Wind River smolt monitoring program. Washington Department of Fish and Wildlife, Vancouver, WA. Unpublished draft.

Rawding, D., P. C. Cochran, and T. King. 1999. Wind River steelhead smolt and parr production monitoring during the 1998 spring outmigration. Washington Department of Fish and Wildlife, Vancouver, WA. 30 pp.

Rawding, D., and P.C. Cochran. 2001. Adult steelhead monitoring in the Wind River, 1999-2001. Washington Department of Fish and Wildlife, Vancouver, WA. 20 pp.

Rawding, D., and P.C. Cochran. 2001. Wind River steelhead smolt and parr production monitoring during the 1999 outmigration. Washington Department of Fish and Wildlife, Vancouver, WA. 23 pp.

Seiler, D, and five co-authors. 1997. Wild salmon production and survival evaluation. Annual Report No. RAD97-03. Washington Department of Fish and Wildlife, Olympia, WA.

Thedinga, J. F., and S. W. Johnson. 1995. Retention of jet-injected marks on juvenile coho and sockeye salmon. Transactions of the American Fisheries Society 124:782-785.

Thedinga, J. F., M. L. Murphy, S. W. Johnson, J. M. Lorenz, and K V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14:837-841.

Report F: Adult Steelhead Monitoring in the Wind River, 1999-2001

Wind River Watershed Project

1999 Annual Report

September 2001

Prepared by:

Dan Rawding and Patrick Charles Cochran

Washington Department of Fish and Wildlife
Fish Management Program
600 Capitol Way
Olympia, WA 98195

Abstract

A total of 140 wild Wind River summer steelhead were estimated to pass the Shipherd Falls adult trap during the 1999-2000 run year. During the winter of the same year, a total of 41 wild winter steelhead were also estimated to pass above Shipherd Falls. The preliminary estimate for 2000-2001 indicated the wild summer steelhead run size increased to 381 adults. These are the **first** complete estimates of wild summer and winter steelhead run sizes in the Wind River. In addition, we develop a methodology to estimate the wild summer steelhead run size from previous snorkel counts. Based on these population estimates the wild summer steelhead population on the Wind River is approaching the short-term goal of 500 fish but well below the lower escapement goal of 1,000 spawners. Continued accurate and unbiased adult counts are needed by fisheries agencies to assess the status of this ESA listed population, and for agencies to determine if habitat restoration projects and strategies are successful in rebuilding steelhead populations.

Introduction

Historically, the Wind River was one of the most productive summer steelhead (*Oncorhynchus mykiss*) watersheds in southwest Washington. Bryant (1949) estimated that the pre-1950's wild run size was approximately 3,250 adult steelhead with an escapement of 2,500 fish and a harvest of 750 fish. McMillan (1981), through discussions with anglers, estimated the wild summer steelhead run was between 2,500 and 5,000 fish. The first wild steelhead estimates based on actual fish counts occurred between 1955 and 1965 with the opening of the Shipherd Falls fish ladder. Ladder counts were highly variable due to differences in trapping effort and flows but the maximum wild steelhead count occurred in 1962 with an April through October count of 1,269 fish (NMFS, unpublished data). In the early 1980s, the Technical Advisory Committee of the Columbia River Fish Management Plan established an escapement goal of 1,000 wild summer steelhead for the Wind River (TAC 1991). A more refined escapement goal of 1,577 wild summer and winter steelhead was established by Lucas and Nawa (1985) based on the methodology of Gibbons et al. (1985).

The Washington Department of Fish and Wildlife (WDFW) and the United States Forest Service (USFS) have monitored steelhead escapement through redd and snorkel surveys and adult trapping since 1985. Over that period the redd index of adult escapement has declined from a high of 826 wild summer steelhead spawners in 1987 to 94 spawners in 1994 (WDFW 1997). Snorkel surveys show a similar decline with a peak count of 274 wild summer steelhead in 1988 to 44 steelhead in 1997 (WDFW 1997). Due to declining abundance, genetic and ecological risks from hatchery fish, loss of productivity and capacity from degraded habitat, mortality from hydroelectric dams, and the potential of over harvest, the National Marine Fisheries Service (NMFS) proposed that Wind River steelhead be listed under the Endangered Species Act (ESA) (Busby et al. 1996). On March 13, 1998, the wild steelhead in the Wind River were listed as threatened under the ESA.

An interagency work group with members from the USFS, WDFW, U.S. Fish and Wildlife Service (USFWS), and the Yakama Nation (YN) was formed in 1993 to determine the factors that led to the decline of wild summer steelhead and to develop a rebuilding plan for this population. Since then, the work group has expanded to include the U.S. Geological Survey-Columbia River Research Laboratory (USGS-CRRL), the Underwood Conservation District (UCD), and Washington Trout (WT). The group's goal is to protect, restore, and enhance the productivity of Wind River wild salmonids and their ecosystem. In addition, the group adopted a short-term goal of restoring the wild summer steelhead population size to at least 500 spawners while maintaining the genetic diversity and long-term productivity of these fish. Funding to assist with the recovery of steelhead and steelhead habitat was provided from the Bonneville Power Administration (BPA) beginning in 1998.

To determine if the wild steelhead population meets an escapement objective, an accurate count of wild summer steelhead is required. As mentioned above, WDFW has used redd and snorkel surveys to estimate wild summer steelhead abundance. Redd surveys typically take place from March through May and cover up to 40 miles of mainstem and tributary spawning habitat. Only 50% of the available spawning habitat is covered because deep snow and remote canyons prevent access. Assumptions are necessary regarding the number of females per redd, the ratio of males to females, and the detection rate of redds by different observers. Mainstem estimates are made using an Area-Under-the-Curve method, and further assumptions are needed regarding mainstem redd life. Redd counts do not differentiate fish by origin or race, therefore hatchery summer, hatchery winter, and wild winter steelhead may have constructed some of the redds observed during the spring surveys since their spawning times overlap with wild summer steelhead.

WDFW initiated summer steelhead snorkel surveys in the Wind River in 1988 to avoid some of these problems but the snorkel surveys have their own set of assumptions. Since snorkel surveys can only be conducted at low flow, from mid to late summer, due to concerns for snorkeler safety, it is unclear what percentage of the wild summer steelhead run has entered the Wind River at the time of the survey. Another concern is that we do not know the detection rate (snorkeling efficiency) of wild summer steelhead by snorkelers. For the reasons discussed above, the numbers from redd or snorkel surveys should be considered an index of wild summer steelhead abundance, not an absolute escapement.

In May 1999, WDFW installed an adult trap in the Shipherd Falls ladder. The purpose of the trap was to obtain accurate counts of summer steelhead using the ladder. Since summer steelhead jump the falls and do not always use the ladder, WDFW tagged all trapped adult steelhead to develop a Petersen population estimate using snorkeling and/or the Trout Creek adult trap to recover the tags. Since high flows and cold water prevent wild winter steelhead from jumping the falls, the winter steelhead escapement above the falls is simply the ladder count.

Methods

An adult trap was reinstalled in the adult fish ladder at Shipherd Falls in May 1999. The trap area is approximately 8 by 12 feet and is located in the upper most vertical slot pool. The trap consists of a V-weir with a 6-inch opening in the vertical slot and an aluminum barrier with 1 inch bar spacing at the upstream end of the trap. The weir and barrier extend from the floor of the ladder to the metal grates on top of the ladder a distance of approximately 13 feet. Attached to the upstream edge of the V-weir are black plastic fingers. These fingers are placed horizontally with a spacing of two inches between each finger and cover the entire opening. As fish migrate into the trap they push the fingers open and the force of the current closes fingers behind them. This device acts as a one-way check valve and prevents fish from exiting the trap. Water depth in the trap varies from 3 feet to 8 feet depending on river flow. During flood stages the depth exceeded 13 feet.

To enumerate and tag adult steelhead, the water depth in the trap is reduced to approximately 2 feet by closing a gate valve at the exit of the fish ladder. Trapped fish are netted and placed into an anesthetic tank. Fish are sampled after they become docile. Data collected includes sex, origin, fork length, scales, fin clips, and tag information. Wild steelhead are then tagged with two Floy tags, which are inserted at the base of both sides of the dorsal fin. A paper punch is placed in the caudal fin as a secondary mark to assess tag loss. After the steelhead have recovered, they are released to continue their migration.

The wild summer steelhead population is estimated using a Petersen mark-recapture estimate. The cumulative number of tagged and untagged wild steelhead upstream of the Shipherd Falls trap is obtained from the Trout Creek adult trap and by snorkeling. The Trout Creek trap is located at River Mile 2 on Trout Creek at Hemlock Dam, which is located 11 miles upstream of the Shipherd Falls trap. The Wind River is snorkeled from Dry Creek to Shipherd Falls, a distance of approximately 16 miles. Since we cannot recover tags during snorkeling, we use a mark-resight to estimate the number of tagged and untagged steelhead. Snorkelers work downstream in groups of two to four to cover the 2 to 5 miles in each section following the methods of Thurow (1994). Snorkelers try to keep equidistant and in a straight line. Each person is responsible for a field of vision, usually from their right shoulder to the adjacent snorkeler's right shoulder or right bank. The right most snorkeler is also responsible from their right shoulder to the left bank. The group stops at the beginning and end of each pool, where most steelhead are observed, and records their count.

Adult and juvenile steelhead, rainbow trout, whitefish and spring chinook salmon are usually observed during snorkel surveys. Most snorkelers have experience differentiating these fishes. For inexperienced personnel, fish identification is reviewed before snorkeling and the team leader reviews fish identification as the different species are encountered. The steelhead are divided into the categories listed in Table 1.

Table 1. Steelhead identification categories

Category	Description
Untagged Wild	Steelhead with no floy tags and with an intact adipose fin
Tagged Wild	Steelhead with floy tagged at the base of the dorsal fin and with an intact adipose fin
Untagged Hatchery	Steelhead with a missing adipose fin and no floy/Petersen disc tags
Tagged Hatchery	Steelhead with a missing adipose fin and floy/Petersen disc tags
Unknown	A steelhead where only the head or tail was observed
Unknown/Untagged	A steelhead with no tag but the area near adipose fin was not observed

The wild summer steelhead population was estimated by NOREMARK, a program to compute mark-resight estimators of population abundance (White 1996) using a joint hypergeometric maximum likelihood estimator (JHE). JHE is the value of N that maximizes the following likelihood:

$$\mathcal{L}(N \mid M, n_i, m_i) = \prod_{i=1}^{k} \frac{\binom{M}{m_i}\binom{N-M}{n_i-m_i}}{\binom{N}{n_i}} \qquad \textbf{(1)}$$

and the terms are defined for all i = 1 to k sighting occasions. Confidence intervals are determined with the profile likelihood method (Hudson 1971; Venzon and Moolgavkar 1988). This estimator assumes that all the marked animals are on the area surveyed for each survey, i.e., that the population is geographically and demographically closed, and thus N is the same for each survey. The number of marked animals (M) is the same for each survey in the above equation, although the probability of sighting animals is not assumed to be the same for each survey.

Notation

T_i Number of tagged wild steelhead in the population at the time of the i^{th} survey, i=1, 2,..., k. When the number of marked animals is assumed constant across surveys, the value is denoted as T.

M_i Number of tagged wild steelhead in the population that are in the survey area surveyed at the time of the i^{th} sighting survey. For all M_i constant, define $M = M_i$.

n_i Number of wild steelhead seen during the i^{th} sighting survey, consisting of m_i marked steelhead and u_i unmarked steelhead, so that $n_i = m_i + u_i$.

m Total number of sightings of marked wild steelhead, so that $m = \Sigma\, m_i = \Sigma\, f_i$.

u Total number of sightings of unmarked wild steelhead, so that $u = \Sigma\, u_i$, where i = 1, 2,..., $N - T$.

WDFW conducts August and September snorkel surveys. In most seasons, snorkel surveys cannot be conducted after the end of September due to fall rains and increased flow. Therefore, we need to estimate the number of steelhead jumping Shipherd Falls from the time of the last snorkel survey in September until flow and temperature make it impossible to successfully jump the falls, usually in late October or early November. The August population estimate is subtracted from the September estimate, yielding an estimate of the increase in population size during the period. This estimate of total fish passing during the period is divided by the number of fish trapped and tagged during the period, which yields a population-to-tag ratio or jumper ratio. Therefore, the total wild summer steelhead population estimate is the sum of the snorkel estimate in September, plus the October tag estimate times the jumper correction factor, plus the number of wild summer steelhead trapped from November 1 through the end of the run year in April.

Wild winter steelhead enter the Wind River from November through May. Flow and cooler water temperatures make Shipherd Falls a complete barrier to wild winter steelhead in most years. The wild winter steelhead ladder count is equal to the escapement above Shipherd Falls. Some winter steelhead are likely to spawn in the mainstem between the Little Wind River and Shipherd Falls and in the Little Wind River. A total escapement for wild Wind River winter steelhead must include both a trap count and a redd survey below the trap. However, in 1999-2000 we only measured the number of wild steelhead trapped at Shipherd Falls and did not estimate the number of redds and/or escapement below the falls.

Scales were collected from the majority of adult steelhead trapped at Shipherd falls during the 1999-2000 run year. It was impossible to accurately age certain individuals due to lost or regenerated scales, so some assumptions were necessary in order to assign these individuals to an age class. Wild steelhead that were measured but were not sampled for scales or had unreadable scales were assigned to a saltwater age class based on analysis of the length at saltwater age relationship from scale analysis, and/or recaptures of wire-tagged adults from known smolt outmigrations. There were instances during the 1999 summer run where steelhead in the trap were recorded as present or absent only, and these individuals were not considered in age composition data. No scales have been collected from steelhead trapped at Trout Creek.

Results and Discussion

Population Estimates

Population estimates for wild summer steelhead in the Wind River in August and September 1999 were 94 and 97, respectively (Table 2). The number of steelhead passing between these two surveys is estimated to be 3 fish. However, 11 fish were tagged between the surveys indicating at least 11 additional fish were present during the September surveys. The August estimate was 94 wild steelhead with a 95% confidence limit of 42 to 146. The September estimate was more precise and it was 97 with a 95% confidence limit from 70 – 157. Since the September estimate was more precise we assume that it is the better estimate and the August estimate was at least 11 fish less or 86 if we assumed no steelhead successfully jumped Shipherd Falls. The August number would be reduced to 75 fish if we assumed an equal number of steelhead successfully jumped the falls as passed through the fish ladder.

Wild summer steelhead were observed in the holding pools near the top of Shipherd Falls through October in 1999. To account for the number of jumpers in October we needed to estimate the jumper rate at Shipherd Falls. Bradford et al. (1996) noted the population to ladder count ratio ranged from 2.2:1 to 3.0:1 on the Kalama River, and averaged 2.6:1, based on snorkel surveys between July and early September.

A total of 10 wild steelhead were trapped from September 26 to October 31, 1999 and this number multiplied by 2.0 yields an estimate of 20 wild summer steelhead. From November 1, 1999 through March 1, 2000, a total of 22 wild steelhead were trapped. This yields a wild summer steelhead estimate of 140 for the 1999-2000 Wind River wild summer steelhead run.

Table 2. Mark-resight population estimation for wild Wind River summer steelhead on August 16, September 16 & 22, 1999 using snorkel and Trout Creek trap observations.

Date	Marked Available	Marked Seen	Unmarked Seen	Lin.-Pet. Estimate	95% Confidence Interval
Aug 10	29	5	13	94.0	41.9 - 146.1
Sep 16	40	7	9	86.1	49.0 - 123.3
Sep 22	41	5	8	97.0	46.2 - 147.8

Minimum number known alive in August is 49
August Population Estimate: 94 95% Confidence Interval: 42 – 146

Minimum number known alive in September is 49
September Population Estimate: 97 95% Confidence Interval: 70 - 157

Population estimates for wild Wind River summer steelhead in August and September 2000 are 196 and 232, respectively (Table 3). The number of steelhead passing between these two surveys is estimated at 36 fish of which 11 were tagged. Since the trap was operational for 35 of 41 (0.88) days between these intervals for maintenance, we would have tagged 13 fish instead 11. The ratio of the population to tagged fish that occurred between the surveys is 2.8:1. This is within the range observed by Bradford et al. (1996) for snorkel and jumper estimates on the Kalama River.

Wild summer steelhead were observed to jump the falls through November 6, 2000. Therefore, the October 1 to October 31 ladder count (40) is multiplied by 2.8 to obtain a total population estimate of 112 for this period. From November 1 to January 31 a total of 25 wild summer steelhead were trapped, and accounting for some jumping through November 6, yields a total of 373 steelhead through January 31. During the 1999/00 summer steelhead run year, 137 of 140 (97.8%) wild summer steelhead were estimated to be have passed Shipherd Falls by January 31. If 2000-2001 timing is similar to the 1999-2000, then the wild summer steelhead run size is estimated to be 373/97.8%, or 381 steelhead. This estimate will be subject to revisions based on the actual number of summer steelhead trapped and snorkel surveys in the winter of 2001.

Table 3. Mark-Resight Population Estimation for wild Wind River summer steelhead on August 18 -19, September 22 - 29, 2000 using snorkel and Trout Creek trap observations.

Date	Marked Available	Marked Seen	Unmarked Seen	Lin.-Pet. Estimate	95% Confidence Interval
Aug 19	52	22	67	206.4	152.5 - 260.3
Aug 20	52	22	54	176.4	131.7 - 221.2
Sep 22	63	17	64	290.6	192.4 - 388.7
Sep 26	63	27	61	202.4	156.5 - 248.4
Sep 29	63	25	61	213.2	161.0 - 265.3

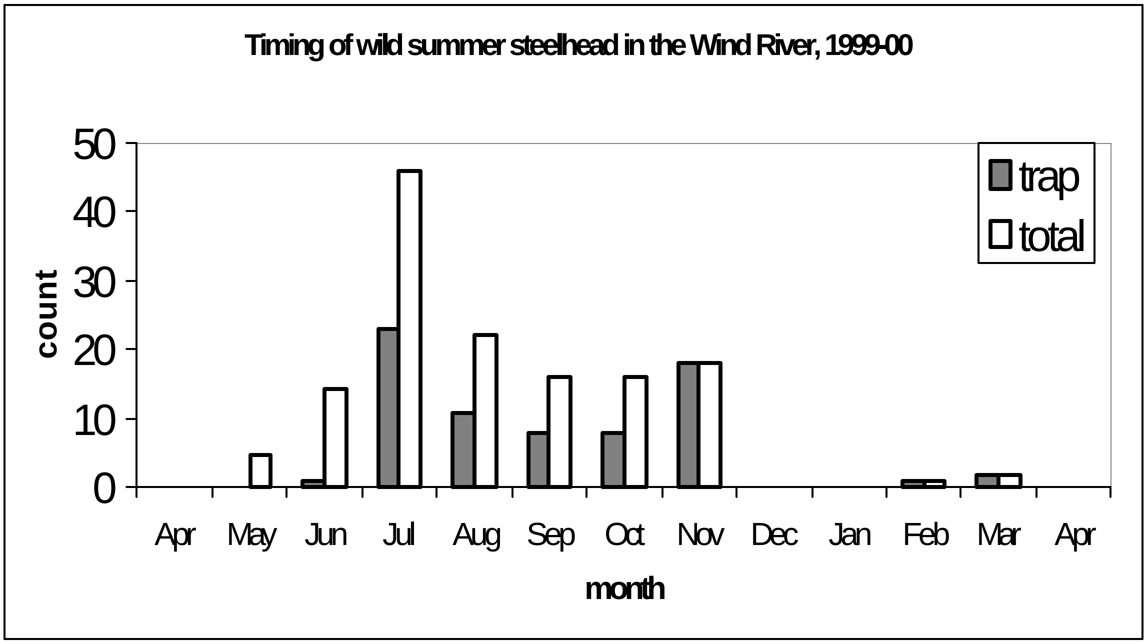
Minimum number known alive in August is 119
August Population Estimate: 196 95% Confidence Interval: 165 - 242

Minimum number known alive in September is 127
September Population Estimate: 232 95% Confidence Interval: 201 - 276

A total of 21wild steelhead were trapped in the Wind River between November 1999 and April 6, 2000. The Shipherd Falls trap was removed on April 6, 2000, to repair damage caused by the 1999 Thanksgiving Day flood. A total of 13 wild winter steelhead entered by April 1. In the NF Toutle River, 40% of the wild winter steelhead pass the trap prior to April 1 (Rawding 1998). On the Kalama River 32% pass prior to April 1 (WDFW, unpublished data). If the run timing in the Wind River is the same as these two rivers, then 13/40% or 33 to 13/32% or 41 wild winter steelhead are believed to have passed Shipherd Falls during the winter of 1999-2000.

Run Timing

Wild summer steelhead run timing in 1999-2000 and 2000-2001 is shown in Figure 1. Summer steelhead enter the river in April and continue until the following April. In both years peak entry into the Wind River occurred in July with a secondary peak in the fall. The secondary peak occurred in November for the 1999 run year and in October for the 2000 run year. In 1999 and in 2000 approximately 50% of the wild steelhead run had passed Shipherd Falls by the annual snorkel survey in mid-August.



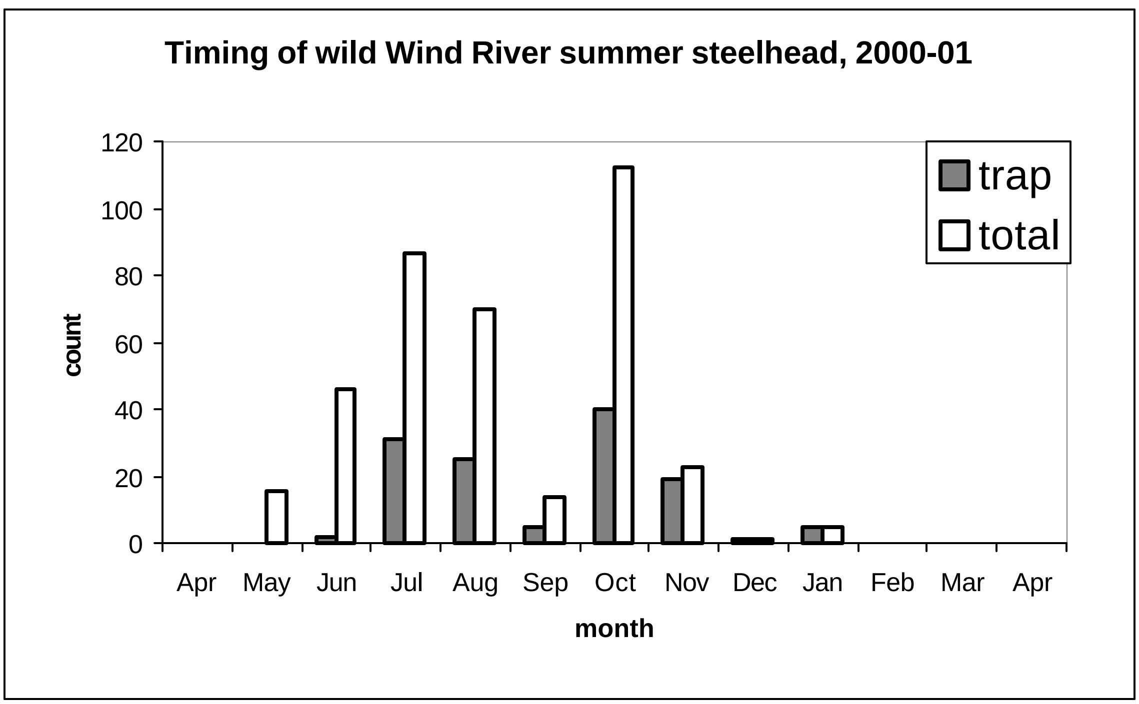
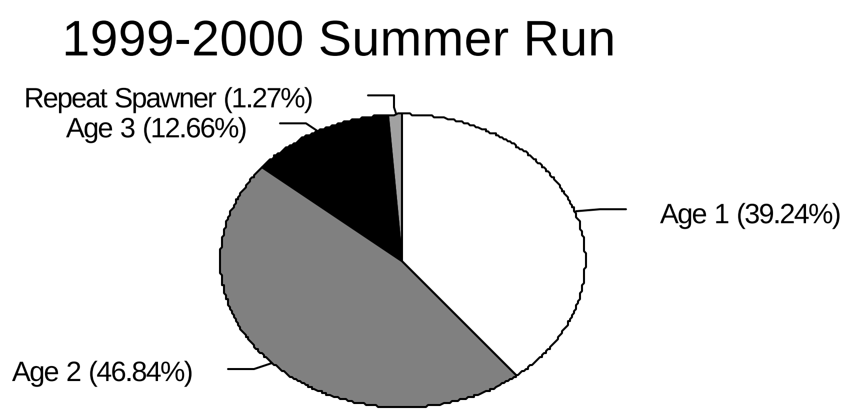


Figure 1. Timing of wild summer steelhead in the Wind River in 1999-2000 and 2000-2001.

Age of Adults

Scale analysis was used to determine saltwater age on 68 summer run and 20 winter run, wild steelhead during the 1999-2000 run year. An additional 11 summer steelhead were assigned to age classes based on the analysis of the length/age relationship and a length/age/run timing relationship. One winter steelhead that did not have readable scales was assigned to the 1^+ age group based on the location of a wire tag in its right cheek. Figure 2 contains the saltwater age composition for wild summer and winter steelhead during the 1999-2000 run year. The only repeat spawner (identified by partial re-absorption of the saltwater growth portion of the scales) had originally returned in 1998-99 after two years in saltwater. This individual would have re-emigrated following spawning in the spring of 1999, and returned in July after 2-4 months in saltwater, and therefore exhibited little additional growth between freshwater migrations. Figure 3 shows the length/age relationship for summer and winter steelhead.



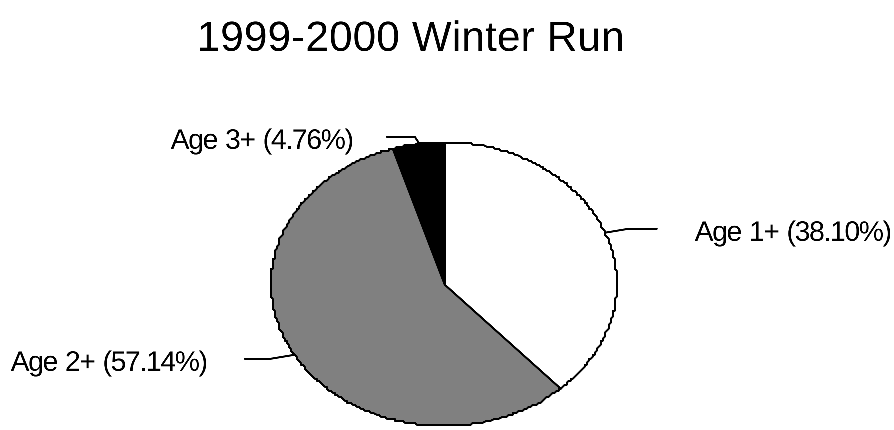
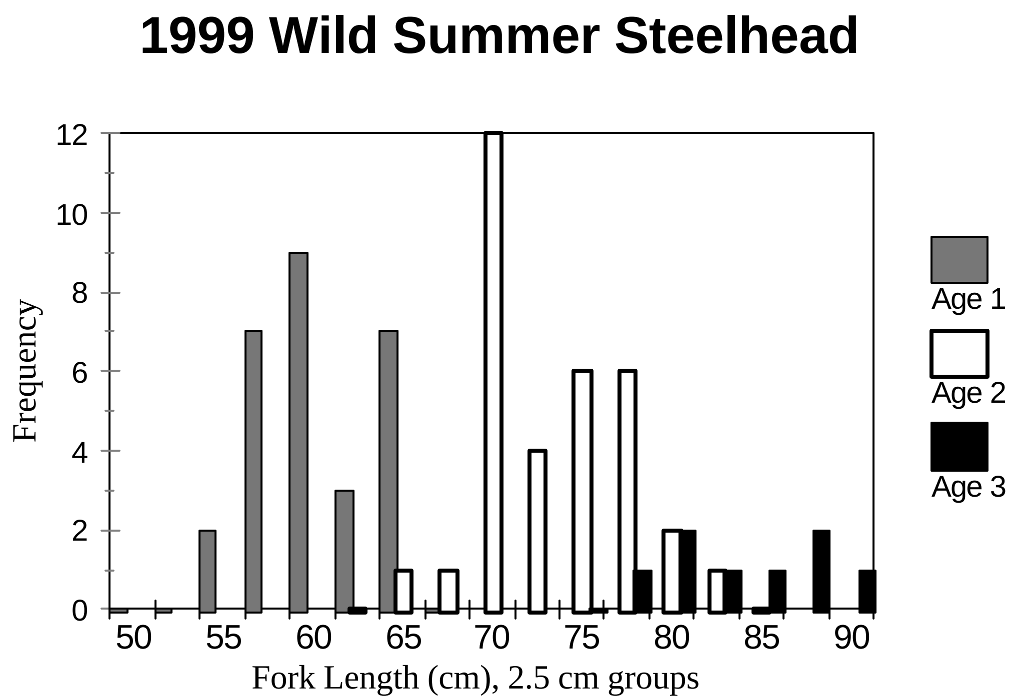


Figure 2. Preliminary ocean age composition of wild summer and winter steelhead trapped at Shipherd Falls, 1999-2000 run year.



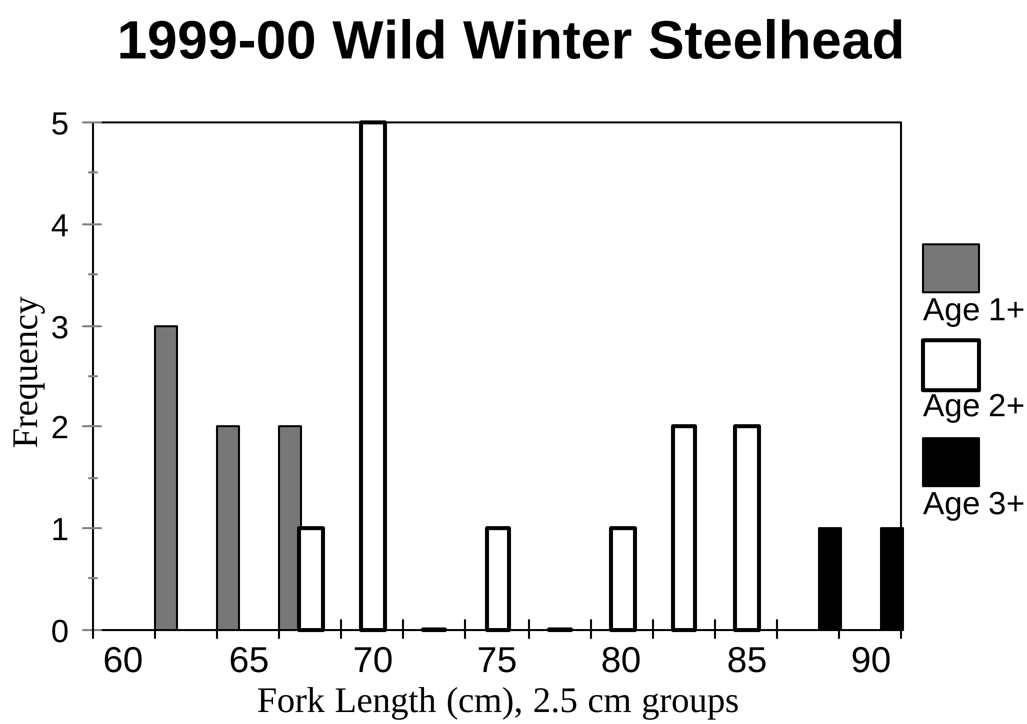


Figure 3. Preliminary wild summer and winter steelhead length frequencies by ocean age at Shipherd Falls, 1999-2000 run year.

Assumptions of the Petersen Estimator

The Petersen estimator can provide accurate and precise population estimates if the following conditions are met: (1) the population is closed; (2) no mark loss; (3) all marked fish are properly recognized; (4) marking has no effect on catchability; and (5) all fish have the same probability of being tagged in the first sample or all fish have the same probability of being captured in the second sample. Before the population estimates are presented we will review steps taken to minimize the violation of these assumptions:

(1) Population is closed; Closure usually implies that no animals enter or leave between the two sample periods. However, as long as the mortality rate is the same for marked and unmarked animals, the Petersen estimate is still valid (Arnason et al. 1996). We incorporated procedures to minimize adult mortality from sampling and handling stress, Prior to sampling adults were anesthetized. Fish were sampled as quickly as possible and were allowed to recover fully before being released into the ladder above the trap. We observed fish holding in the upper ladder for at least a few hours until they were full recovered. It appeared that most fully recovered steelhead then exited into the river between 2 and 24 hours after trapping. Occasionally, a fish stayed in the ladder up to 48 hours or more after trapping. This occurred in the winter during cold water temperatures when adult steelhead are known to enter a holding behavior. These procedures helped reduce stress and decrease delayed mortality.

(2) No mark loss; Schroder et al. (1999) indicated that when hatchery spring chinook were double floy tagged, 100% of the fish had retained at least one tag when they returned to the hatchery. In 1999, 40 out of 41 tagged steelhead were double tagged. During the course of snorkel surveys 15 of 17 observed steelhead with tags had both tags. Of the two fish with only one tag, one was known to be the same fish that was tagged only once based on the tag color and size of the fish. In 2000, 109 of 113 observed steelhead with tags had both tags. Total incidence of fish losing one of two tags based on 1999 and 2000 snorkel survey observations was 5/129 (3.9%).

To more accurately assess tag loss in fish tagged at Shipherd Falls a caudal punch was used as a secondary mark on all tagged steelhead. Some of the fish tagged at Shipherd Falls fall back and then reascend the fish ladder at a later date. The Trout Creek trap is in a tributary of the Wind River located upstream of the Shipherd Falls trap and a portion of the fish tagged at Shipherd Falls spawn above the Trout Creek Trap. All wild steelhead in the Trout Creek trap and Shipherd Falls traps were examined for tag loss. A total of 32 recaptured steelhead (those with tags or a secondary mark) have been handled in the traps in 1999-2000. Of these, 30 or 94% had both tags and 2 (6%) had lost one tag. In addition one steelhead tagged at Shipherd Falls in September 1999 returned as a repeat spawner in 2000 and it had retained both tags. Overall tag loss on recaptured steelhead is 2/66 (since all 33 fish originally had two tags), or 3%. The probability of any one fish losing both tags is (3%*3%), or 0.09%.

(3) All marked fish are properly recognized; To meet this observation criteria, 1¼ inch floy tags were placed at the dorsal on both sides. The colors used were fluorescent hot pink, chartreuse, blue, and white. All of these colors provide good contrast in clear water, and against the dark background of the river bottom and fish's backs. Visibility in the Wind River is typically 20+ feet during August and September snorkel surveys. All tags were treated with algae fungicide to minimize algae growth and maintain maximum visibility. Most snorkelers actually look down on steelhead as they pass under them and see both tags. Double tags allowed snorkelers to identify tagged fish even if they only have a side view. During snorkeling a percentage of the fish are classified as steelhead but it is unknown if they are tagged or not. This usually occurs as a snorkeler encounters fish in turbulent fast whitewater, where either the anterior or posterior of the fish is observed. Unknown fish are not used in the population estimate.

(4) Marking has no effect on catchability; This is a difficult assumption to test since catchability for this experiment is defined as observing a fish while snorkeling. The potential bias is that snorkelers observe tagged fish at a higher rate due to the presence of a bright tag. If this is the case the Petersen estimate will be biased low. The minimum size of adult summer steelhead in 1999 was 57 cm and the fish averaged 68 cm. When snorkeling most observers noted that they saw the fish first and then noted if it was tagged or untagged. Due to the large size of the steelhead, we think the potential bias resulting in unequal observations between tagged and untagged fish is low.

(5) All fish have the same probability of being tagged in the first sample or all fish have the same probability of being captured in the second sample; This assumption is difficult to validate using sample data alone and is likely to cause most the bias in the Petersen estimator. The probability that all fish have the same likelihood of capture in the first sample may not always be met due to differences in migration patterns. For example, Shipherd Falls is a barrier to steelhead at high flow and when water temperatures are low. Therefore during these periods a higher percentage of steelhead use the ladder. In addition, thousands of hatchery spring chinook adults migrate past the trap on their return to Carson National Fish Hatchery. During peak passage over 100 fish/day and in some years up to 1000 fish/day may pass through the ladder. Current funding does not allow personnel to work the trap 24 hours a day between early May and mid-June to sort the few steelhead from the thousands of spring chinook. Therefore, the trap does not operate during this time.

The extent of bias due to these potential violations is unknown. Wild summer steelhead are known to hold in portions of the mainstem Wind River up to Paradise Creek (RM 22), and in Trout and Panther creeks. Population estimates are made from snorkel observation in mainstem Wind River from the trap to Dry Creek (RM 19) and the Trout Creek trap count in August and September. If sufficient personnel are available, up to 5 miles of Panther Creek may be snorkeled. Snorkel survey results indicate that tagged and untagged fish are found in all sections. The few tagged fish observed in 1999 did not allow any comparison of tagged and untagged fish by sections. However in 2000 snorkel surveys indicate that tagged steelhead are observed from the upper most survey sections to the lowest sections in the mainstem Wind River. The Trout Creek trap data for 2000 indicated that only untagged steelhead entered the trap by the August and September surveys, indicating the potential that fish passing during May and June may distribute differently. This would affect the probability of second capture because uppermost sections are not surveyed, or the snorkeling efficiency in these uppermost sections may be different than in other sections due to very low water. As more data becomes available we will be able to more accurately assess this assumption.

Data accuracy and precision

It is important to develop unbiased, accurate, and precise estimates of smolt production in the Wind River. Robust wild steelhead adult estimates are needed by the NMFS and WDFW to assess the status of steelhead in the Wind River and are needed by the USFS and BPA to evaluate the effectiveness of habitat restoration projects that they have funded. Robson and Regier (1964) identified that investigators should target 95% confidence limits for the population estimate at ± 25% for management and ± 10% for research applications. Since the confidence limits are asymmetrical we took the range and divided by 2 to estimate the 95% confidence interval. The precision of the estimates is found in Table 4. The September snorkel estimates improved from ± 45% in 1999 to ± 16% in 2000. This was primarily due to three factors: 1) we tagged 50% more fish in 2000, 2) we increased the number of snorkel surveys from two in 1999 to three in 2000, and 3) the snorkel efficiency increased from 14%-20% in 1999 to 27%-43% in 2000. It is not presently possible to put confidence intervals on the estimates of the number of steelhead successfully jumping the falls from the end of the snorkel survey to October 31. During the winter of 2001 Trout Creek trap catch and winter snorkeling will provide us with estimates of the summer steelhead population and the confidence intervals. Finally, since summer steelhead are not observed jumping the falls for the remainder of the run year, the trap count is the estimate and the 95% confidence interval is ± 0%.

Table 4. Estimates of wild summer steelhead by period from May 1999 to January 2000.

	1999	1999		2000	2000	
	Period	Pop	1999	Period	Pop	2000
Period	Estimate	Estimate	95% CI	Estimate	Estimate	95% CL
> Aug Snorkel	75	75	± 71%	196	196	± 20%
> Sep Snorkel	22	97	± 45%	36	232	± 16%
Sep Snorkel -Nov 1	22	119	NA	112	344	NA
Nov-Jan	18	137	± 0%	29	373	± 0%
Jan-Apr	3	140	± 0%	8*	381*	± 0%

* Estimate expanded based on run timing in 1999.

The wild winter steelhead estimate has a 95% confidence interval of + 0% when the trap is operational. The trap only operated until April 5, 2000 and in most years we do not expect that it could operate beyond May 1 due to large returns of hatchery spring chinook. The hatchery spring chinook return to Wind River in 1999 was estimated to be 12,000 and approximately 90% of these fish are estimated to pass through the Shipherd Falls trap in May and June. Given the trap facilities and staffing it will be difficult to trap during the end of the wild winter steelhead run in May. Run timing in the Kalama and Toutle Rivers suggest approximately 75% of the wild winter steelhead enter by May 1

(WDFW, unpublished). Trapping through late April should provide a more accurate estimate but it will be difficult to determine confidence limits using this methodology.

Population variation and population goals

Figure 4 is the wild summer steelhead abundance as measured by snorkel surveys. This data indicates that wild abundance was highest in the initial monitoring year and dropped to a relatively stable level between 1989 and 1996. The snorkel abundance declined to the lowest levels from 1997 to 1999 and the abundance rebounded in 2000 to just slightly less than the stable period from 1989 to 1996. It should be noted that the August snorkel survey abundance estimate was only 12% and 20% of the mark recapture estimate in 1999 and 2000, respectively. During the periods of low abundance in 1997 and 1998, we reasoned that more hiding places were available for wild fish. During periods of higher abundance we believed that it fish tended to pool more and we saw a higher percentage of the fish. Therefore, we used a linear regression between our two data points to establish a relationship between wild steelhead population estimate and the August snorkel count. To approximate the number of wild summer steelhead run size in the Wind River in previous years, we used equation (2). This approximation of wild steelhead run size will be reviewed in the next annual report.

$$\text{Wild Steelhead Pop. Estimate} = 73.05 + 3.87 * (\text{Aug Snorkel Count}) \qquad (2)$$

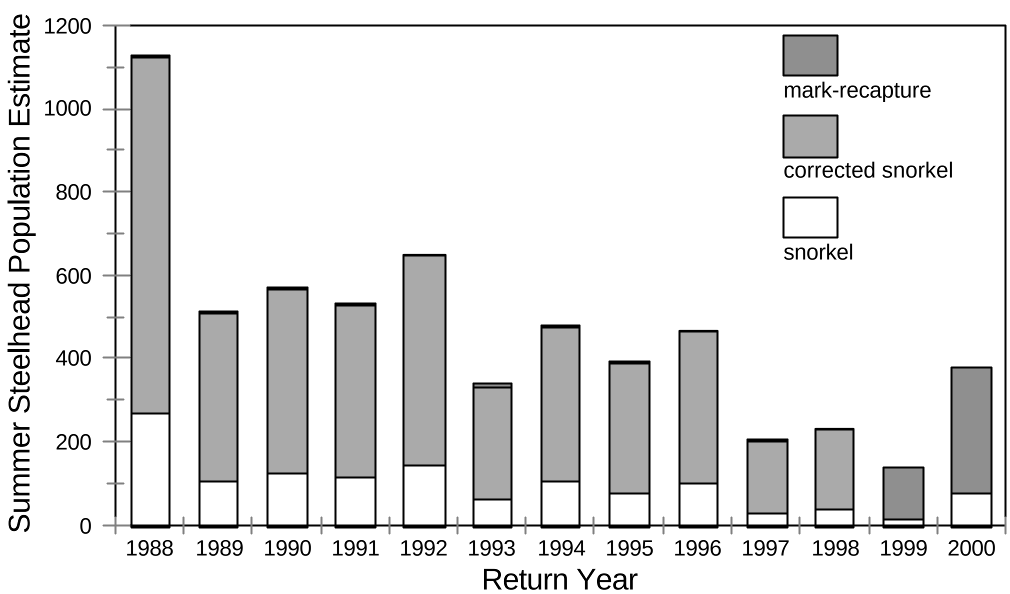


Figure 4. Annual snorkel counts and population estimates of wild summer steelhead in the Wind River, 1988-2000.

Adult counts were made in the Shipherd Falls ladder between 1962 and 1964 to evaluate the effectiveness of the hatchery spring chinook program at Carson National Fish Hatchery. Skamania Stock hatchery summer steelhead were first released into the Wind River in 1961 and since Skamania Stock has few 1-salt steelhead, the 1962 return is believed to consist of almost all wild steelhead. The 1963 and 1964 returns are influenced by an unknown number of hatchery steelhead. Since trapping in 1999 and 2000 took place from July through October, we compared these wild counts to the 1962 count. The 1999 and 2000 counts for this period are 50 and 101 fish, respectively. The count in 1962 was 454, which is four times greater than the 2000 count and nine times greater than the 1999 count (Table 5).

Table 5. Shipherd Falls ladder counts for wild Wind River steelhead.

Run Year	April	May	June	July	August	September	October	Jul - Oct	Total
1962	43	231	532	196	68	96	94	454	1250
1963*	20	139	240	103	53	19	5	181	580
1964*	0	102	110	214	12	41	21	288	500
1999	NA	NA	NA	23	11	8	8	50	50
2000	9	NA	NA	31	25	5	40	101	110

* Hatchery steelhead are included with the wild steelhead totals during these years.

The Technical Advisory Committee of the Columbia River Fish Management Plan established an escapement goal of 1000 wild summer steelhead. The wild summer steelhead escapement in 1999 and 2000 was estimated to be 140 and 381, respectively. These runs sizes are between 14 % and 38% of the TAC escapement objectives. In 1985 WDFW estimated the total steelhead escapement goal for the Wind River should be 1557 wild steelhead. Further analysis indicates that the escapement goal above Shipherd Falls should consist of 1480 summer and winter steelhead. A total of 140 wild summer and 41 wild winter steelhead passed Shipherd Falls in 1999-2000. This is 12% of the WDFW escapement goal. The run size estimate of 381 in 2000 is 68% of the short-term escapement objective of 500 spawners that was established by the interagency work group.

Summary

The 1999 and 2000 steelhead counts were the **first** complete estimates of run size for wild summer and winter steelhead in the Wind River. Current estimates indicate the wild summer steelhead population is rebuilding and approaching the short-term goal of 500 adult spawners but well below the minimum long-term escapement objective of 1,000 adults. Based on ratio of current snorkel surveys to the mark-recapture population estimates, we developed a methodology to estimate the wild summer steelhead population from 1988 to the present from past snorkel surveys. The adult monitoring component is an essential part of the Wind River life cycle monitoring program, which also includes juvenile monitoring components. The intent of the life cycle monitoring program is to evaluate habitat restoration projects relative to freshwater survival and productivity. From adult trapping and escapement data, we are able to estimate potential egg deposition, egg to fry, egg to parr, and egg to smolt survival. Continued unbiased, accurate, and precise estimates of wild adult steelhead are needed by WDFW to assess the status of this stock, and NMFS to determine if this population still needs protection under ESA.

Acknowledgements

Several individuals and agencies contributed to the success of this project. WDFW Habitat Program (SHEAR staff) designed and installed the adult fish trap; we appreciate the efforts of Tom Burns for coordination, and Tom McClure and Greg Locken for fish ladder maintenance & repair, and trap installation & repair. Dan Blatt (WDFW) and his crew assisted with the fish ladder clean out of over 66 cubic yards of debris, sediment, and gravel deposited in upper most section of the fish ladder from the November 25, 1999 flood. Tim King and Brian McNamara (WDFW) assisted with the tagging of wild summer steelhead at the Shipherd Falls trap. A crew of dedicated individuals from WDFW, USFS, YN, USGS-CRRL, USFWS, Clark-Skamania Flyfishers, and other volunteers successfully snorkeled the Wind River and recorded the number of tagged and untagged steelhead used in the population estimates. USFS personnel provided data from the Trout Creek trap that was also used in some of the population estimates. Mike Faler (USFWS) introduced us to the paper by White (1996) and the Noremark program. Finally, we would like to thank John Baugher (BPA) for providing support and the resources needed for this project.

References

Arnason, A. N., C. W. Kirby, C. J. Schwarz, and J. R. Irvine. 1996. Computer analysis of data from stratified mark-recovery experiments for estimation of salmon escapement and other populations. Canadian Tech. Report of Fisheries and Aquatic Science 2106. 37p.

Bradford, R. H., S. A. Leider, P. L. Hulett, and C. W. Wagemann. 1996. Differential leaping success by adult summer and winter steelhead at Kalama Falls: implications for estimation of steelhead spawner escapement. Washington Department of Fish and Wildlife. Fish Management Program Report No. RAD 96-02. Olympia.

Bryant, F. G. 1949. A survey of the Columbia River and its tributaries with special reference to its fishery resources. 2: Washington streams from the mouth of the Columbia River to and including the Klickitat River (Area 1). U.S. Fish and Wildlife Service. Spec. Sci. Rep. No. 62.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Oregon, and California. U.S. Dept of Commerce, NOAA Tech. Memo. NMFS-NWDSC-27, 261p.

Gibbons, R. G., P. K. Hahn, and T. H. Johnson. 1985. Methodology for determining MSH steelhead spawning escapement requirements. Washington State Game Department, Fisheries Management Division. 85-11. 22p.

Hudson, D. J. 1971. Interval estimation from the likelihood function. J. Royal Stat. Soc. Series B 33:256-262.

Lucas, B., and R. Nawa. 1985. Wind River steelhead survey and management analysis. Wash. State Game Department. Fisheries Management Division 86-04, 22p.

McMillan, B. 1981. Wind River controversy. Salmon, Trout, and Steelheader: June - September, 1981.

Rawding, D. 1998. A methodology for estimating the adult wild winter steelhead sportfishing mortality in the Lower Columbia River. Washington Department of Fish and Wildlife, unpublished draft. 16pp.

Robson, D. S., and H. A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society 93:215-226.

Schroeder, R. K., K. R. Kenaston, and R. B. Lindsay. 1999. Spring chinook salmon in the Willamette and Sandy Rivers. Fish Research Project Annual Progress Report. Oregon Department of Fish and Wildlife. Portland, Oregon.

TAC (Technical Advisory Committee). 1991. 1991 - All species review: Columbia River fish management plan.

Thurow, R. 1994. Underwater methods for study of salmonids in the intermountain west. USDA Forest Service, General Technical Report INT-307.

Venzon, D. J., and S. H. Moolgavkar. 1988. A method for computing profile-likelihood based confidence intervals. Appl. Stat. 37:87-94.

White, G. C. 1996. Program NOREMARK software reference manual. Department of Fish and Wildlife, Colorado State University, Fort Collins.

WDFW (Washington Department of Fish and Wildlife). 1997. Stock status update for steelhead in the lower Columbia River, Washington. Washington Department of Fish and Wildlife, Olympia, WA.

Wind River Watershed Restoration

Volume IV: Restoration Activities

1999 Annual Report

September 2001

Edited by:

Patrick J. Connolly

U.S. Geological Survey
Columbia River Research Laboratory
5501-a Cook-Underwood Road
Cook, WA 98605

Prepared for:

Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number: 1998-019-01
Contract Number 00004973
(previously 98-AI-09728-002)

Volume IV: Physical Habitat Monitoring

Contents

Report G: Sediment Monitoring

Wind River Watershed Project

1999 Annual Report

September 2001

Prepared by:

Kenneth Wieman
And
Marshall Barrows

USDA Forest Service
Mt Adams Ranger District
2455 Highway 141
Trout Lake, WA

Abstract

Fine sediment is one useful measure of stream health (Young 1991). Reduction in salmonid production is linked to fine sediment production (Maret et al. 1993). Some adverse effects of increased fine sediment loads include the following: loss of juvenile salmonid rearing habitat, increased water temperatures, declines in aquatic primary production, and loss of suitable spawning habitat. Our methods were to collect randomly stratified sediment samples at suitable spawning sites in seven streams in the Wind River Watershed using the McNeil core sediment sampler. Our analysis evaluated the relative abundance of fine sediment (< 0.84 mm). We compared the abundance of fine sediment between streams for two different sampling periods (1998 and 1999 field seasons). We also evaluated the spatial distribution of fine sediment measured in 1999 within each of the seven streams. Our results indicated that there was relatively little net change between sampling periods (-2.5% to 3.6%) in Layout Creek and Paradise Creeks, respectively. The distribution of fine sediment within each stream was related to channel position. In each of the seven streams sampled the relative abundance of fines increased as samples proceed downstream. Based on two years of data we concluded that fine sediments in suitable spawning sites do not reach a threshold (12-18%) that could inhibit salmonid egg to fry survival. Although the McNeil sampling procedure is labor intensive, it is a reliable and valid means of assessing fine sediments. We recommend that sampling be intensified and include areas outside of suitable spawning habitat to look for local trends. In conjunction with other large-scale stream restoration and monitoring activities currently occurring throughout the Wind River Watershed, an intensive steelhead spawning site substrate analysis has been initiated to assess and compare the amount of fine sediment in suspected spawning gravel of seven sub-watersheds within the Wind River Watershed. Thirty-two core samples were taken from potential steelhead spawning sites in each of seven streams, providing a total of 224 samples.

Introduction

This report is intended to function as a reference to aid in the planning, design and analysis of future management activities and research in the Wind River Watershed. Future analysis of this material as well as comparing it with other habitat and wildlife monitoring data would prove to be beneficial.

Healthy streams, even though they may be considered stable and free from various land use activities, are characterized by a continuously shifting equilibrium. The sediment of a stream is constantly being broken down, transported, and deposited. Pools may be scoured of deposited sediment at high flows while riffles may be filled. The opposite may occur at lower discharge levels. Forest management and related road practices throughout the Wind River watershed over the last century have resulted in degraded riparian habitat, detrimentally altered stream channels, and sediment loading. These aforementioned influences upset the stable equilibrium found in healthy streams. This loss of equilibrium and habitat degradation potentially results in elevated water temperatures, insufficient vegetation in and around streams, loss of suitable spawning habitat, and excessive fine sediments in spawning areas. Fine sediment reduces the flow of water through spawning gravel, effectively reducing the amount of dissolved oxygen (DO) delivered to incubating fish eggs. Survival to emergence tends to decrease as the amount of fine sediment increases in the incubation environment (Maret et al. 1993). Therefore, to attain our fish management objectives, land managers must be able to recognize whether fine sediment has reached a critical threshold where salmonid populations are adversely affected.

The goals of stream habitat management are to protect or improve stream habitat such that fish populations can be sustained or increased. This often entails restoring degraded habitat to a historic condition. Areas in need of restoration work are sometimes not easily detected by simple visual examination. For this reason, there exists an imperative need for physical habitat monitoring.

This project is a continuation of an intensive spawning site substrate analysis that was initiated in 1988. This data will serve as a monitoring tool for large-scale instream and riparian area restoration activities currently occurring throughout the Wind River Watershed. In this report, the sediment composition data has been compared with other habitat monitoring data sets as well as other land use activities.

Monitoring and evaluation efforts will serve to characterize the sediment regime in the Wind River Watershed. This study will identify problem areas and prioritize restoration projects. Additionally, sediment sampling efforts will serve to monitor ongoing restoration efforts in the watershed, and what habitat treatments will be needed in specific areas.

Study Area

A total of seven sub-watersheds within the Wind River watershed were sampled during this study: Dry Creek, Layout Creek, Martha Creek, Panther Creek, Paradise Creek, Trapper Creek, and the Upper Wind River (Figure 1; Appendix Figures G-1, G-2, and G-3). These creeks were chosen for the study due to their relative importance as potential steelhead spawning habitat and uniform channel character.

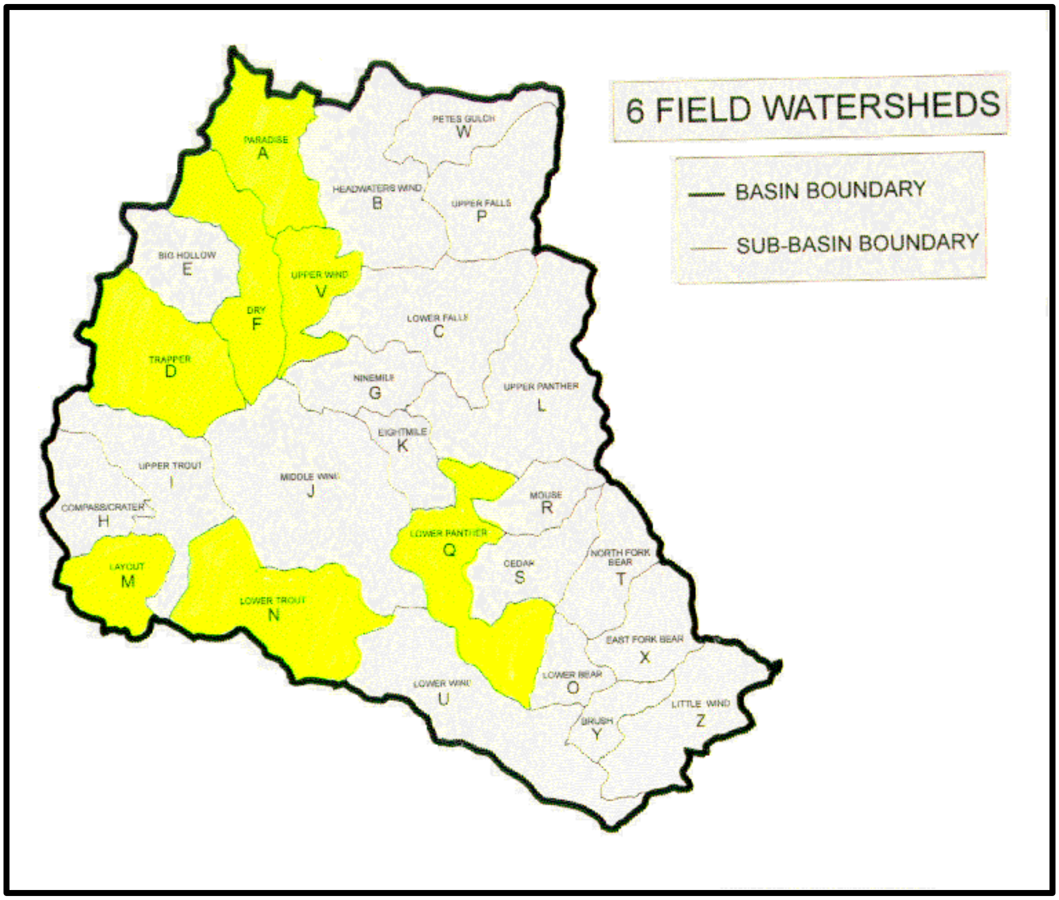


Figure 1. Map of Wind River watershed identifying the seven sub-watersheds where sediment samples were collected, Skamania County, Washington.

Methods

Introduction to sediment sampling

Salmonid spawning area sediment research and methods vary according to monitoring objectives. We adapted our methods to accommodate our specific limitations including: budget, available research staff and facilities, and watershed characteristics.

The fisheries program at the Wind River Information and Work Center in the Gifford Pinchot National Forest (USDA Forest Service) has developed and adopted a method for salmonid spawning site sediment monitoring and analysis. This method utilizes the McNeil Core sampler. The Yakima River Resource Management Plan (YRRMP), the Yakama Nation (YN), and the report issued by Young et al. (1991) support the accuracy of this sediment sampling technique.

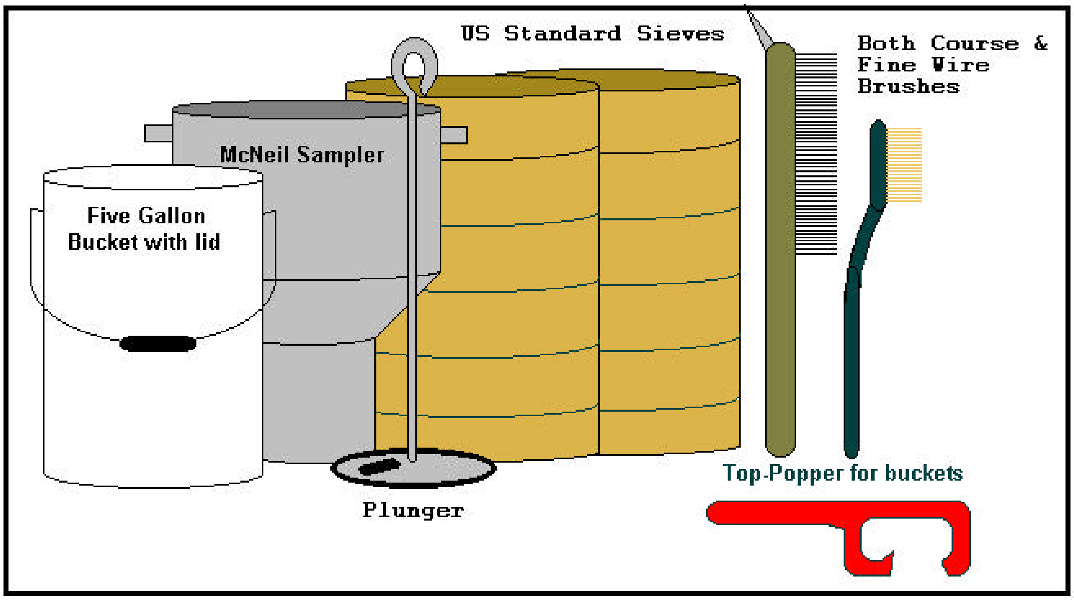


Figure 2. Sediment sampling tools and equipment used in the Wind River study area, Skamania County, Washington.

Sediment sampling tools and procedure

Following is a detailed description of sampling equipment and procedures followed in the Wind River sediment study protocol.

Tools

1. It is necessary to have 32 five-gallon buckets available for each stream that is to be sampled (Figure 2). They must be clean, have significantly sturdy handles, and each must have a snug-fitting lid. In the 1999-2000 sampling season, seven streams were included in the research project. This means it was necessary to have at least 224 buckets with lids to complete the survey. Additional buckets and lids can be obtained for no cost from the International Yogurt Company (sometimes they are called Yocream International), and they can be reached at 503-256-3754. It often takes them a week or two to accumulate many buckets, so plan accordingly and contact them early. They are located off of Columbia Avenue in Portland, Oregon.

2. A tool for removing the lids from the buckets is very helpful because the lids fit extremely tight and are not easily removed by hand. There is a red top-popping tool with the rest of the sampling equipment (Figure 2).

3. A thermometer is needed to monitor water temperatures at each spawning site that is sampled.

4. Permanent markers are needed for marking and writing on flagging to identify potential sample sites and to label sediment samples in the buckets.

5. Pencils instead of pens are preferable to be used when writing on the data sheets because they do not smear as readily as pens do when exposed to the elements.

6. A good clipboard with sediment sampling data field forms that have been printed on Rite-in-the-Rain paper. This paper is water-resistant and does not fall apart and lose its integrity when wet.

7. A tape measure is needed to measure the wetted width of each riffle that is sampled.

8. One hip box is necessary. It is used to measure the quarter mile sections of the creek that is to be sampled.

9. At least one but preferably two McNeil samplers are needed to extract the core samples from the selected sites (Figure 2). Use only the McNeil core samplers that have six-inch diameter necks and penetrate the gravel to six inches. A sampler with a longer neck does not work as well because it penetrates too deeply and often hits bedrock or excessively large rocks making good samples difficult to attain.

10. At least one complete set of twelve standard sieve screens is needed at screen opening sizes of 76.1 mm, 50.0 mm, 25.0 mm, 12.5 mm, 9.51 mm, 6.35 mm, 4.76 mm, 2.36 mm, 1.70 mm, 0.841 mm, 0.425 mm, and 0.297 mm. Be sure to use twelve-inch diameter sieves (Figure 2).

11. One automated sieve shaker is needed to sufficiently shake the sediment samples through the various sized sieves in a consistent manner. The shaker at Wind River holds exactly five sieves at a time, no more and no less. This shaker needs to be on without a load for about ten minutes to warm it up (especially in lower temperatures).

12. Samples are dried on plastic-lined trays and stacked on carts that are placed in a ventilated drying tunnel (a kiln in the Wind River Nursery Seed Extractory building).

13. An accurate Metler scale is needed to weigh the dry sieved samples. There is one in the Seed Extractory that is available for use at Wind River.

14. A hose with a spray nozzle is needed as a source of water at the Seed Extractory. There is no working indoor plumbing. Water can be obtained from the fire hydrant in the parking lot via hose.

Sediment sampling procedure

Clarke and Scruton (1997) assessed the use of modified Whitlock-Viebert boxes for measuring fine sediment and determined it as one viable method for studying fine sediment accumulation in streams. Gee (1979) compared gravimetric and photographic methods of stream substrate analysis and determined that photography can be used only to accurately determine the composition of surface, and not sub-surface sediment. Young et al. (1991) determined that the McNeil Sampler was a reliable tool for sediment sampling. At the Wind River Information and Work Center, the facilities available proved more functional for the use of the McNeil Sampler method of sediment collection and processing.

This study was designed to gather spawning site sediment composition information in the Wind River Watershed. Nine total sub-watersheds were selected in 1998 to be included in this study. These sub-watersheds were selected for the current forestland management activities in the particular areas and also due to slope and soil stability. In the 1999-2000 sampling season, seven of the nine sub-watersheds sampled include Dry Creek, Layout Creek, Martha Creek, Panther Creek, Paradise Creek, Trapper Creek, and Upper Wind River. Middle Wind River and Trout Creek were not sampled in the 1999-2000 season. Maps of the seven streams are provided in Appendices D-1 to D-3.

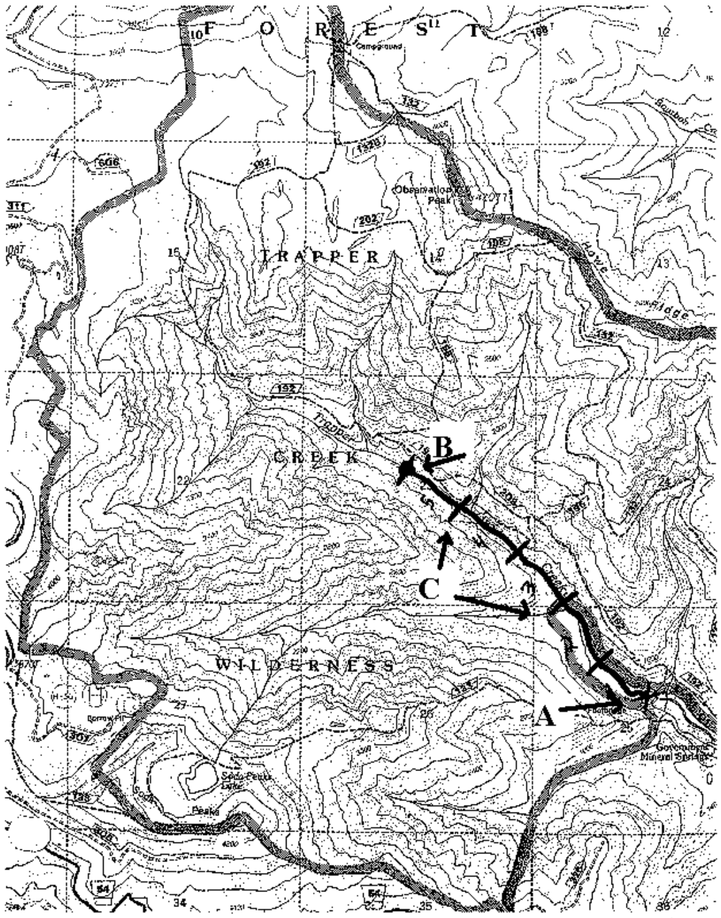


Figure 3. Sampling regime used on the Wind River sediment survey. This figure demonstrates random stratification of ¼-mile segments (C), starting points (A), and ending points (B) on a map.

For each individual stream, determine a starting point and an end point prior to heading out to the field. The starting point (A in Figure 3) is downstream from the end point (B in Figure 3). Always start downstream and work your way upstream to avoid the potential contamination of future samples by disturbing upstream sediment. Using the hip box, start at the starting point and measure and flag ¼-mile segments. While doing this, identify and flag all potential spawning sites within the segments and record how many there are total in each ¼-mile segment. Flag the segments: "START SEGMENT 2 SEDIMENT 1999". Flag the spawning sites: "SEGMENT 2 SITE 1 SEDIMENT 1999", or some variation of these suggestions. Mark where each segment starts and ends on your map (C in Figure 3).

Randomly select four segments per stream (if the stream section being sampled is at least one mile long). Randomly select two of the marked/flagged sample sites in each of your chosen ¼-mile segments (Figure 4).

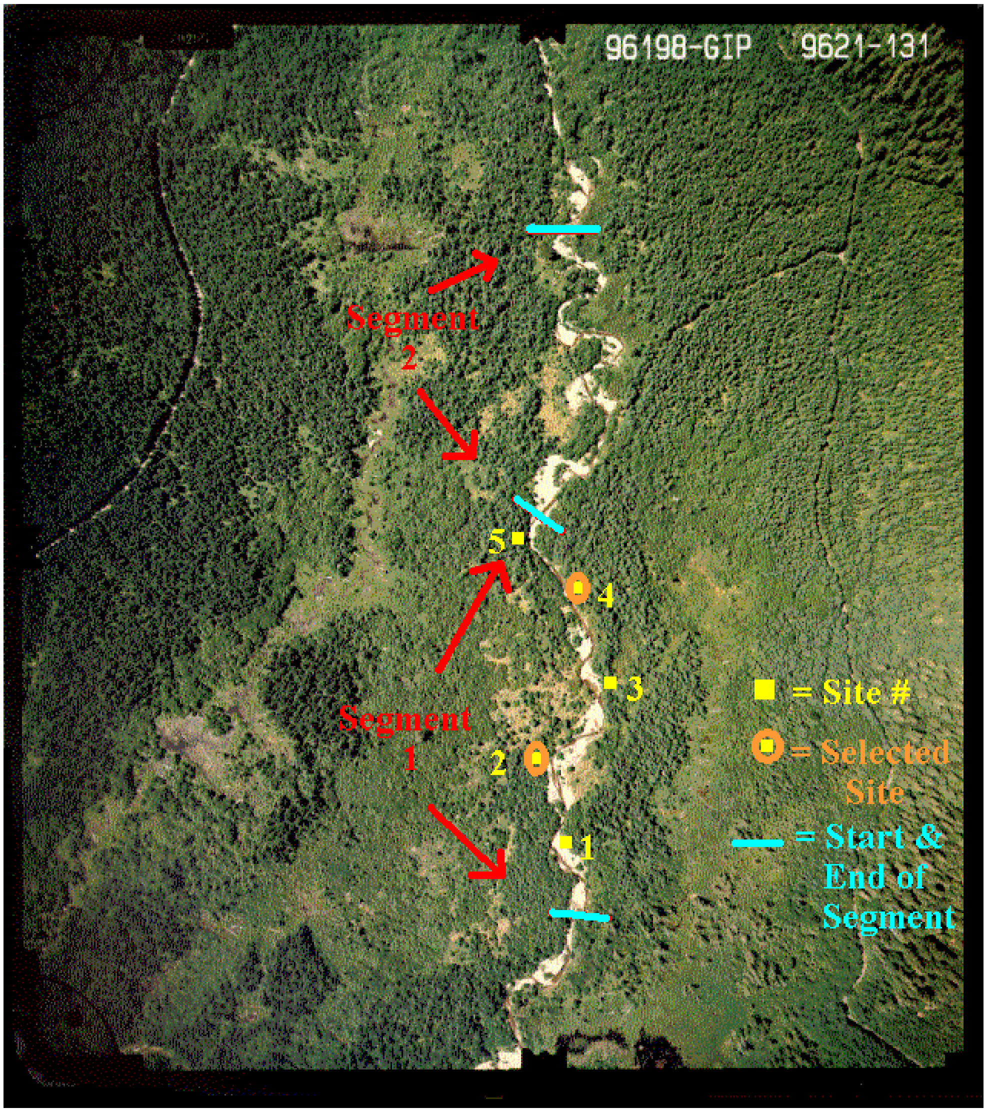


Figure 4. Spawning site-sampling regime used in the Wind River sediment study. This air photo indicates sample sites within selected stream ¼-segments of the Wind River watershed, Skamania County, Washington.

Potential steelhead spawning sites are likely to be found at the tail of a pool where water is slowed down and is approximately 3 to 18 inches deep with good spawning gravel for successful steelhead reproduction (Figure 5).

When sampling the chosen site, start downstream and sample moving upstream (Figure 6). While remaining as random as possible, place the McNeil core sampler on the gravel of the site and, while applying substantial downward pressure, work the neck of the sampler into the sediment. Numerous times during this process, excavate the sediment from within the neck to the collection bowl on the sampler.

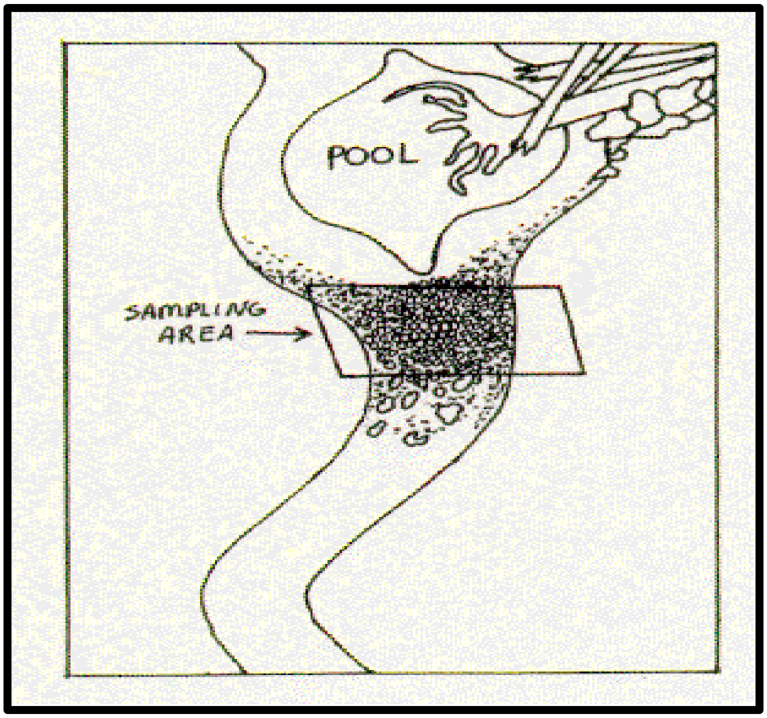


Figure 5. Plan view of representative channel with a potential spawning site in the pool tail-out.

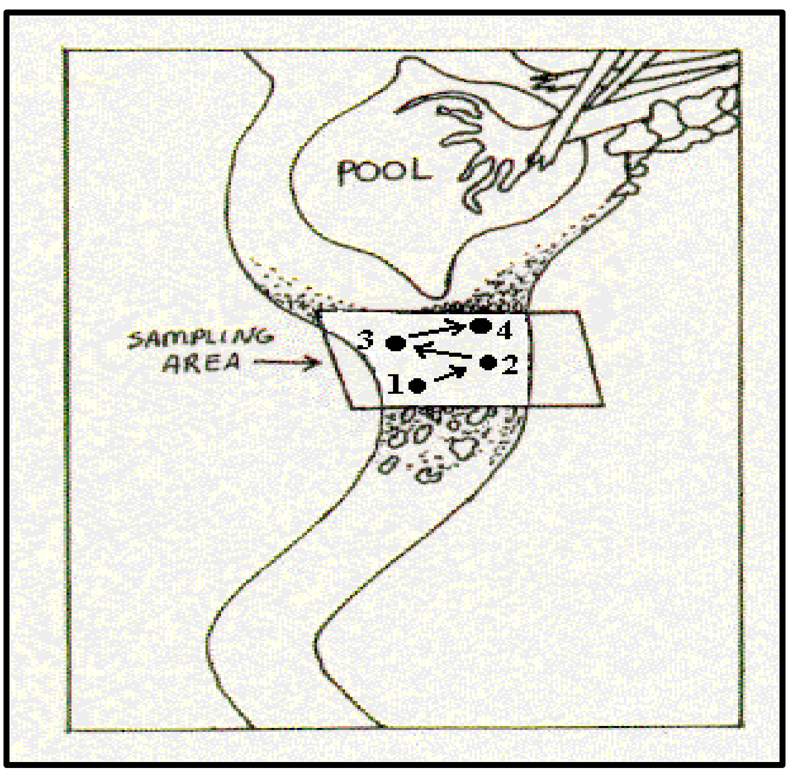


Figure 6. Upstream sampling technique used in the Wind River sediment study, 1998-1999, Wind River basin.

A complete sample is taken when the outside lip/bowl of the sampler is flush with the surrounding gravel and the sediment is excavated completely until even with the bottom lip on the neck of the McNeil sampler (Figure 7). Often (very often) multiple attempts must be taken to obtain a good sample due to hitting rocks that are too big to be sampled or bedrock is reached. In larger sites and when it will not disturb the sampling area, two McNeil samplers can be utilized when two people are working at the site to speed up the process.

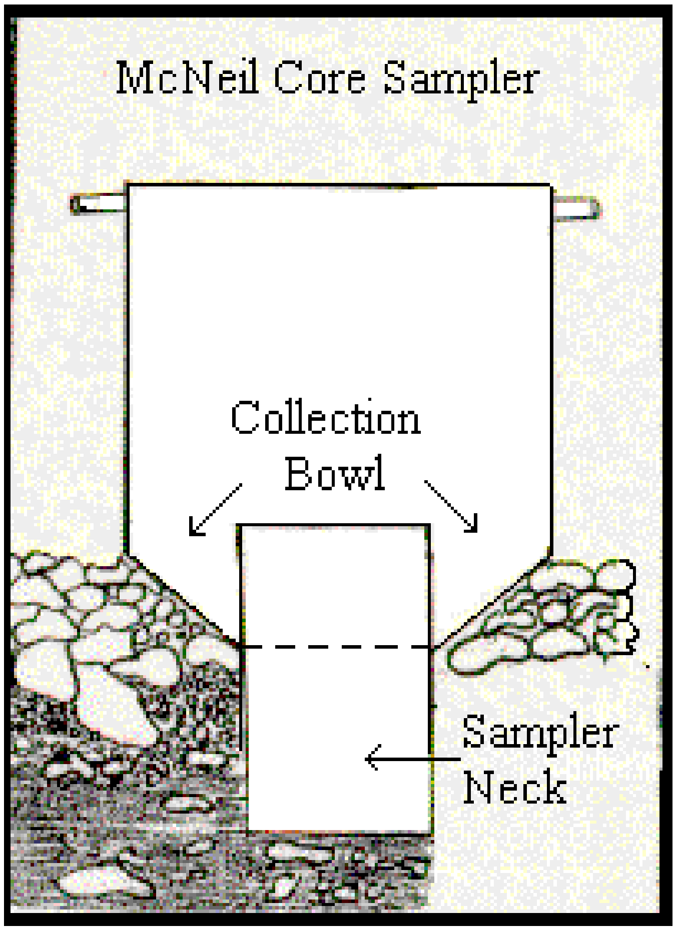


Figure 7. Cross sectional view of the McNeil Core Sampler use in the Wind River sediment study. This drawing shows the proper insertion of the McNeil Core Sampler into the substrate, 1998-99, Wind River, WA.

When finished excavating the sediment from the neck of the sampler, insert the plunger into the neck and all the way to the bottom lip, then pull it up slightly (Figure 8). Grasp the plunger and the sampler firmly, then lift the sampler into a 5-gallon bucket; release the plunger and remove the collected sediment into the bucket, paying special attention not to lose any of the sediment. The plunger has a one-way valve on it so water and suspended fine sediment is let into the neck of the sampler, but not allowed to drain out when the sampler is picked up. Be sure to rinse out the sampler before beginning the next sample. After finishing sampling, be sure to label (by using flagging) each sample both inside the bucket and outside the bucket (tied to handle). An example of how to label the samples would be "LAYOUT CREEK SEGEMENT 2 SITE 1 SAMPLE 1". Secure lids tightly on the buckets and move buckets to a flat, high spot and not on game trails.

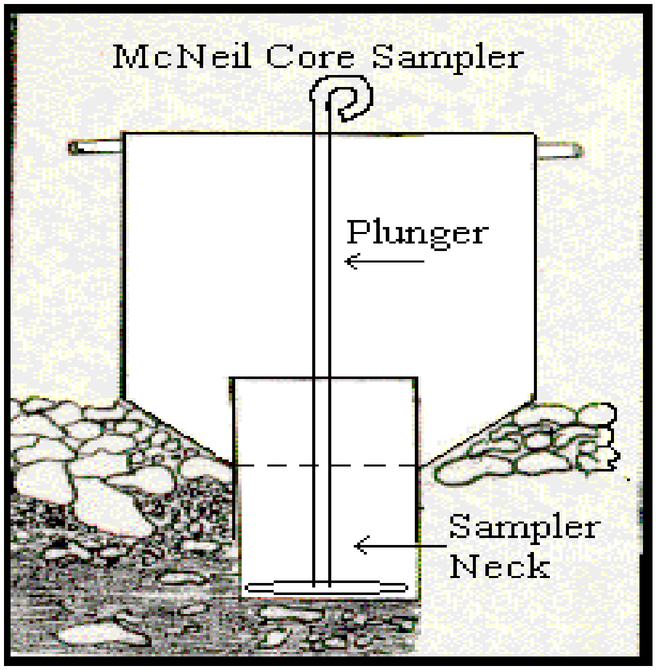


Figure 8. Plunger insertion method for the McNeil Core Sampler used in Wind River sediment analysis, Skamania County, Washington.

Before carrying buckets out of the stream and back to the laboratory, allow time for the fine sediment to settle to the bottom of the buckets (usually takes a day or two), then decant as much clear water as possible off the top without losing any of the sediment. When carrying the sample buckets out by hand, it is well worth the time spent determining the shortest, easiest, best route to take back to the truck. Hauling buckets down the stream back to the starting point is not always the best route to take. Log jams are difficult, time-consuming, and frustrating to cross with buckets. Footing down the stream is usually rough and awkward and makes for numerous twisted ankles. Look for trails, two-tracks, and decommissioned roads on your map that may be helpful to haul buckets out on. Ask you supervisors if they know anything that may help. Try to avoid going uphill and through extremely thick vegetation, even for relatively short distances. Carrying buckets many days in a row is not good for joints (elbows, knees, and ankles). Be sure to pace yourself and allow for rest between bucket-carrying days.

To dry the samples, pour the contents of each individual bucket through the smallest sieve size (297 microns). Be sure not so leave any sediment stuck to the inside walls of the bucket. Spread the sample evenly over the plastic-lined drying tray. Place the tray on the drying racks. Then roll the racks into the seed extractory drying kilns. Turn the fan on at the breaker and let the samples dry for 1 to 3 days (depending on humidity and temperature). After sediment is completely dried, the sample is sieved through 12 different sizes of U.S. Standard sieve screens. (76.1 mm, 50.0 mm, 25.0 mm, 12.5 mm, 9.51 mm, 6.35 mm, 4.76 mm, 2.36 mm, 1.70 mm, 0.841 mm, 0.425 mm, and 0.297 mm) The sample must be completely dry before processed. Shake the sample for 10 minutes. The electric shaker at the seed extractory is only able to hold 5 sieves at one time, so the sediment will be shaken through the 2 largest sieves first, the next 5 largest sieves next, and the 5 smallest sieves last for a total of 30 minutes of shaking. After completing shaking, weigh the contents of each sieve in grams using the Metler scale in the lab of the seed extractory. Record weights and calculate percent total on the data sheets. The shaker is a rather ancient piece of equipment and does not work well. At the beginning of the season, hit all cirques with the grease gun. Colder weather seems to adversely affect the shaker as well. In the early morning, before use, run the shaker without weight on it for 10 minutes to heat it up. Sometimes it will bog down due to weight and temperature. It may help to spin the drive shaft by hand to get it going. If the shaker does bog down, immediately turn it off, for if it were left running, the electric engine would burn up.

To winterize the equipment, put all tools in one spot, cover the shaker motor with plastic, and stack and store all of the buckets upside down because the roof leaks severely and they all fill up with water if left right side up. (The leaking roof may have been fixed by now.)

Results

This study collected and processed a total of 224 samples from 56 potential steelhead-spawning sites throughout 28 quarter-mile segments. These samples were all gathered from seven different Rosgen stream-type C channels within the Wind River Watershed.

The sediment sampling was completed between July 6, 1999 and October 14, 1999. The processing of samples was completed between October 15, 1999 and December 3, 1999.

Comparison of fine sediment in all streams sampled in 1999

A comparison of all streams sampled in 1999 is portrayed in Figure 9. Sediment size classes are shown as an average percent of each of four size classes and are useful in comparing the relative abundance of fine sediments (Table1).

Table 1. Comparison of sediments size classes from all streams sampled in 1999 on the Wind River watershed, Skamania County, Washington.

Stream Name	(>76.1-25.0) Large	(>12.5-6.35) Medium	(>4.76-.841) Small	(>.425-silts) Fines
Dry Creek	58.45%	21.48%	15.09%	6.59%
Panther Creek	45.62%	23.75%	23.56%	8.95%
Upper Wind R.	46.59%	24.31%	23.60%	6.74%
Layout Creek	47.32%	29.75%	19.00%	5.16%
Trapper Creek	44.40%	26.42%	26.16%	3.55%
Paradise Creek	48.27%	23.27%	24.02%	5.52%
Martha Creek	45.37%	28.77%	21.43%	5.52%

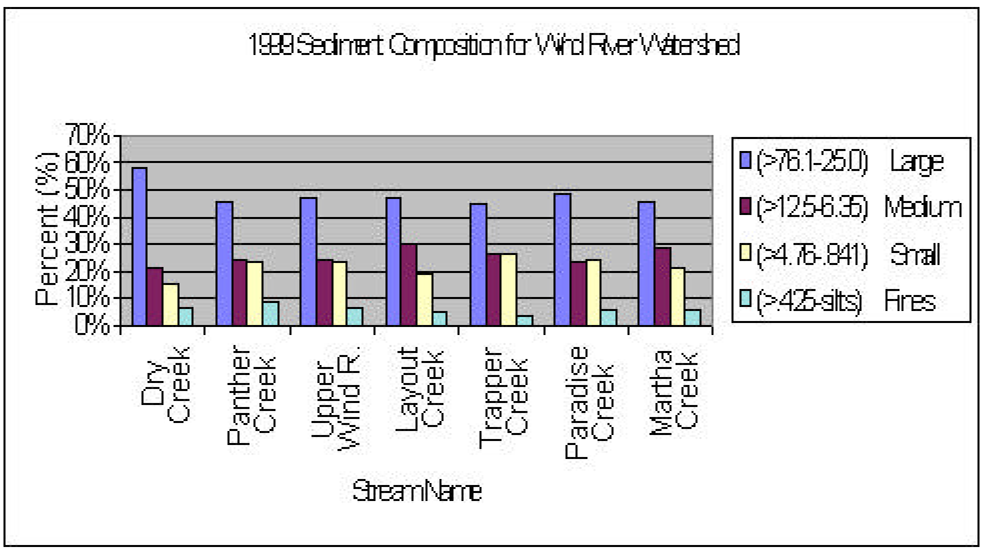


Figure 9. Comparison of sediments size classes from all streams sampled in the 1999 from the Wind River watershed, Skamania County, Washington.

Comparison of percent fines between each stream sampled in 1998

A comparison of all streams sampled in 1998 is portrayed in Figure 10. Sediment size classes are shown as an average percent of each of four size classes and are useful in comparing the relative abundance of fine sediments (Table 2). Results from 1998 and 1999 are contrasted in Figure 11.

Table 2. Comparison of sediments from all streams sampled in 1998 sediment samples from Wind River watershed, Skamania County, Washington.

Stream	(>76.1-25.0) Large	(>12.5-6.35) Medium	(>4.76-.841) Small	(>.425-silts) Fines
Dry Creek	41.86%	25.15%	27.11%	7.44%
Panther Creek	48.79%	22.96%	22.79%	6.50%
Martha Creek	45.85%	24.72%	24.99%	5.90%
Upper Wind R.	42.18%	22.71%	29.14%	7.13%
Layout Creek	54.39%	28.23%	14.69%	3.58%
Trapper Creek	40.92%	31.75%	25.36%	2.46%
Paradise Creek	46.53%	23.58%	24.76%	6.17%

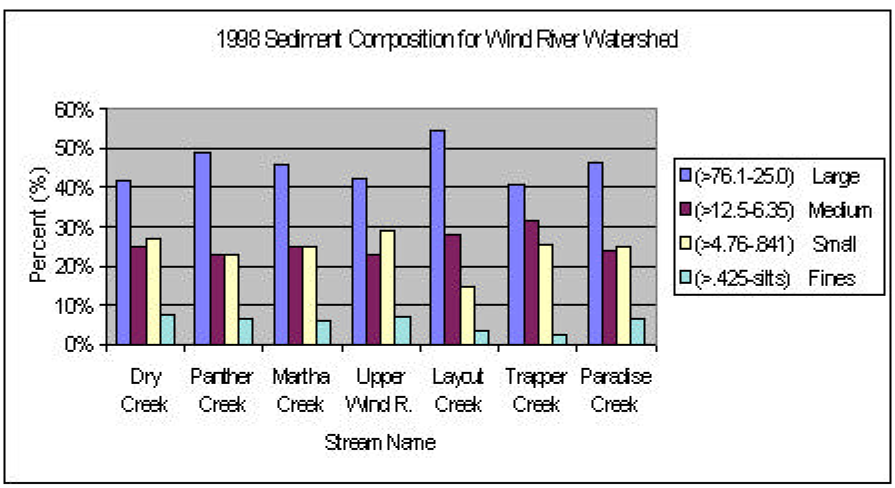


Figure 10. Comparison of sediments from all streams sampled in the Wind River watershed in 1999, Skamania County, Washington.

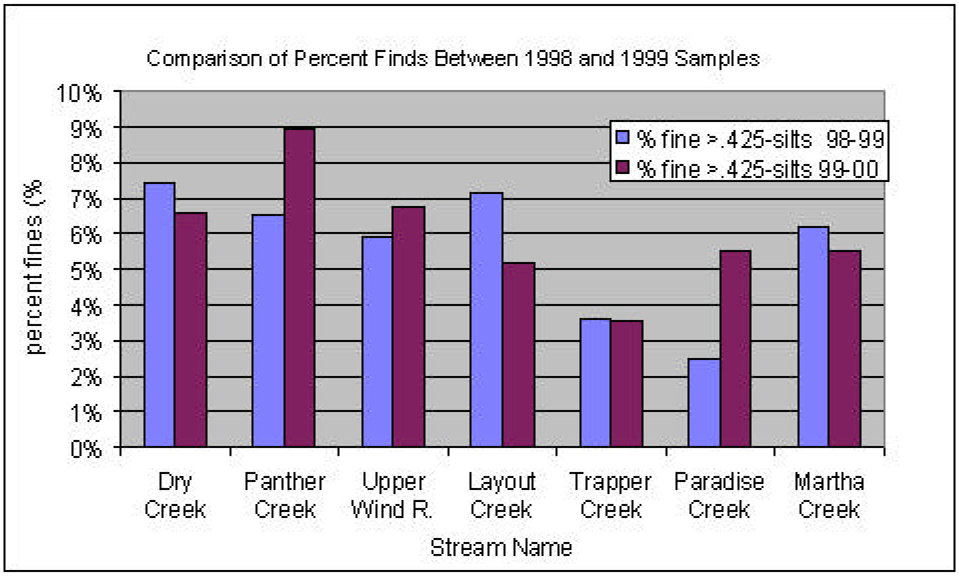


Figure 11. Comparison of percent fines between 1998 and 1999 field samples of fine sediment samples collected in the Wind River basin, Skamania County, Washington.

Assessment of fine sediment within each stream sampled in 1999

Dry Creek

Dry Creek linear trend analysis revealed a negative sloping line (m = - 0.13). This indicates a slight tendency for the relative abundance of fine sediments to increase as samples proceed downstream (Figure 12).

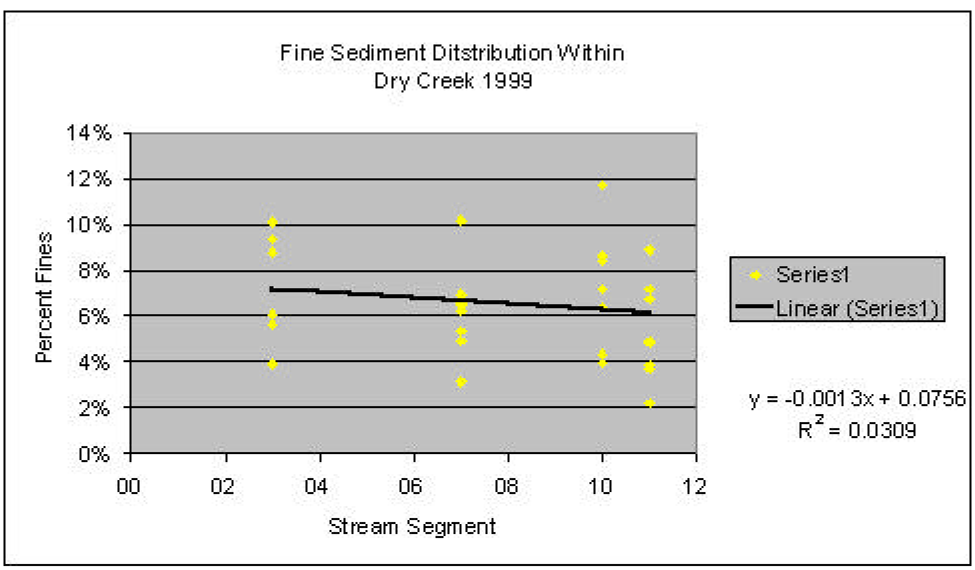


Figure 12. Dry Creek linear trend for fine sediment sampled in 1999. Skamania County, Washington.

Layout Creek

Layout Creek linear trend analysis revealed a negative sloping line (m = -0.799) indicating a tendency for a higher concentration of fines in downstream samples relative to upstream samples (Figure 13).

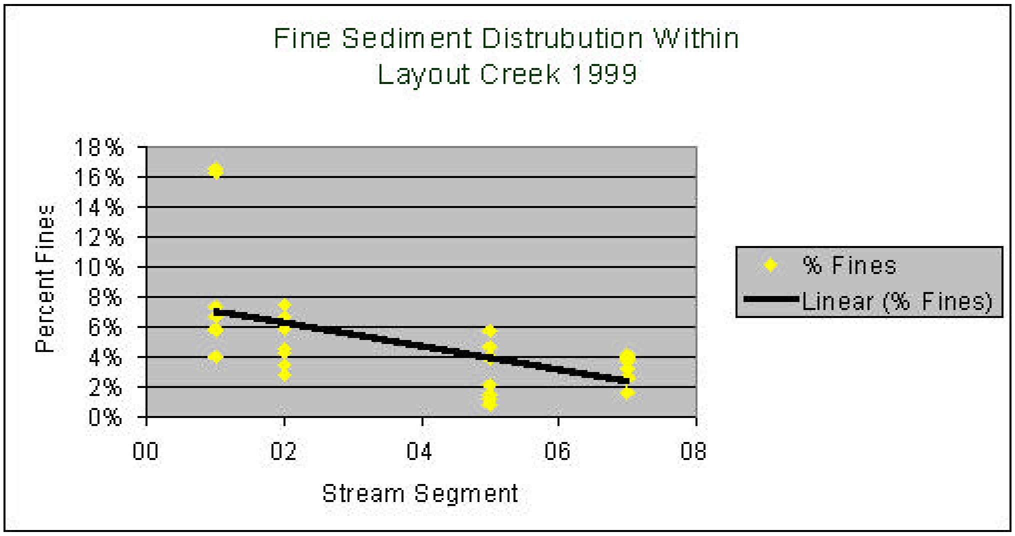


Figure 13. Layout Creek linear trends for fine sediments sampled in 1999, Skamania County, Washington.

Trapper Creek

Trapper Creek linear trend analysis revealed a negative sloping line (m = - 0.04) indicating a slight tendency for an increase in fine sediments as samples progress downstream (Figure 14).

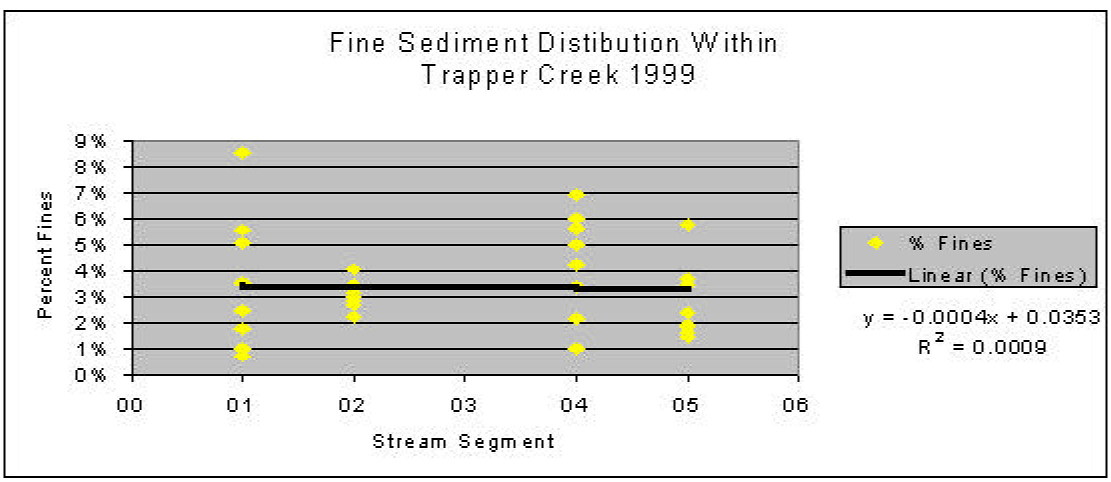


Figure 14. Trapper Creek linear trends in fine sediment collected in 1999, Skamania County, Washington.

Upper Wind River (Mining Reach)

Upper Wind River linear trend analysis revealed a negative sloping line (m = -2.17) indicating a rather pronounced progression of increased fine sediment as samples proceed downstream (Figure 15).

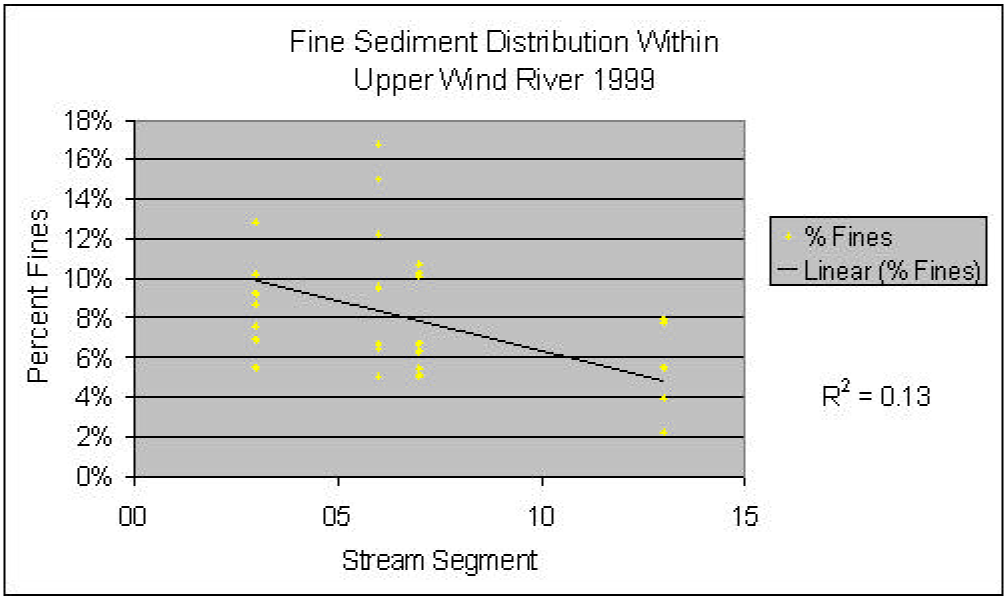


Figure 15. Upper Wind River (Mining Reach) linear trends for fine sediment samples collected in 1999, Skamania County, Washington.

Paradise Creek

Paradise Creek linear trend analysis revealed a steep negative sloping line (m=-0.99). This indicates that the relative concentration of fines sediment increases as samples proceed downstream (Figure 16).

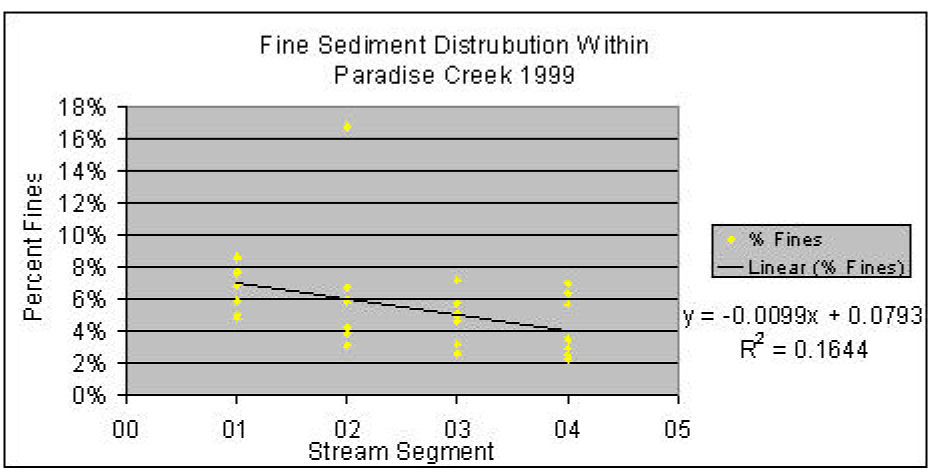


Figure 16. Paradise Creek data shows the general pattern of higher percent fines nearer to the mouth.

Martha Creek

Martha Creek displayed a negative sloping line (m = -0.175) indicating a downstream progression of increased fine sediment (Figure 17).

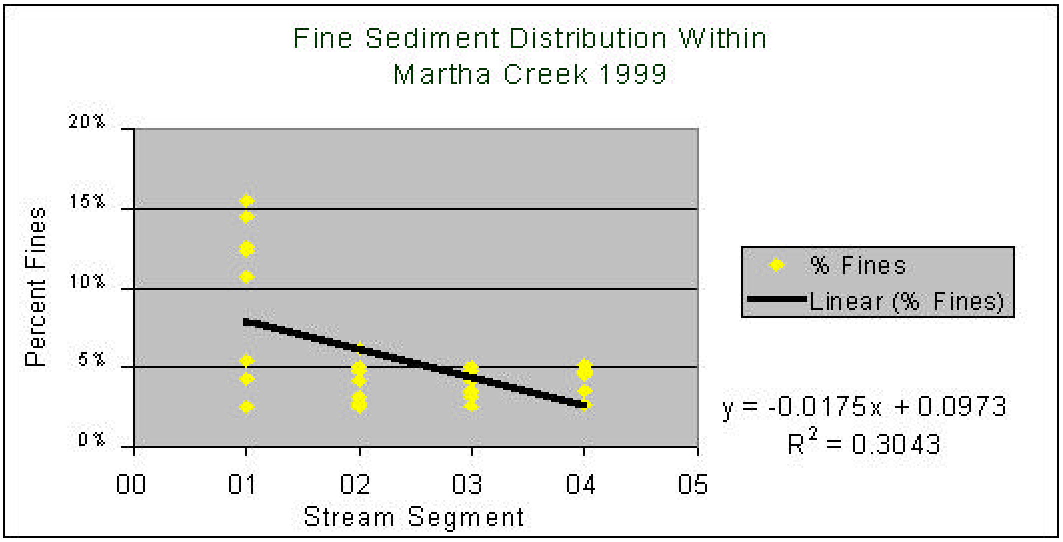


Figure 17. Martha Creek linear trend line for the sediment samples taken in 1999, Skamania County, Washington.

Panther Creek

Panther Creek linear trend analysis exhibits a negative relationship (m = 0.54) between fine sediment and sample proximity from the mouth. As samples proceed upstream there is a tendency to increase the percent of fine sediment (Figure 18).

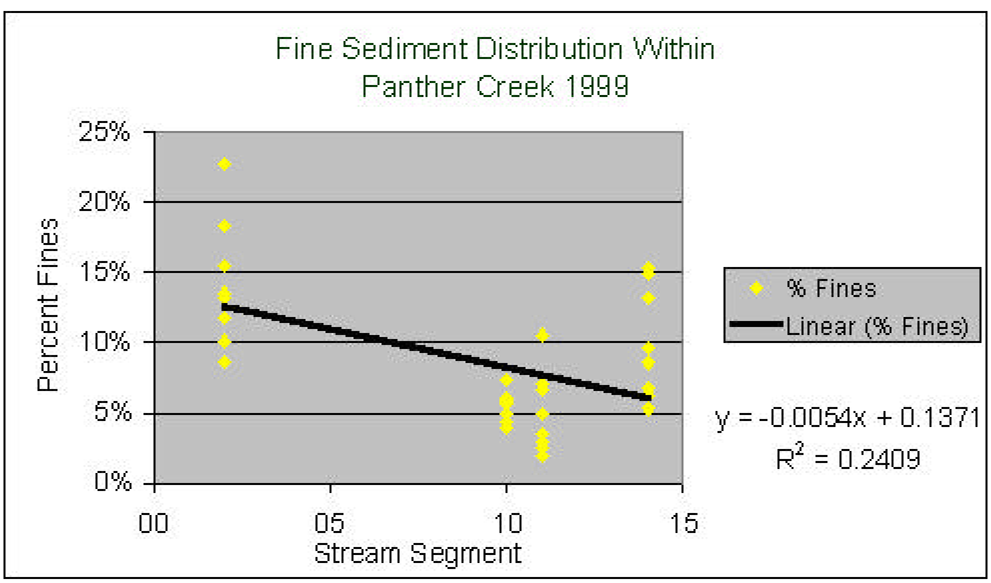


Figure 18. Panther Creek linear trend line for fines sediment samples taken in 1999, Skamania County, Washington.

Discussion

Average percent fines between streams

A focus of this study was to compare the percent of fine between streams in the Wind River Watershed. We evaluated sediment data collected in 1998 and 1999 and then compared the two data sets. Fine sediment in this study is defined as particles of < 0.84 mm in diameter.

The 1999 data indicates that fine sediments range from 3.55%-8.95% in the Wind River study area (Figure 9). Panther Creek ranked the highest and Trapper Creek ranked the lowest. The average percent fine for all samples was 6.0 percent. The variance between streams suggests that there are obviously some site-specific variables that influence fine sediment.

The 1998 data indicates that the fine sediment component ranged from 2.46% to 7.44% in the Wind River study area (Figure 10). Dry Creek had the highest average percent fines (7.44%) while Trapper Creek ranked lowest (2.46%). The average percent fines for all streams in the study area was 5.59 percent. The relatively wide variance between streams in the 1998 data supports the notion that all streams are not equal in their fine sediment loading.

The data sets from two consecutive years show a relatively consistent result between 1998 and 1999 sediment monitoring. The range of variation between sampling years was from 0.01% to 3.08%, and the correlation was moderately high ($r = 0.471$). The average change was just 1.33% for all samples combined. Considering we are dealing with data from a natural system where there is naturally a high degree of variation this is a fair predictor. Three of the systems were relatively unchanged (Trapper, Upper Wind River, and Dry Creek), showing less than 1% change between years. Not all change in sediment composition was in the same direction. The two largest changes were both significant increases in percent fines seen in the Panther Creek system (2.45%) and Paradise Creek (3.06%). Layout Creek was one system that showed a marked decrease in fine sediments between the two sampling periods (1.99%).

Determination of a cause and effect relationship for fine sediment distribution in the Wind River is highly complex and goes beyond the scope of this paper. However, three primary environmental variables discussed in the literature (Wieman 1998) that are relevant to the Wind River system include: local variability within steams, channel stability, and road density. We will explore these in more detail.

Assessment of fine sediment within a stream

A cursory look at the randomly stratified samples gathered from each of seven streams reveals a consistent and predictable distribution pattern of fine sediment within a stream. A closer look at each of the individual streams gives further insight into local relationships.

Dry Creek

Fine sediment seems to be related to the upstream location of a given sample. A slightly higher percentage of fine sediment was measured in the samples taken in the downstream segments and tends to decrease in segments that were sampled upstream (Figure 12). When compared with the other six streams, this pattern is not unique. The other six streams generally show a higher percentage of fine sediment in the samples taken from the segments closer to the mouth, and lower percentages in the samples taken in segments upstream as well. When the data was examined and graphed including particles < 1.70mm in diameter, the opposite trend results. This infers that Dry Creek sediment, which is > 0.425 and < 4.76, is at very low concentrations near its mouth.

Dry Creek is somewhat unique in the fact that at base flows it almost always goes subterranean at or near river mile 1.5 (sample segment 6). The Wind River Watershed Analysis (USFS 1996) supports that removal of riparian vegetation results in decreased lower bank stability. Unstable banks can substantially increase sediment deliver into the stream. In streams like Dry Creek, increased channel aggradation can result in subterranean flows through deposited gravel. The subterranean flow regime is known to strand fish and presents fish migration barriers during low flow periods.

Stream flow is an obvious factor influencing fine sediment distribution. Due to the subterranean flow during the summer months, one might expect a bimodal distribution of fine sediment. However this did not seem to be the case as there was no evidence of increased fines near the point of subterranean flow (note: some of the Dry Creek samples were taken in areas where there was no water. It may be reasoned that small size class particles are deposited further upstream while fine sediment remain in suspension long enough to be carried down to the mouth by lesser flows.

The average percent of fines in all samples of the Dry Creek sub-watershed is 6.59%, well below the accepted 17% fine sediment limit that threatens juvenile salmonid survival to emergence (Wieman 1999).

Sampling error should be taken into consideration when trying to explain this data. There is always the possibility of samples being taken in areas that are misrepresentative of the fine sediment within the segments. There may also be some temporal and/or spatial variation in sediment movement that is not captured in this randomly stratified sample regime.

Layout Creek

Layout Creek samples indicated an expected pattern of high percents of fine sediment near the mouth of the stream and generally less fine sediments in each segment further upstream (Figure 13).

The average percent of fine sediment is low compared to other streams within the study (5.16%). Fine sediment is well below the accepted threshold and does not pose a threat to salmonid egg to fry survival. Layout Creek has 82% course textured material (large and medium size class), exceeding the next closest stream (Trapper Creek) by over nine percent (Figure 10). Local geology may be a contributing factor in this matter.

Intensive instream restoration efforts may play a role in Layout Creek's sediment pattern. In recent years (1991-1999) the U. S. Forest Service has treated certain parts of Layout Creek with large-scale stream channel restoration activities that were designed to reduce lower bank lateral migration, decrease channel width to depth ratio, decease channel slope, increase instream LWD and reclaim the natural flood plain (Bair 1998). Although the bioengineering restoration objective in Layout Creek will not be fully realized for several decades (60-80 years), it already appears that the once highly degraded channel has benefited from the recovery effort. No sediment data is available prior to the restoration activities and it is not known to what extent the sediment composition has been effected by the restoration treatments. However, Layout Creek showed the largest decline (1.99%) in fine sediment of all streams tested between 1998 and 1999. This is clear evidence that recovery efforts have not exasperated the sediment regime in the highly disturbed Layout Creek system.

The selective nature of this sample design could result in a skewed data set in Layout Creek. The investigator noted intermittent "plugs" of sediment in this system, which were, by design, not sampled. Inherent in the protocol is a purposeful selection of "suitable spawning habitat", which may lead to misrepresenting the actual sediment regime.

Trapper Creek

Trapper Creek supports the model that suggests land management may lead to increased fine sediment. The majority of Trapper Creek, located within the Trapper Creek Wilderness Area, is nearly pristine and has not been impacted by forest management practices (e.g. timber harvest and road building). Trapper Creek has the lowest percent of fine sediment (2.46%) of all streams tested (Figure 10). The system appears to be very stable (USDA 1996) and was virtually unchanged (0.01%) between the 1998 and 1999 sample period (Figure 11). Trapper Creek is expected to be a reliable model of what a healthy stream with good spawning habitat should be like.

Trapper Creek also supports the model that implies samples taken downstream are likely to have higher fine sediment content than those take upstream (Figure 14). It is important to note that sampling started above the influence of Government Mineral Springs Homes (RM 1.0) and did not include the lowest reaches of the stream as in most other samples (Martha Creek and Upper Wind are also exceptions).

Channel form is likely to have an influence on fine sediment distribution in this system. Generally, Trapper Creek has a steeper gradient system than other streams sampled in this study. The availability of "suitable spawning habitat" is much more limited to periodic slope breaks and is often associated with large woody debris.

Upper Wind River (Mining Reach)

The Upper Wind River shows the expected pattern of an increase in fines as sampling progresses downstream (Figure 15). In fact, the linear trend line shows the second steepest decline (m = - 0.217) and is only second to Dry Creek spatial variation of all streams tested in this study. Coincidently, the test area for Dry Creek and the Upper Wind River are the two longest reaches of stream sampled (15 segments long).

The average percentage of fine sediment for the Upper Wind River (7.13%) ranks second to Dry Creek and is considerably higher than the rest of the sub-watersheds within the study area. Several factors may contribute to the relatively high amount of fine sediment in this system.

Land management practices (e.g., logging and road building) have influenced the Upper Wind River and resulted poor bank stability, low numbers of in-stream woody debris and low quality pool habitat (USFS 1996). Increased fine sediment may result from degraded habitat conditions and poor channel stability (Table 3 and Figure 4).

A large-scale restoration treatment was initiated in 1998 in an attempt to reduce bank instability, decrease width to depth ratios, and to restore channel form and function (USFS 1997). Future sediment sampling would be beneficial to determine the effects the restoration activities will have on the composition and distribution of sediment in the system.

Paradise Creek

Paradise Creek is somewhat anomalous in terms of its fine sediment composition. It falls into the middle ranks (Figure 10) in terms of abundance of fine sediment (6.17%) but has shown the greatest increase in fine sediment (3.06 %) between the 1998 and 1999 sampling periods (Figure 11).

Wieman (1998) suggested that a high percentage of fines might be related to the inherent soil conditions in this basin. Paradise basin is as a high-risk surface soil erosion candidate and has and estimated 25% of the drainage subject to active and past-active slides (1994 USFS Soil Resource Inventory). Although, Paradise Creek exists as the second least affected by land use (i.e. logging activity) of the seven tested sub-watersheds (USFS 1996), it appears to have an inherent naturally high degree of instability.

Paradise Creek supports the model suggesting fine sediment is more abundant in lower reaches compared to the upper reaches (Figure 16).

Martha Creek

Martha Creek is a tributary to Trout Creek and has a history of being a major producer of steelhead. Only the upper half of Martha Creek is managed by the USFS and as a consequence the sediment samples were taken approximately between river miles 1.5 and 2.75 on USFS lands.

This system is shown to have a relatively low amount of fine sediment (5.9%) and showed a minor change (0.65%) between 1998 and 1999 sample periods. Martha Creek was subject to agricultural practices associated with the former Wind River Nursery (WRN) for many years (1909 – 1997). Water withdrawal, tillage and road building are believed to have affected the sediment regime over time. Cochran (1994) noted that this system becomes very turbid during intense rainstorms. This system has experienced extreme low flows and often exhibits subterranean flow near its junction with Trout Creek. Steelhead production is believed to suffer as a result of migration barriers, elevated high water temperatures, and predation (USDA 1996).

Two significant changes have developed in land use management in the Martha Creek basin. In 1997 the WRN was decommissioned and active nursery management ceased. In 1998 the USFS successfully decommissioned over four miles of road in this watershed and the hydrologic function was restored (Coffin 1999) on one-time impervious road surfaces. Sediment sampling will serve as a useful tool to monitor these two noteworthy events.

Figure 17 shows the trend of higher percentages of fine sediment in downstream reaches relative to upstream reaches (Note: all samples were taken above the subterranean flows).

<u>Panther Creek</u>

Panther Creek is somewhat distinct in terms of its fine sediment composition. It has the second highest abundance of fine sediment (6.5%) and has shown a marked increase in fine sediment (2.45%) between the two sampling periods (1998 and 1999).

There are several plausible explanations of why Panther Creek is the highest producer of fine sediment in the Wind River study area. Sediment samples gathered from Panther Creek started approximately at river mile 4.0 (near the Clark Prestia residence) on private land. Therefore, the samples gathered from the lowest stream segments may reflect the riparian harvest and general aggressive timber management practices on private land. Federal lands in the basin are also subject to increased roaded densities (2.28 miles/sq. mi.) and substantial timber harvest (USDA 1996).

Panther Creek is a popular recreational area with many dispersed campsites interrupting over three miles of stream (approximately RM 3-6). Motorized traffic and trampling has adversely affected lower bank stability and could be a source of sediment delivery.

Panther Creek is a large tributary to the Wind River. Water temperatures taken while collecting samples showed this creek as being the coldest of the seven streams sampled.

Although the Panther Creek survey started upstream from its mouth, it did exhibit the pattern of having of increased fine sediment in the downstream segments relative to upstream segments (Figure 18).

Critique of the McNeil sediment core sampler

The process of obtaining accurate, consistent and non-biased stream sediment samples is difficult and requires much patience, time, and physical exertion. During this study, one of the objectives was to evaluate the use of the McNeil Core Sampler as a tool to conduct reliable stream sediment surveys.

The Yakima River Resource Management Plan (YRRMP), the Yakama Nation (YN), and the report issued by Young et al (1991), support the accuracy of this sediment sampling technique.

Through approximately three months of daily sediment sampling, we have determined that the McNeil core samplers proved to be awkward and difficult to carry in the field. The uneven terrain, downed logs, thick vegetation, and logjams common to most riparian areas made carrying McNeil samplers a chore. When two people must carry eight to sixteen buckets, tape measures, clipboards, work vests, water, and their lunches for miles up a stream, a smaller or easier carried sampler (or sampling method) may be beneficial.

The major deficiency of the McNeil Sampler is that the sampler is difficult to insert to the specified depth if the substrate is coarse or compacted (Weshe et al. 1989) It was also noted that the McNeil samplers used in this study were difficult to insert into the spawning gravel. A saw-tooth design on the point of contact would provide an easier insertion into the sediment without inadvertently kicking up as much fine sediment (potentially skewing the results). The loss of some fine sediment occurs during the sampling processes regardless of the sampler design. When inserting the plunger, some fine sediment gets inadvertently pushed out the bottom of the sampler and is lost.

The relatively small diameter of the sampler neck restricts the size of sediment that can be taken in the sample resulting in the change of sample spot to where the rocks will all fit up through the sampler neck. This resulted in sample locations within the sample site that are not completely random because the bio-tech must visually pick spots where a good sample might be obtained, potentially skewing the results.

There is the possibility that this method of substrate sampling may falsely represent the sites and streams that are being sampled. After the numerous tries at finding a sample, the final sample may not be representative of the spawning site. The McNeil core sampler creates a bias because of the limited neck diameter, in turn making the samples between different sites and of different streams appear more alike then they actually are. This could possibly make an instance of fine sediment loading in a particular stream appear less significant compared to the results from a known healthy stream.

Although there are some deficiencies and difficulties involved with using the McNeil Core Sampler, we believe the samples we obtained are of good quality. By analyzing the results, there appear to be notable and consistent differences between the samples taken from different sites and streams. This indicates that the use of the McNeil Sampler was successful in gaining our desired results. A definite advantage to using the McNeil Core Sampler over other methods of sediment sampling (examples include shovels, other sampler designs, and the use of slide photography) is that the sample is consistently taken from every site. The main concern in all research is the necessity to stay consistent in every aspect. The McNeil Sampler allows us to remain very consistent, resulting in better, more accurate results.

Since we were evaluating the use of the McNeil Core Sampler as a tool to conduct reliable stream sediment surveys, we can reach this conclusion: the McNeil Core sampler is an effective method for successfully and accurately obtaining sediment samples when conducting a steelhead spawning site substrate analysis.

Recommendations and Conclusions

Results--Summary

The results showed no alarming instances where fine sediment levels, in the seven streams studied, exceeded levels that would be expected to detrimentally affect salmonid spawning sites. The data was compared with mass wasting data, road density, total estimated road sediment and other land use data. The resulting correlations raised many questions as to the sources, distribution, and composition of sediment in the Wind River Watershed.

Recommendations

Continue to study this data set, intensify monitoring of restoration sites, and correlate the data with physical and biological resource data (e.g., geology, fish distribution).

Sampling equipment

The McNeil Core Samplers proved to be an affective method to obtain accurate and consistent sediment composition samples.

The McNeil Core Samplers are bulky and difficult to carry in the field, but as long as at least two bio-techs are sampling together, all of the equipment, buckets and samplers can be efficiently transported to the sampling sites with a reasonable degree of effort. Future consideration might include processing samples in the field. This would reduce the need to transport sediments back to the lab. However, it would require significantly more time to process during the prime field season. It may also require an alternative means of measuring samples. A displacement method using a large graduated cylinder could be a practical substitute to the Metler balance.

When drying and processing the sediment, the drying racks and kilns in the Seed Extractory worked extremely well. Samples dried in a short time period and were easily handled without losing any sediment.

The sieve shaker should be replaced. This piece of equipment is temperamental and unreliable. Surplus equipment may be available on the Forest.

There are currently approximately one and a half complete sets of U.S. Standard Sieves available for use in the Seed Extractory. I would recommend another complete set be obtained. This will increase the processing efficiency.

Five-gallon buckets appear to be the proper method for storing and transporting sediment samples. It is very difficult to remove these buckets from the field. Repeated and prolonged handling of heavy buckets pose a health and safety risk. Job Hazard Analysis (JHA) should recognize the inherent risk to elbows, knees and ankles. Buckets should be carried out of the field periodically, over a long period of time to reduce and prevent accidents. Consideration should be given to alternative means of transporting sediment from the field (e.g., assemble a backboard or backpack that can carry two buckets securely on a person's back, develop a floating transportation system). Handlers should be able to free to his or her hands while moving through the woods.

Data analysis

All samples taken from Wind River spawning sites were below the accepted threshold for salmonid egg to fry survival.

Increasing the total number of samples taken per stream from 16 to 32 helped validated our conclusions and produced statistically credible results. It is beneficial to obtain as many samples as feasibly and logistically possible to ensure an accurate and useable data set.

The data collected in this study would benefit from further analysis. Consideration should be given to a professional statistician and or extensive statistics software to develop conclusions from this data set.

Particular attention should go toward comparing samples between streams. Because the samples were taken from randomly selected ¼-mile segments and randomly selected potential spawning sites within those segments, it was difficult to detect spatial variation. Modifications to the project design are necessary to characterize the sediment regime throughout the entire stream segment (not just suitable spawning habitat).

Project design

This project design was adequate to characterize a subbasin spawning habitat condition. This project should intensify its effort into a select few subwatersheds. Project modifications should include a more structured and consistent site selection process, and an increase in total samples per stream.

Future projects

Sediment sources

Identification of specific point sources of sediment is not well understood. For example, lower bank conditions are believed to be major sources of sediment loading in the Wind River Watershed. This may be possible by conducting surveys concerning distance, area, and volume of bank erosion.

Biological use locations

Consideration should be given to distinct correlations between fine sediments and redd counts, steelhead population dynamics, and macro-invertebrates. These biological indicators are one means of substantiating habitat monitoring.

Fine sediment in the spawning gravel does influence steelhead; however it is unclear how steelhead may influence fine sediment in spawning gravel. An investigation should pursue how the in-redd environment differs from the out of redd environment and post spawning changes to the gravel.

Water quality issues

Turbidity and elevated water temperatures are affected by the amount of fine sediment in a system. Targeting water quality may result in some interesting relationships.

Geomorphology

Fine sediment may depend upon parent material or underlying geology. Various types of rocks and minerals fragment and break down at differing rates. Can geology explain our sediment regime in the Wind River?

Acknowledgements

This document was made possible through the efforts of many people. Marshall Barrows deserves credit for leading the effort from start to finish. He was instrumental in refining protocol, coordinating field collection efforts, processing samples and documenting findings. His steadfast energy and persistence saw this project through to its end. Data collection assistance came from a number of able bodies including Chris Bove, Jennifer Brady, Rebecca Chapa, Seth Defoe, Greg Robertson, Chrissy Rybel, and Keiki Yamasaki. I appreciate their conscientiousness toward details and resilience toward strenuous conditions. This study was funded in part by the Bonneville Power Administration, which could not have been possible without the support of John Baugher. My sincere thanks go out to all.

References

Bair, T. B. 1997. Trout Creek restoration completion report. USDA Forest Service, Gifford Pinchot National Forest, Carson, Washington.

Bilby, R. E., and J. W. Ward. 1991. Characteristics and function of large woody debris in streams draining old growth, clear-cut, and second-growth forests in southwestern Washington. Canadian Journal of Fisheries and Aquatic Sciences 48:2499-2508.

Clarke, K. D., and D. A. Scruton. 1997. Use of the Wesche method to evaluate fine-sediment dynamics in small boreal forest headwater streams. North American Journal of Fisheries Management 17:188-193.

Cochran, P. C. 1994. Personal communication. USDA Forest Service, Gifford Pinchot National Forest, Carson, Washington.

Coffin, B. A., and S. Defoe. 1998. Analysis of Wind River road decommissioning projects. USDA Forest Service, Gifford Pinchot National Forest, Trout Lake, Washington.

Dawson, F. H. 1981. The downstream transport of fine material and the organic matter balance for a section of a small chalk stream in southern England. Journal of Ecology 69:367-380.

Devore, J., and R. Peck. 1986. Statistics: the exploration and analysis of data. West Publishing Company. St. Paul, MN.

Gee, J. H. R. 1979. A comparison of gravimetric and photographic methods of stream substrate analysis in a study of benthos microdistribution. Oikos 33:74-79.

Hawkins, C. P., M. L. Murphy, N. H. Anderson, and M. A. Wilzbach. 1983. Density of fish and salamanders in relation to riparian canopy and physical habitat in streams of the northwestern United States. Canadian Journal of Fisheries and Aquatic Sciences 40:1173-1185.

Kohler, C. C., and W. A. Hubert. 1993. Inland fisheries management in North America. American Fisheries Society. Bethesda, Maryland, USA.

Maret, T. R., T. A. Burton, G. W. Harvey, and W. H. Clark. 1993. Field testing of new monitoring protocols to assess brown trout spawning habitat in an Idaho Stream. North American Journal of Fisheries Management 13:567-580.

Murphy, M. L., C. P. Hawkins, and N. H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. Transactions of the American Fisheries Society 110:469-478.

Rosgen, D. L. 1994. A classification of natural rivers. Elsevier Science, B.V. Amsterdam. Catena 22:169-199.

Shepard, B. B., and P. J. Graham. 1983. Fish resource monitoring program for the upper Flathead basin. Environmental Protection Agency Region VIII.

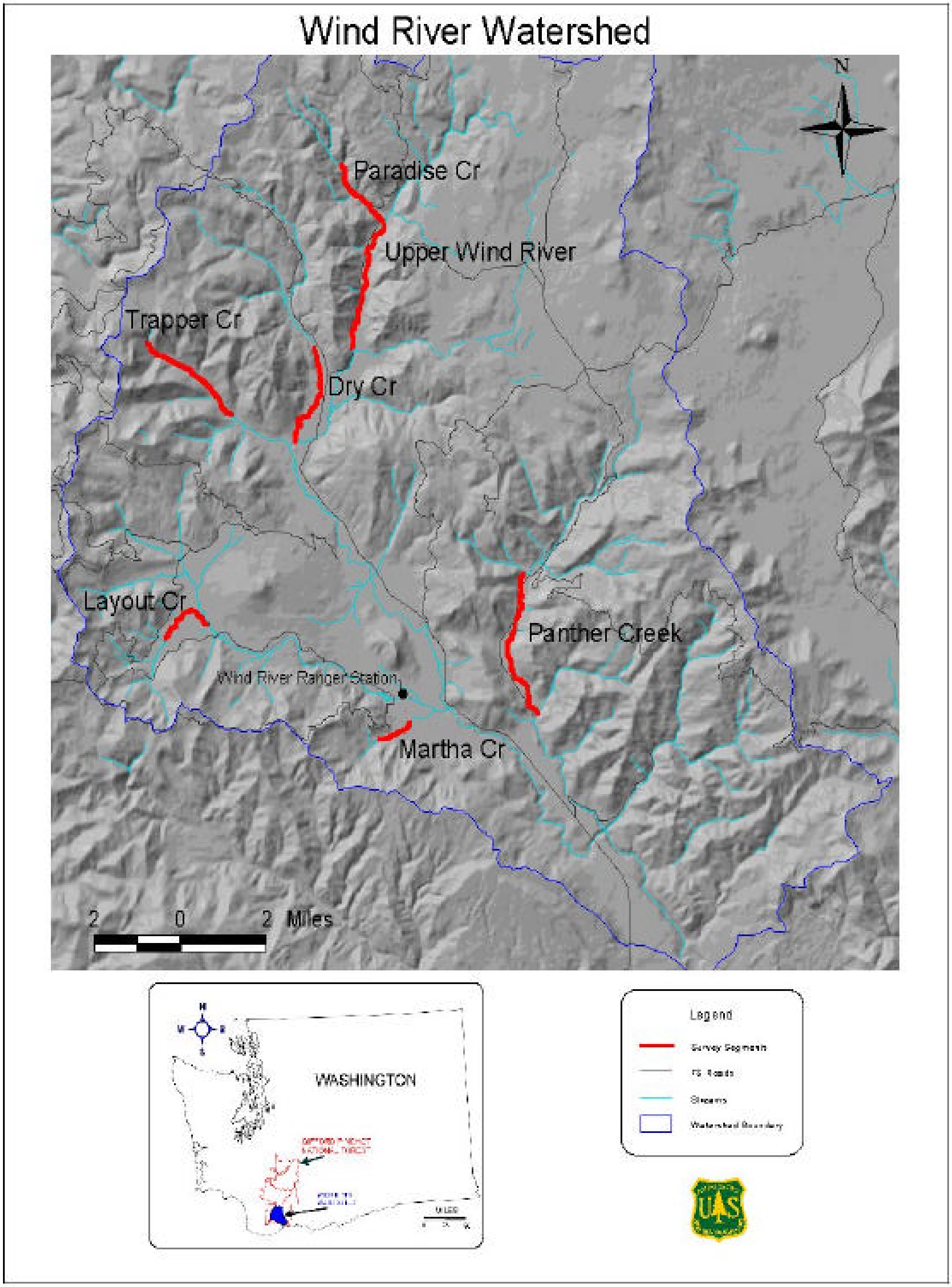
USFS (United States Forest Service). 1996. Wind River basin watershed analysis. USDA Forest Service- Pacific Northwest Region.

Wesche, T. A., D. W. Reiser, V. R. Hasfurther, W. A. Hubert, and Q. D. Skinner. 1989. New technique for measuring fine sediment in streams. North American Journal of Fisheries Management 9:234-238.

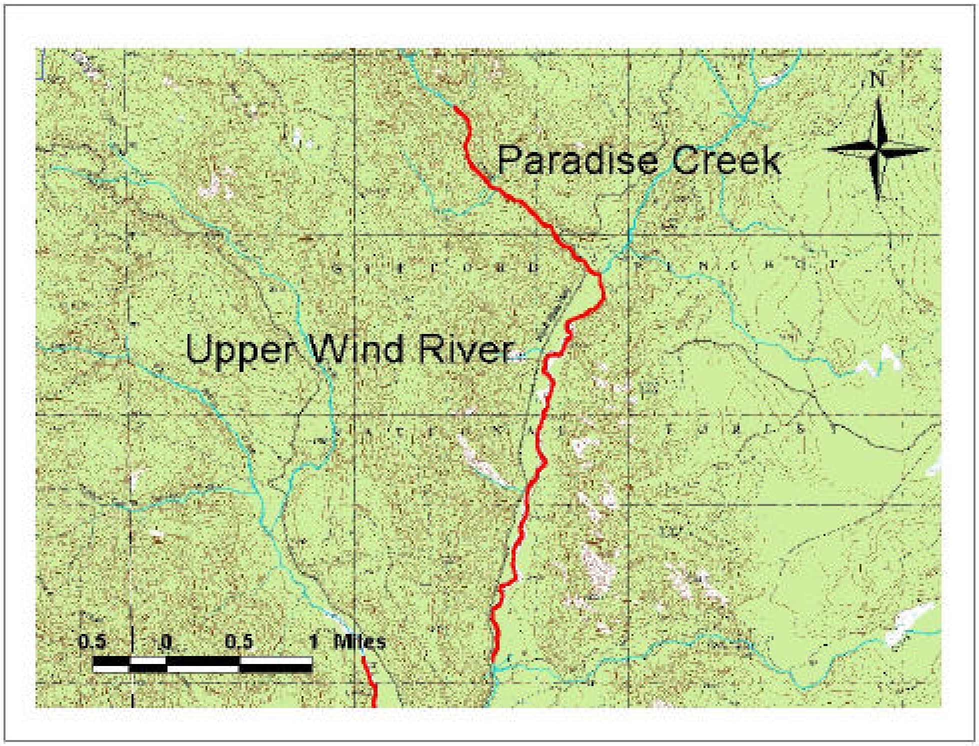
Wieman, K. 1999. Report C: Physical habitat monitoring- Wind River watershed project. Annual Report. USDA Forest Service, Gifford Pinchot National Forest.

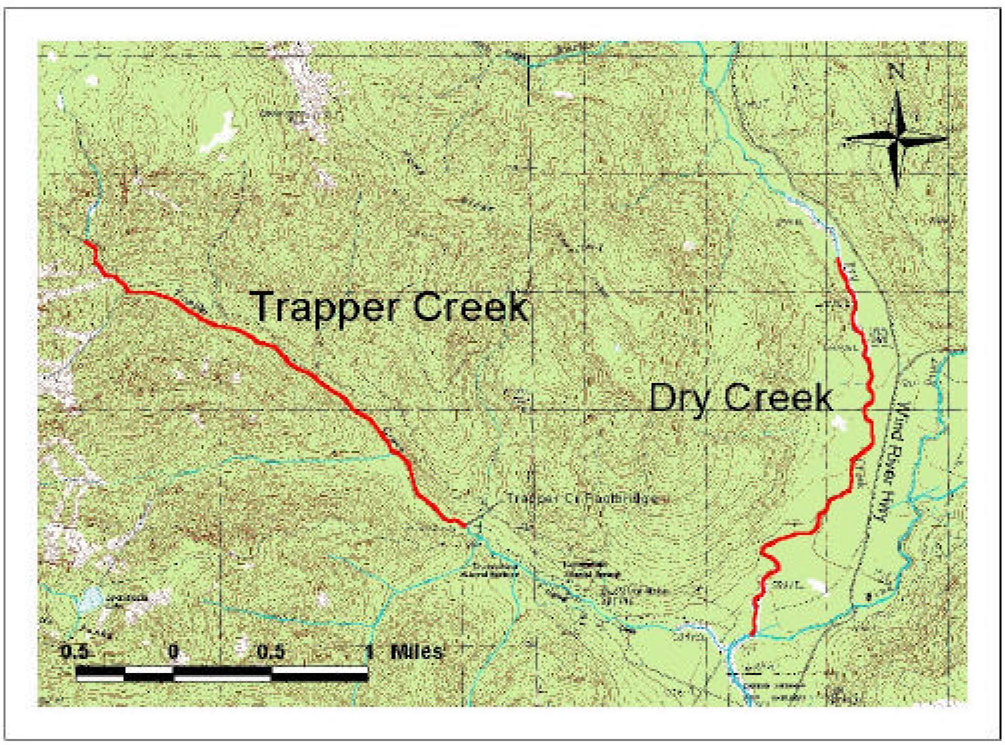
Young, M. K., W. A. Hubert, and T. A. Wesche. 1991. Selection and measures of substrate composition to estimate survival to emergence of salmonids and to detect changes in stream substrates. North American Journal of Fish Management 11:339-346.

YRRMP and YIN (Yakima River Resource Management Plan and Yakama Indian Nation). 1992. Little Naches sediment monitoring plan “Cookbook” for sampling and sieving protocol.

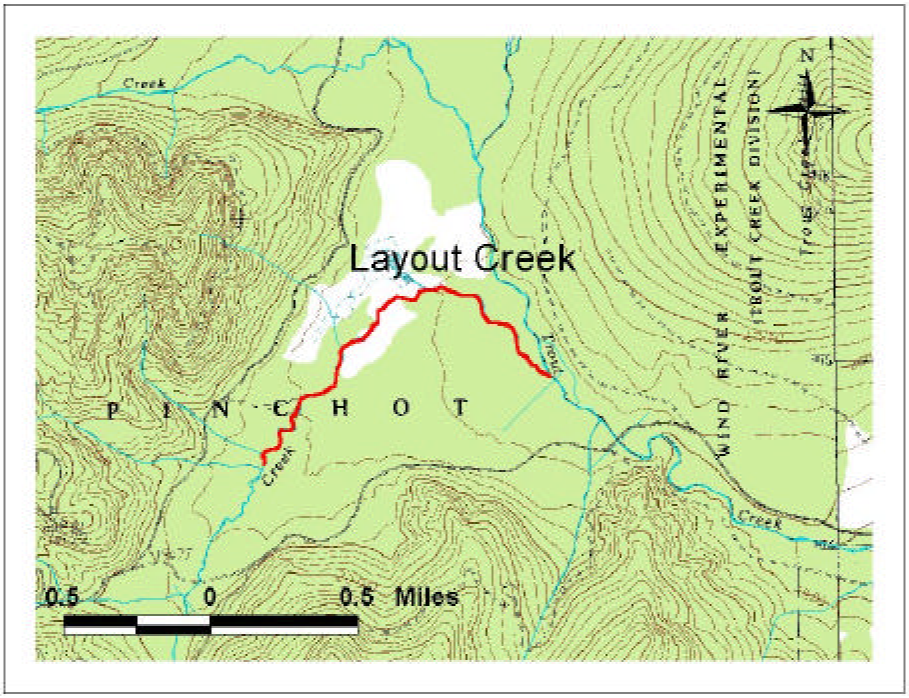


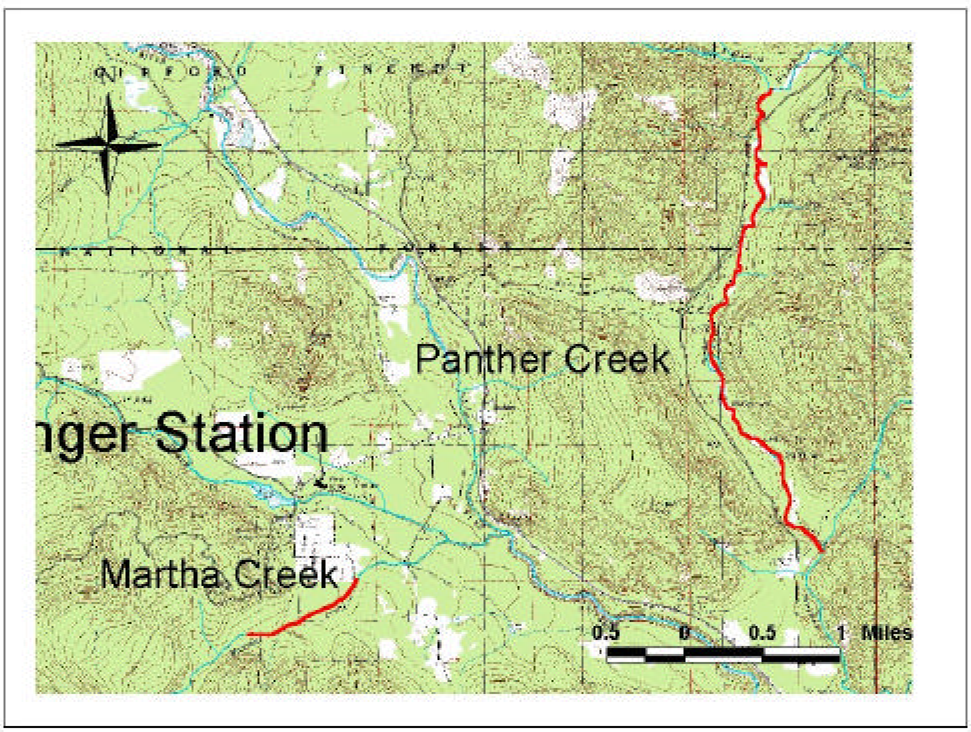
Appendix Figure G-1. The 1999 Wind River watershed stream sediment survey segments, Skamania County, Washington.





Appendix Figure G-2. The 1999 stream sediment survey segments for Paradise Creek, the Upper Wind River, Trapper Creek, and Dry Creek in the Wind River watershed, Skamania County, Washington.





Appendix Figure G-3. The 1999 stream sediment survey segments for Layout Creek, Martha Creek, and Panther Creek in the Wind River watershed, Skamania County, Washington.

Report H: Flow, Temperature, and Habitat Conditions in the Wind River Watershed

Wind River Watershed Project

1999 Annual Report

September 2001

Prepared by:

Ian G. Jezorek and Patrick J. Connolly

U.S. Geological Survey-Biological Resources Division
Columbia River Research Laboratory
5501-a Cook-Underwood Road
Cook, WA 98605

Introduction

Efforts and results covered by this report include watershed scale, stream-reach type surveys (hereafter referred to as reach surveys), as well as stream temperature and flow information that we have gathered on a regular basis at key sites within the Wind River subbasin. This report covers a portion of the work completed under Tasks 2a and 2b of Objective 2 as stated in the Statement of Work (SOW) submitted in January 2000 by the USGS-CRRL.

We used results from habitat surveying, temperature profiling, and flow monitoring to characterize physical habitat conditions and their variation among and within streams of the subbasin. Habitat characterization in concert with our fish population, condition, and survival data (See Report I of this document) will allow us to assess rearing conditions for steelhead within the subbasin. Using these data, for example, in our Ecological Diagnosis and Treatment modeling effort (see Report C of this document) will help us determine sites in need of restoration and will help us judge the success or failure of ongoing restoration activities.

Study Area

The Wind River watershed covers 582 km^2 and supports a fifth-order stream system with the largest tributary watersheds of Trout (88 km^2) and Panther (107 km^2) creeks supporting third-order systems (Figure 1). Elevations range from 25 m at the mouth of the Wind River, which is at the watershed's southern edge, to 1,190 m at ridge tops near its northern edge. The watershed is exposed to a temperate marine climate with most of the average annual precipitation of 280 cm occurring between November and April. Precipitation in the winter is largely delivered as rain in the lower elevations of the watershed and as snow in the higher elevations.

Methods

Reach Survey

Our reach surveys generally started at the mouth of a stream (exceptions being where a stream starts on private land) and continued upstream until a fish barrier was reached or we deemed the stream unsuited for anadromous fish. We walked the stream channel and performed a series of measurements at 20-m intervals. At each interval, we measured stream width, took a densitometer reading, and measured stream gradient using an Abney level. Within each 20-m interval, we counted large woody debris (LWD; length $\geq$ 1.0 m, diameter $\geq$ 0.3 m), boulders (diameter $\geq$ 0.5 m), and number of pools. We measured maximum depth in each pool and estimated percent cover for each pool. We also estimated percent spawning area and canopy closure within each of these 20-m intervals. In addition, we classified LWD as conifer or hardwood and tallied pieces into four size classes by length (L) and diameter (D): 1) L > 5 m and D = 0.3-0.6 m, 2) L > 5 m and D > 0.6 m, 3) L = 1-5 m and D = 0.3-0.6 m, and 4) L = 1-5 m and D > 0.6 m).

Every 100 m, we formed a transect where we characterized riparian vegetation and channel confinement. At these transects, we described vegetation found within the riparian area and measured distances to terraces and hillslopes.

Water Temperature

A network of 22 thermographs was maintained by CRRL throughout the Wind River subbasin for all or part of 1999 (Table 1). All thermograph units deployed and maintained by CRRL personnel were Optic StowAway Thermograph devices from Onset Computer Corporation (OCC). Prior to deployment, the units were tested at our lab for accuracy and adequacy of response time to change in temperature as per instructions from OCC's operating manual.

Thermographs were left in the stream all year and were set to record temperature every two hours. Temperature data are and continue to be downloaded twice a year (Spring and Fall). Downloads occur in the field with use of an OCC optic shuttle to minimize time out of water and missed readings. We calculated the daily mean temperature as the mean of the resulting twelve daily readings. We derived the daily minimum and maximum temperatures from the minimum and maximum reading of the twelve daily readings.

Underwood Conservation District (UCD) personnel maintained seven thermographs throughout the Wind River subbasin from mid June to early October (Table 2). The units deployed by UCD were OCC Hobo Thermographs. These units were set to take 20 readings per day. We derived daily maximum, minimum and mean temperatures from these 20 readings.

Flow

Nine flow monitoring stations were visited periodically throughout summer 1999 (Table 3). Our earliest flow measurement was 9 June and latest was 5 October. Each site was visited every two weeks. Several of these stations were new for 1999 (lower Layout Cr. and both sites on Dry Cr.); all others were established in previous years. Flows were taken with a Marsh-McBirney flow meter following the protocol of Gallagher and Stevenson (1999).

Results

Reach Survey

Personnel from CRRL completed reach surveys on 21.6 km of stream in 1999. A total of 2.8 km were surveyed in 1998, and 5.9 km were surveyed in 1996 (Appendix Table 1). Our focus in 1999 was on tributaries in the upper Trout Creek and upper Wind River watersheds. Primary data generated by these reach surveys include stream gradient and counts of LWD, pools, and boulders. Gradient ranged from 0.8% on reach 1 of Dry Creek to 6.9% on Mouse Creek. Counts of KEY pieces of LWD (conifer and hardwood $\geq$ 5 m length and $\geq$ 0.6 m diameter) ranged from 0.5 pieces per 100 m in Mouse Creek to 7.1 pieces per 100 m in Reach 5 of Dry Creek (Appendix Table 1). Boulder counts showed large variability with zero boulders per 100 m in reach 1 of Layout Creek to 297 per 100 m in reach 1 of Eightmile Creek (Appendix Table 1).

Several sections of stream had much higher amounts of LWD than others: East Fork Trout Creek, Paradise Creek, and the upper 1000 m of Dry Creek had high levels of LWD (Figures 2, 3, and 4, Appendix Table 1). Eightmile Creek had high densities of LWD, however this is largely the result of two large logjams at the base of landslide areas and does not reflect an even distribution of LWD throughout the surveyed length (Figure 4). Layout Creek had high densities of LWD throughout the lower 1000 m, which is the result of LWD placement as a restoration project conducted by the Forest Service in 1996.

Water Temperature

The Wind River Restoration Project has a database of stream temperatures dating from December 1996. Our thermal coverage for the period 1997-1999 is excellent for the Trout and Panther Creek watersheds with coverage expanded to the upper Wind River watershed during 2000. We have year-round thermograph coverage for the subbasin, but we have limited our analyses to summer temperatures in this report.

During 1997-1999 we recorded water temperatures that met or exceeded 16 ^{o}C at 14 sites in the Wind River subbasin (Table 4). This 16 ^{o}C limit has been set by the Washington Department of Ecology (Washington Department of Ecology, November 18 1997, Chapter 173-201A, Water Quality Standards for the Surface Waters of the State of Washington) as an indicator of stream health. The warmest year was 1998 followed by 1997 and then by 1999. There are seven creeks for which we have complete data for each summer period of July-September 1997-1999.

The location with the highest maximum reading during 1999 (20.3 ^{o}C) was in the mainstem of Trout Creek just below Hemlock Lake and Dam (HEML) (Table 5). This location recorded 44 days in 1999 when the maximum temperature met or exceeded 16 ^{o}C, 28 days when the maximum temperature met or exceeded 18 ^{o}C, and 6 days when the maximum temperature met or exceeded 20 ^{o}C (Table 5). Sites which experienced $\geq$ 15 days that met or exceeded 16 ^{o}C during 1999 include Crater, East Fork Trout, Layout, Martha, and lower Eightmile creeks. The highest temperature reading recorded during the 1997-1999 monitoring period was 23.2 ^{o}C in 1998 at the lower Trout Creek site (LTRO). We do not have summer 1998 data for the HEML site but it almost certainly would have been warmer than the LTRO site.

The locations which experienced the lowest maximum summer temperatures in 1999 were mainstem Trout Creek at the 33 Road Bridge (MS33) and upper Panther Creek. These sites had maximum temperatures during summer 1999 of 9.0 and 9.3^{o}C, respectively. From past years, we know that the water temperature of upper Trout Creek (UTRO) is lower above the Crater Creek influence (upper Trout Cr.; Table 4). The mainstem Wind River below Falls Creek (Figure 5) and lower mainstem Panther Creek stayed relatively cool through the summer 1999 with a maximum temperature of 14.1 and 13.5 ^{o}C respectively (Tables 4 and 5).

In 1999 mainstem Trout Creek warmed considerably between MS33, where maximum temperature was 9.0 ^{o}C, and a site 3.4 km downstream at the 43 Road Bridge (MS43) where maximum temperature in 1999 was 15.7 ^{o}C. Additional warming of Trout Creek occurred between the MS43 and HEML a distance of 6 km. A similar pattern of warming can be seen for both 1998 and 1999 (Figure 6). The rate of warming between the MS33 and LTRO sites was similar between 1998 and 1999 (Figures 7 and 8). The highest rate of warming which we have recorded was between the UTRO site and the MS33 site (Figure 7). This reflects the influence of Crater Creek on the Trout Creek as upper Trout is largely spring-fed and remains cold. Temperatures routinely exceeded 16 ^{o}C at HEML and the maximum temperature was 20.3 ^{o}C (Tables 4 and 5, Figure 8). The UCD thermograph site near the mouth of Trout Creek recorded slightly cooler temperatures than the HEML site (Table 5, Figure 6). Not only do the lower sites on Trout Creek reach high temperatures, but they also experience a large diel range (Figure 9). The MS43 and LTRO sites experience particularly large diel fluctuations, though the range is less at LTRO. The site below Hemlock Dam recorded the highest temperature reading in 1999, but it had a diel range slightly smaller than LTRO. Fish in Hemlock Lake or immediately downstream may experience long periods of temperatures near the upper end of their tolerance range.

In contrast to Trout Creek, the mainstem of Panther Creek warmed little in the 8 km between the upper and lower thermographs. In 1999 maximum temperature at the upper site was 9.3 ^{o}C while the lower Panther site was 13.5 ^{o}C (Table 5). Eightmile Creek experienced considerable warming between the upper and lower thermograph sites. The sites are separated by approximately 650 m. Lower Eightmile Creek (LEIG) had 32 days with temperature $\geq$ 16 ^{o}C with a maximum temperature of 17.8 ^{o}C. Upper Eightmile Creek (UEIG) had no days $\geq$ 16 ^{o}C with a maximum temperature of 14.9 ^{o}C. The LEIG site is in an area that experienced a debris flow in February 1996 and has much less stream shading than the unaffected UEIG site. The mainstem Wind River warmed little in the 15 km between the site below Falls Creek and the site at Stabler (Figure 5). It is unknown how much the mainstem Wind River might warm between Stabler and it's mouth.

Flow

Flows throughout most of the summer 1999 were higher than those in 1997 and 1998 (Figures 10, 11, and 12). By early September 1999, flows had dropped to base levels similar to the previous two years.

Upper Trout Creek had the most stable flow throughout the late June to early October monitoring period, with a surface flow reduction of less than 75%. All other streams showed a surface flow reduction of over 90% from early July to early September. Dry Creek and Martha Creek both lost all surface flow at our flow sites by early September. Residual pools in Dry Creek were completely lost before surface flow resumed. Fish had been present in some of these pools. Residual pools were maintained in Martha Creek and they contained fish. Both creeks maintained surface flow upstream of the areas that became dry. Martha Creek had surface flow approximately 400 m above our flow site; it is unknown how far below the flow site the lack of surface flow continued because the stream flows onto private land and was not surveyed. Dry Creek was dry from our flow site at the mouth and upstream for approximately 3 km.

Discussion

Reach surveys provide a picture of geomorphological characteristics and overall condition of a stream that allow comparison within and between streams. Paired with fish data, and corresponding unit-scale habitat information, reach surveys will provide an indication of which streams show healthy reach-scale habitat conditions. For example our data on LWD frequency reflects what stream reaches have healthy levels of LWD, which can serve as index sites for restoration efforts on other reaches. Our approach to this data and the relationships therein will be conceptually similar to the hierarchical (microhabitat and mesohabitat) approach to fish-habitat relationships advocated by Rabeni and Sowa (1995). Future sampling and analyses should begin to provide clues on the habitat conditions most favored by steelhead in the Wind River subbasin.

Water temperature in the Wind River subbasin has been a major focus of CRRL personnel. Spence et al. (1996) state "Perhaps no other environmental factor has a more pervasive influence on salmonids and other aquatic biota than temperature". Small changes in the temperature regime of a stream can affect fish. Life stages from developing embryos to spawning adults can be affected (Beacham and Murray 1990; Hotlby 1988; Monan et al. 1975).

The Trout Creek watershed is of particular concern as temperatures often exceed the preferred range for steelhead of 10-13 ^{o}C (Bell 1986). We have recorded temperatures in the lower portion of Trout Creek near the lethal level for steelhead of 23.9 ^{o}C (Bell 1986). This area also is subject to a large diel range of water temperatures that could be stressful to fish. There is a springtime downstream migration of parr in Trout Creek (Rawding 1999), which may reside in the lower portion of the creek.

Eightmile Creek also experienced a large increase in temperature between our upper and lower thermograph sites. In 1996 a landslide originated out of a tributary gully and scoured the lower 500 m of the stream. The debris flow removed much of the riparian vegetation and left the stream open to direct solar heating.

The sites with the lowest maximum water temperatures in the Wind River subbasin are upper Trout Creek and upper Panther Creek (Tables 4 and 5). In contrast to Trout Creek, which warmed greatly between our upper and lower thermograph sites, Panther Creek stayed cool between our upper and lower thermograph sites. Panther Creek may help to moderate temperatures in the lower Wind River during the period when adult summer steelhead enter the river.

The higher flows during the early and mid summer period in 1999 may have helped to moderate water temperatures. Maximum water temperatures in 1999 were lower than 1998 and 1997. The period of maximum stream temperatures proceeded the period of minimum flow by approximately three weeks in tributaries of the Wind River during 1997-1999.

Acknowledgements

A number of people helped with this work. Jim Petersen and Julie Parsons were fellow USGS personnel crucial to this effort. Jim helped with administration and planning of the project. Julie was a member of the field crew and did much data entry and some analysis. Susan James of UCD provided some of the thermograph data reported here. A thanks goes to Tim Cummings of the USFWS-FPO (Vancouver, WA) for providing some needed field gear. An acknowledgement goes to John Baugher, our BPA Contracting Officer.

References

Beacham, T. D., and C. B. Murray. 1990. Temperature, egg size, and development of embryos and alevins of five species of Pacific salmon: a comparative analysis. Transactions of the American Fisheries Society 119:927-945.

Bell, M. C. 1986. Fisheries handbook of engineering requirements and biological criteria. U.S. Army, Corps of Engineers, Office of the Chief of Engineers, Fish Passage Development and Evaluation Program, Portland, Oregon.

Gallagher, A. S., and N. J. Stevenson. 1999. Streamflow. Pages 149-155 *in* M. B. Bain and N. J. Stevenson, editors. Aquatic habitat assessment: common methods. American Fisheries Society, Bethesda, Maryland.

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 45:502-515.

Monan, G. E., J. H. Johnson, and G. F. Esterberg. 1975. Electronic tags and related tracking techniques aid in study of migrating salmon and steelhead trout in the Columbia River basin. Marine Fisheries Review 37:9-15.

Rabeni, C. F., and S. P. Sowa. 1996. Integrating biological realism into habitat restoration and conservation strategies for small streams. Canadian Journal of Fisheries and Aquatic Sciences 53 (Suppl. 1): 252-259.

Rawding, D., P. C. Cochran, and T. King. 1999. Report D *in* P. J. Connolly, editor. Wind River Watershed Project 1998 Annual Report. Project No. 9054. Prepared for Bonneville Power Administration, Portland, Oregon.

Rosgen, D. L. 1994. A classification of natural rivers. Catena 22:169-199.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Nowitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR.

Table 1. Locations of thermographs deployed and maintained by USGS within the Wind River subbasin. Sites are listed from upstream to downstream within a subbasin. Coordinates are from a hand-held Global Positioning System (GPS) using North American Datum 1927.

Watershed Subwatershed Subdrainage	GPS reading North	 West	Elevation (ft)	Distance upstream from mouth (km)	Date start (mm/yy)	Date end (mm/yy)
Trout Creek						
Trout Cr. – upper	45º 50.798'	122º 01.962'	1,920	15.2	12/96	10/98
Crater Cr.	45º 50.769'	122º 01.997'	1,920	0.1	12/96	10/99
					6/00[a]	present
Trout Cr. – 33 bridge	45º 50.727'	122º 01.987'	1,900	14.4	12/96[b]	present
Compass Cr.	45º 50.427'	122º 02.051'	1,900	0.2	12/96	present
East Fork Trout Cr.	RNO[c]		1,860	0.2	5/99	present
Trout Cr. – upper OG[d]	45º 49.867'	122º 01.428'	1,835	12.2	11/97	6/00
					7/00	present
Upper Layout Cr.	RNO		1,930	2.9	5/99	present
Layout Cr.	45º 49.776'	122º 01.525'	1,830	0.1	11/97[e]	10/99
					7/00	present
Trout Cr. – lower OG	45º 49.656'	122º 01.278'	1,810	11.6	11/97[f]	present
Trout Cr. – 43 bridge	45º 49.320'	122º 00.894'	1,805	11.0	08/97[g]	present
Planting Cr.	45º 48.972'	121º 59.436'	1,730	0.2	05/97[g]	10/99
Trout Cr. – above Hemlock	RNO[b]		1,120	6.0	11/98[g,h,i]	present
Trout Cr. – below Hemlock	45º 48.126'	121º 55.810'	1,080	4.9	10/98	present
Upper Martha Cr.	RNO		1,130	1.8	5/99	present
Martha Cr.	45º 47.737'	121º 55.342'	1,080	1.0	10/97[j]	present

Continued.

Table 1. Continued.

Watershed Subwatershed Subdrainage	GPS reading North	West	Elevation (ft)	Distance upstream from mouth (km)	Date start (mm/yy)	Date end (mm/yy)
Upper Wind River						
Wind R. – ab. Paradise Cr.	45º 57.047'	121º 55.815'	1,560	40.9	7/00	present
Paradise Cr.	45º 57.149'	121º 56.400'	1,550	1.0	10/98[g]	present
Wind R – lower mining	45º 54.793'	121º 56.926'	1,360	36.5	7/00	present
Falls Cr.	45º 54.486'	121º 56.844'	1,340	0.1	7/00	present
Ninemile Cr.	45º 53.651'	121º 56.752'	1,300	0.2	6/00	present
Dry Cr. 1	45º 54.127'	121º 57.874'	1,190	1.5	5/99[g]	6/00
Dry Cr. 2	RNO		1.250	3.3	6/00	present
Trapper Cr.	45º 53.431'	122º 00.593'	1,360	1.5	10/98	present
Wind R. – bl Trapper Cr.	45º 52.501'	121º 58.629'	1,090	30.0	10/98[g,k]	present
Panther Creek						
Panther Cr. – upper	45º 50.573'	121º 51.567'	1,070	12.0	10/98	present
Eightmile Cr. – upper	RNO		1,090	0.6	07/97	present
Eightmile Cr. – lower	45º 50.393'	121º 52.069'	1,030	0.2	07/97[g]	present
Cedar Cr.	45º 48.176'	121º 51.404'	940	1.2	05/97	12/99
Panther Cr. – lower 1	RNO		730	4.0	07/97	09/97
Panther Cr. – lower 2	RNO		730	4.0	11/98	present

[a] No data from 10/4/99-6/15/00 because of thermograph loss.
[b] No data from 10/7/98-6/17/99 because of thermograph failure.
[c] RNO = Reading not obtained.
[d] OG = Restored old-growth channel.
[e] No data from 10/4/99-7/28/00 because of thermograph loss.
[f] No data from 4/22/98-10/19/98 because of thermograph failure.
[g] Exposed to air during low water in September-October 1999.
[h] Data for 11/96-5/97 are available from the US Forest Service.
[i] No data from 10/18/99-6/16/00 because of thermograph failure.
[j] No data from 2/7/99-6/17/99 because of thermograph failure.
[k] No data from 2/1/99-8/13/99 because of thermograph failure.

Table 2. Locations of thermographs deployed and maintained by Underwood Conservation District within the Wind River subbasin. Sites are listed from upstream to downstream within a subbasin.

Watershed Subwatershed Subdrainage	GPS reading North	GPS reading West	Elevation (ft)	Distance upstream from mouth (km)	Date start (mm/yy)	Date end (mm/yy)
Upper Wind River						
Wind R. – blw. Falls Cr.	---		1,250	33.5	6/99	10/99
Trapper Cr. at mouth	---		1,015	0.3	6/99	10/99
Middle Wind River						
Wind R. – at Stabler Bridge	---		890	18.5	6/99	10/99
Trout Creek						
Trout Cr. – blw. Martha Cr.	---		865	0.2	6/99	10/99
Lower Wind River						
Bear Cr.	---		317	2.4	6/99	10/99
Little Wind River	---		85	0.2	6/99	10/99
Lower Wind River			80	1.5	6/99	10/99

Table 3. Flow measurement locations within the Wind River subbasin, 1996-1999. Readings are from a hand-held Global Positioning System (GPS) using North American Datum 1927. Sites are listed from upstream to downstream within a subbasin.

Watershed Subwatershed	GPS reading North	GPS reading West	Elevation (ft)	Distance upstream of mouth (km)	Year sampled[a] 1996	1997	1998	1999	2000
Upper Wind River[b]									
Wind R. – ab. Paradise Cr.	45° 57.047'	121° 55.815'	1,560	40.6	No	No	No	No	Yes
Paradise Cr.	45° 56.951'	121° 56.957'	1,550	0.5	No	No	Yes	Yes	Yes
Falls Cr.	45° 54.534'	121° 56.772'	1,340	0.1	No	No	No	No	Yes
Ninemile Cr.	RNO[c]		1,300	0.2	No	No	No	No	Yes
Dry Cr. – upper	RNO		1,190	1.5	No	No	No	Yes	Yes
Dry Cr. – lower	RNO		1,120	0.1	No	No	No	Yes	Yes
Trapper Cr.	45° 52.761'	121° 58.849'	1,120	0.1	No	No	Yes	Yes	Yes
Wind R. – bl. Trapper Cr.	45° 52.581'	121° 58.682'	1,090	30.3	No	No	No	No	Yes
Trout Creek[d]									
Trout Cr. – upper	45° 50.794'	122° 01.961'	1,920	15.2	Yes	Yes	Yes	Yes	Yes
Crater Cr.	45° 50.779'	122° 01.036'	1,920	0.1	Yes	Yes	Yes	Yes	Yes
Layout Cr. – upper	RNO		1,940	2.5	No	No	Yes	Yes	No
Layout Cr. – lower	RNO		1,830	0.1	No	No	No	Yes	Yes
MS43 Bridge	45° 49.434'	122° 00.978'	1,805	11.3	No	No	No	No	Yes
Planting Cr.	45° 48.972'	121° 59.436'	1,730	0.1	No	Yes	Yes	No	No
Martha Cr.	45° 47.767'	121° 55.255'	1,070	1.0	No	Yes	Yes	Yes	No
Panther Creek									
Eightmile Cr. – lower	RNO		1,020	0.1	No	Yes	Yes	No	No
Mouse Cr.	RNO		1,080	0.1	Yes	No	No	No	No
Cedar Cr.	45° 48.176'	121° 51.404'	940	1.2	Yes	Yes	No	No	No
Panther Cr. – lower	RNO		1,010	4.0	Yes	No	No	No	No

[a] Flows generally taken at regular intervals of time from June through October.
[b] In addition, a flow reading was taken on the mainstem Wind River above Paradise Cr. and below Trapper Cr. on 10/6/99.
[c] RNO = Reading not obtainable by GPS because of topography of basin.
[d] Trout Cr. 2000 flows were measured only once on 10/13/00.

Table 4. Annual number of days when maximum water temperature exceeded 16, 18, and 20^{o}C and the maximum water temperature recorded at sites in the Wind River subbasin, 1997-1999. Data are from Onset Corporation's StowAway thermographs, which recorded temperature every two hours. Sites are listed from upstream to downstream within a subbasin.

Watershed Subwatershed Subdrainage	No. days >=16 ^{o}C			No. days >=18 ^{o}C			No. days >=20 ^{o}C			Maximum (^{o}C)		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Trout Creek												
Trout Cr. – upper	0	0	---[a]	0	0	---	0	0	---	8.3	8.5	---
Crater Cr.	23	44	15	1	17	0	0	1	0	18.3	20.0	17.4
Trout Cr. – 33 bridge	0	0	0	0	0	0	0	0	0	10.1	10.7	9.0
Compass Cr.	0	5	0	0	0	0	0	0	0	14.9	16.3	14.0
East Fork Trout Cr.	---	---	42	---	---	7	---	---	0	---	---	19.0
Trout Cr. – upper OG[b]	---	0	0	---	0	0	---	0	0	---	15.9	13.5
Upper Layout Cr.	---	---	0	---	---	0	---	---	0	---	---	14.0
Layout Cr.	---	56	23	---	24	0	---	0	0	---	19.6	17.4
Trout Cr. – lower OG	---	---	1	---	---	0	---	---	0	---	---	16.1
Trout Cr. – 43 bridge	13	37	0	0	6	0	0	0	0	17.8	18.6	15.7
Planting Cr.	16	33	---	1	7	---	0	0	---	18.7	19.2	---
Trout Cr. – above Hemlock	---	74	---	---	46	---	---	23	---	---	23.2	---
Trout Cr. – blw. Hemlock	---	---	44	---	---	28	---	---	6	---	---	20.3
Upper Martha Cr.	---	---	22	---	---	0	---	---	0	---	---	17.0
Martha Cr.	---	62	45	---	29	10	---	5	0	---	21.2	18.7
Trout Cr. – blw. Martha Cr.[c]	---	---	37	---	---	10	---	---	0	---	---	18.7

Continued.

Table 4. Continued.

Watershed / Subwatershed / Subdrainage	No. days >=16°C			No. days >=18°C			No. days >=20°C			Maximum (°C)		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Upper Wind River												
Paradise Cr.	---	---	---	---	---	---	---	---	---	---	---	---
Wind R. – blw. Falls Cr.	---	---	0	---	---	0	---	---	0	---	---	14.1
Dry Cr.	---	---	---	---	---	---	---	---	---	---	---	---
Trapper Cr.	---	---	0	---	---	0	---	---	0	---	---	13.8
Trapper Cr.[c]	---	---	0	---	---	0	---	---	0	---	---	14.5
Wind R. – blw. Trapper Cr.	---	---	---	---	---	---	---	---	---	---	---	---
Middle Wind River												
Wind R. – at Stabler Bridge[c]	---	---	6	---	---	0	---	---	0	---	---	16.4
Panther Creek												
Panther Cr. – upper	---	---	0	---	---	0	---	---	0	---	---	9.3
Eightmile Cr. – upper	0	4	0	0	0	0	0	0	0	15.3	16.1	14.9
Eightmile Cr. – lower	29	39	32	4	6	0	0	0	0	18.4	18.6	17.8
Cedar Cr.	0	10	0	0	0	0	0	0	0	15.8	16.9	15.6
Panther Cr. – lower 1	0	---	---	0	---	---	0	---	---	13.9	---	---
Panther Cr. – lower 2	---	---	0	---	---	0	---	---	0	---	---	13.5
Lower Wind River												
Bear Cr.[c]	---	---	25	---	---	0	---	---	0	---	---	16.8
Little Wind River[c]	---	---	42	---	---	10	---	---	0	---	---	18.3
Lower Wind River[c]	---	---	---	---	---	---	---	---	---	---	---	---

[a] --- = Thermograph not in place or not operating properly during period of maximum temperatures.
[b] OG = Restored old-growth channel
[c] Thermographs deployed and maintained by Underwood Conservation District.

Table 5. Mean, minimum, and maximum water temperature recorded at sites within the Wind River subbasin during summer 1999. Data are from Onset Corporation's StowAway Thermographs, which recorded water temperature every two hours. Sites are listed from upstream to downstream within a subbasin.

Watershed Subwatershed Subdrainage	Minimum (^{o}C)			Mean (^{o}C)			Maximum (^{o}C)		
	July	Aug.	Sept.	July	Aug.	Sept.	July	Aug.	Sept.
Trout Creek									
Crater Cr.	5.3	11.1	6.8	9.9	14.1	11.1	15.3	17.4	13.5
Trout Cr. – 33 bridge	4.7	6.2	4.4	6.8	7.3	6.2	9.0	9.0	7.8
Compass Cr	5.8	10.9	8.0	9.5	12.5	10.5	13.1	14.0	12.0
East Fork Trout Cr.	8.4	10.9	5.2	13.6	14.7	10.1	18.7	19.0	12.7
Trout Cr. – upper OG[a]	5.2	7.5	4.9	8.5	9.6	8.2	13.5	13.4	11.8
Upper Layout Cr.	6.1	8.7	6.4	8.8	10.8	9.8	12.9	14.0	12.6
Layout Cr.	6.4	11.2	8.1	11.0	13.9	11.9	16.4	17.4	14.8
Trout Cr. – lower OG	5.4	8.5	5.5	9.5	10.8	9.2	16.1	14.7	12.5
Trout Cr. – 43 bridge	5.5	8.4	5.2	9.5	11.4	9.6	15.3	15.7	12.9
Trout Cr. – blw. Hemlock	8.2	13.0	8.3	13.6	16.9	13.2	19.6	20.3	15.9
Upper Martha Cr.	9.0	12.8	9.5	12.6	14.7	12.5	16.2	17.0	15.1
Lower Martha Cr	8.8	12.9	7.3	13.5	15.7	11.8	18.7	18.4	17.4
Trout Cr. – blw. Martha Cr.[b]	8.2	12.9	7.8	13.3	16.1	12.4	18.3	18.7	15.2

Continued.

Table 5. Continued

Watershed / Subwatershed / Subdrainage	Minimum (°C)			Mean (°C)			Maximum (°C)		
	July	Aug.	Sept.	July	Aug.	Sept.	July	Aug.	Sept.
Upper Wind River									
Wind R. – blw. Falls Cr.[b]	5.8	9.4	5.4	9.4	11.7	9.3	12.9	14.1	11.4
Trapper Cr.	6.2	10.7	8.0	9.6	12.2	10.5	13.0	13.8	11.9
Trapper Cr. at mouth[b]	6.2	11.0	8.2	9.7	12.8	10.9	13.7	14.5	12.2
Middle Wind River									
Wind R. – at Stabler Bridge[b]	7.0	9.8	6.6	10.8	12.5	10.7	15.6	16.4	13.7
Panther Creek									
Panther Cr. – upper	5.7	6.2	5.0	7.1	7.2	6.6	9.1	9.0	8.1
Eightmile Cr. – upper	10.1	12.9	9.9	12.4	13.9	12.0	14.6	14.9	13.0
Cedar Creek	9.1	11.5	8.5	12.1	13.2	11.1	15.6	15.6	12.9
Panther Cr. – lower 2	6.7	7.8	5.3	9.5	9.7	8.3	13.5	13.4	11.0
Lower Wind River									
Bear Cr.[b]	9.0	12.6	8.2	12.8	14.6	12.2	16.8	16.8	14.5
Little Wind River[b]	10.2	12.9	8.6	14.2	15.8	12.8	18.3	18.3	15.6

[a] OG = Restored old-growth channel.

[b] Thermographs deployed and maintained by Underwood Conservation District.

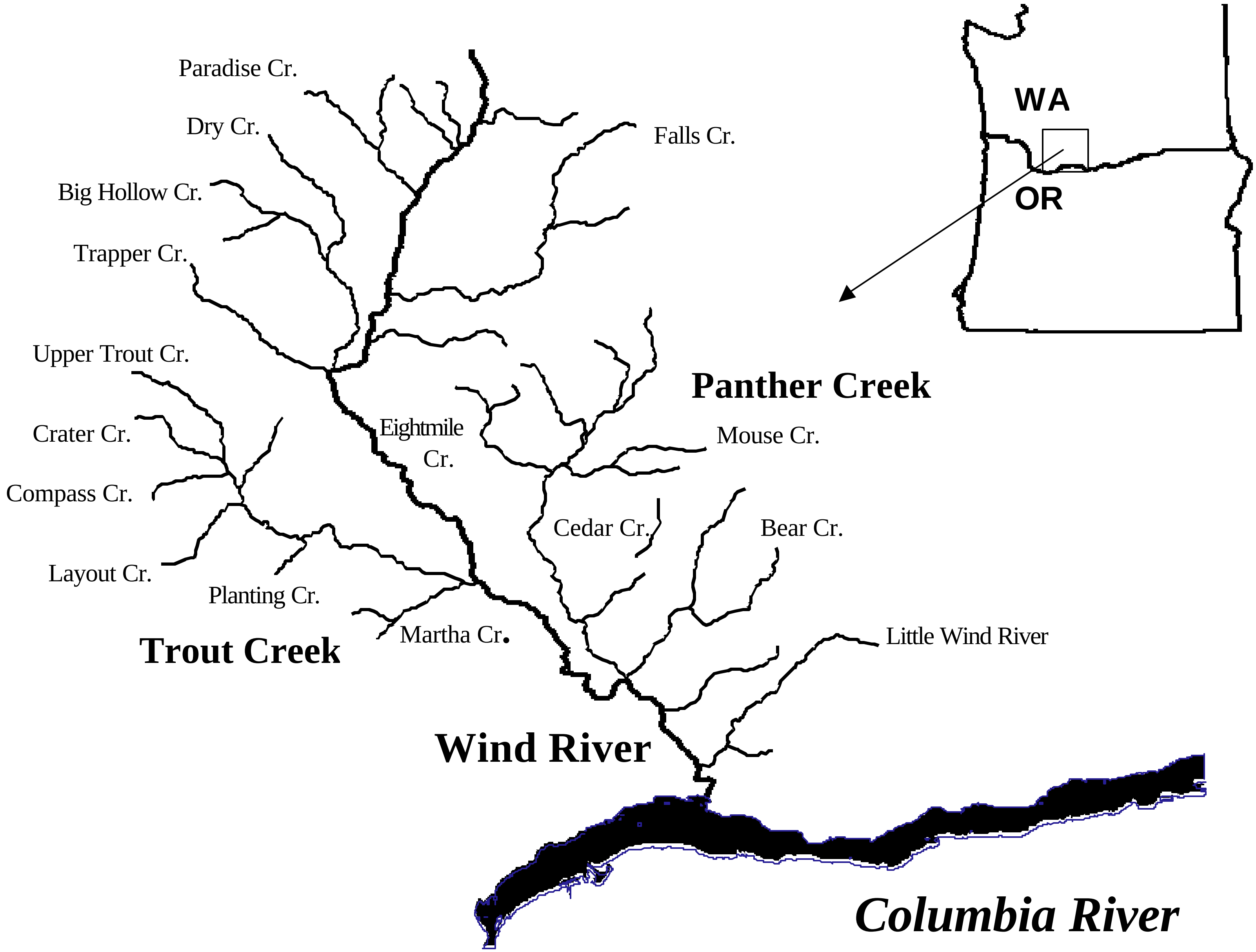


Figure 1. Wind River subbasin.

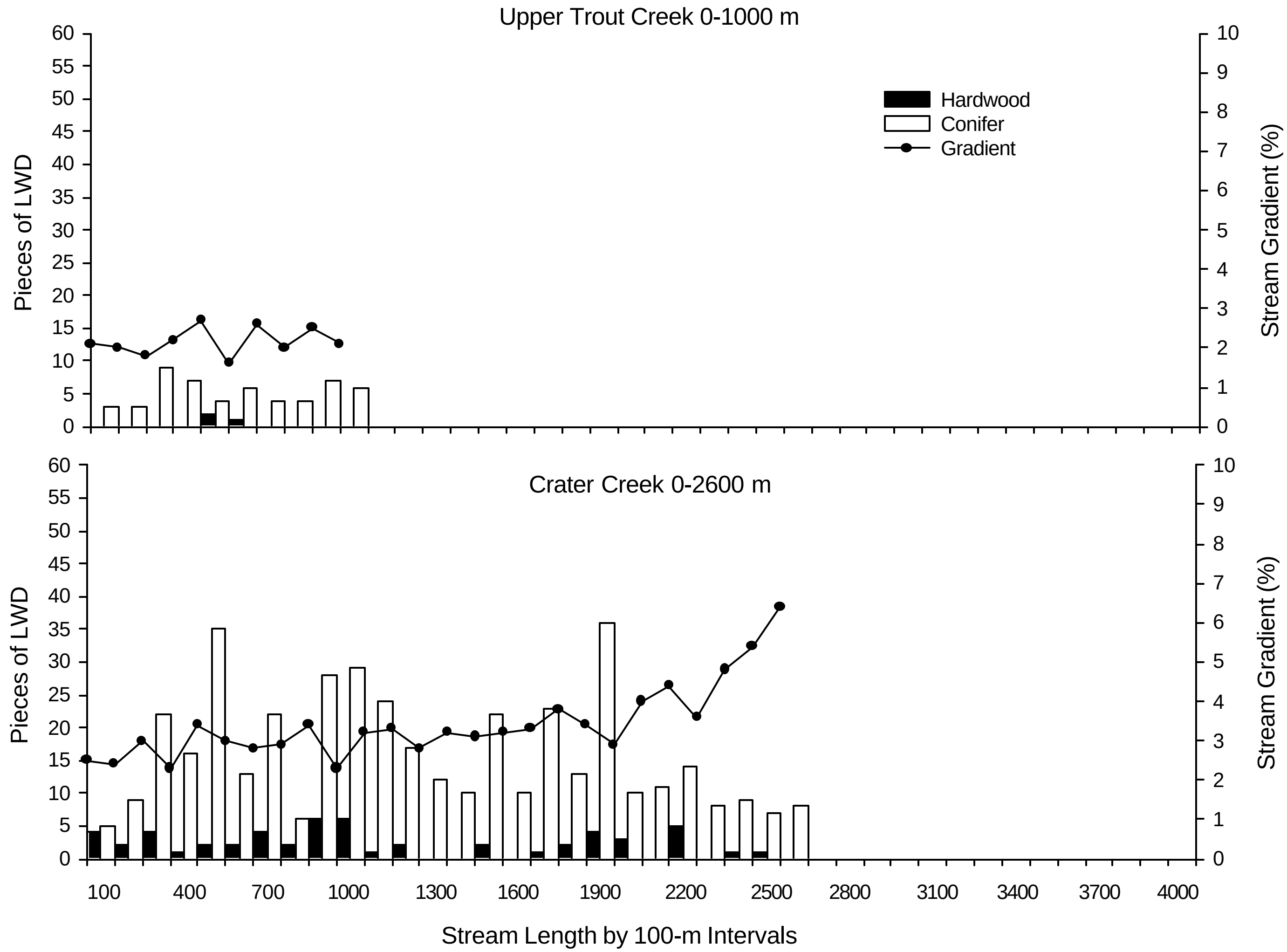


Figure 2. Reach survey data for tributaries of Trout Creek. Shown are counts of hardwood and conifer large woody debris (LWD; length ≥ 1.0 m and diameter ≥ 0.3 m) and stream gradient (%) for 100-m intervals.

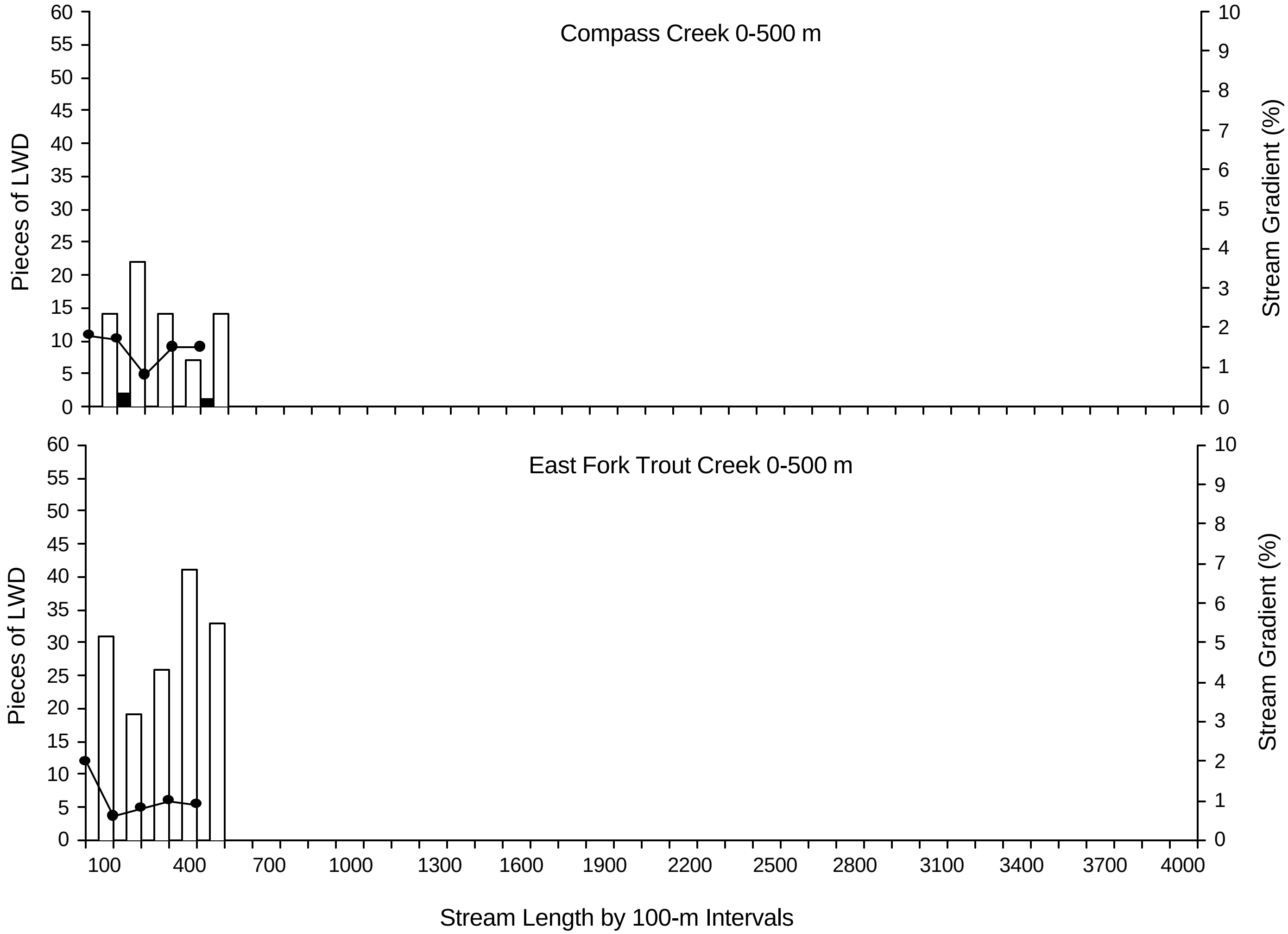


Figure 2. Continued.

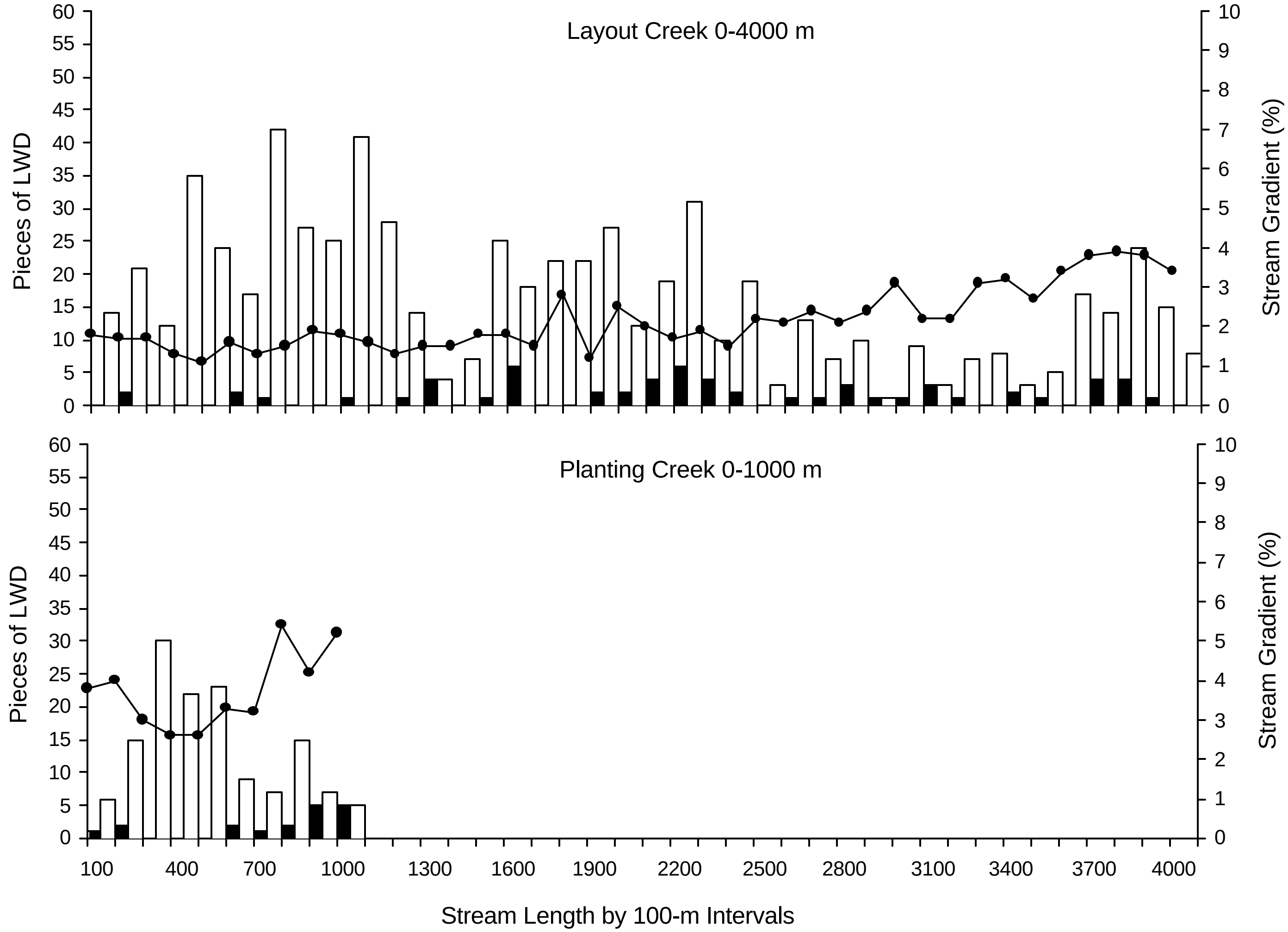


Figure 2. Continued.

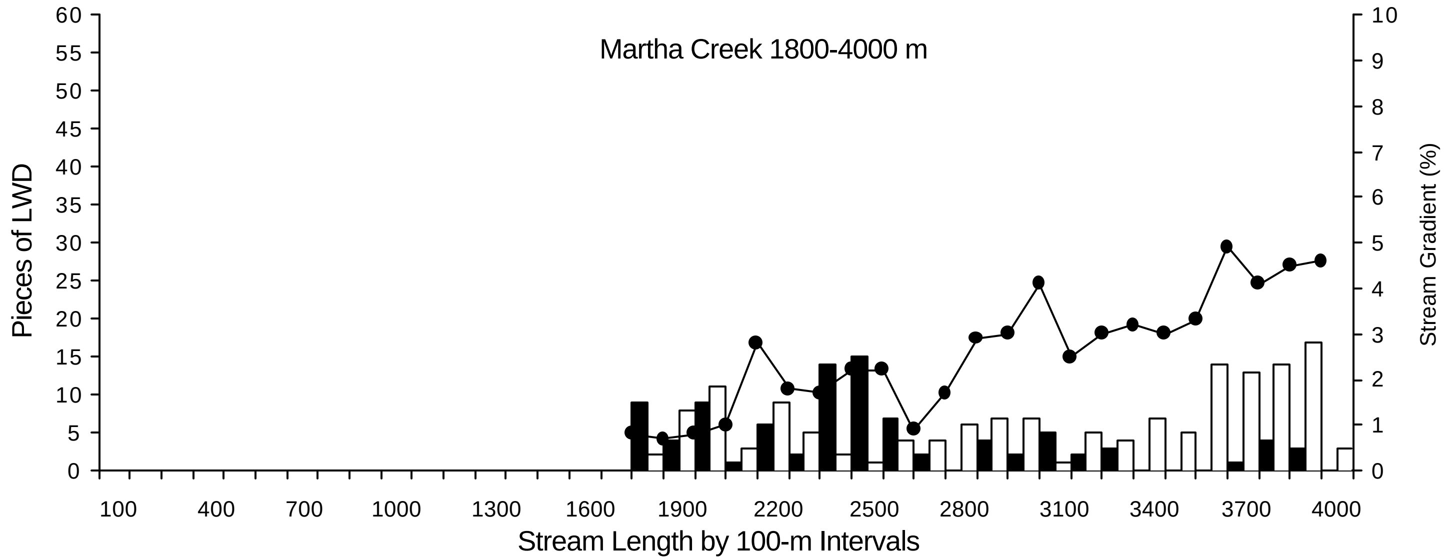


Figure 2. Continued.

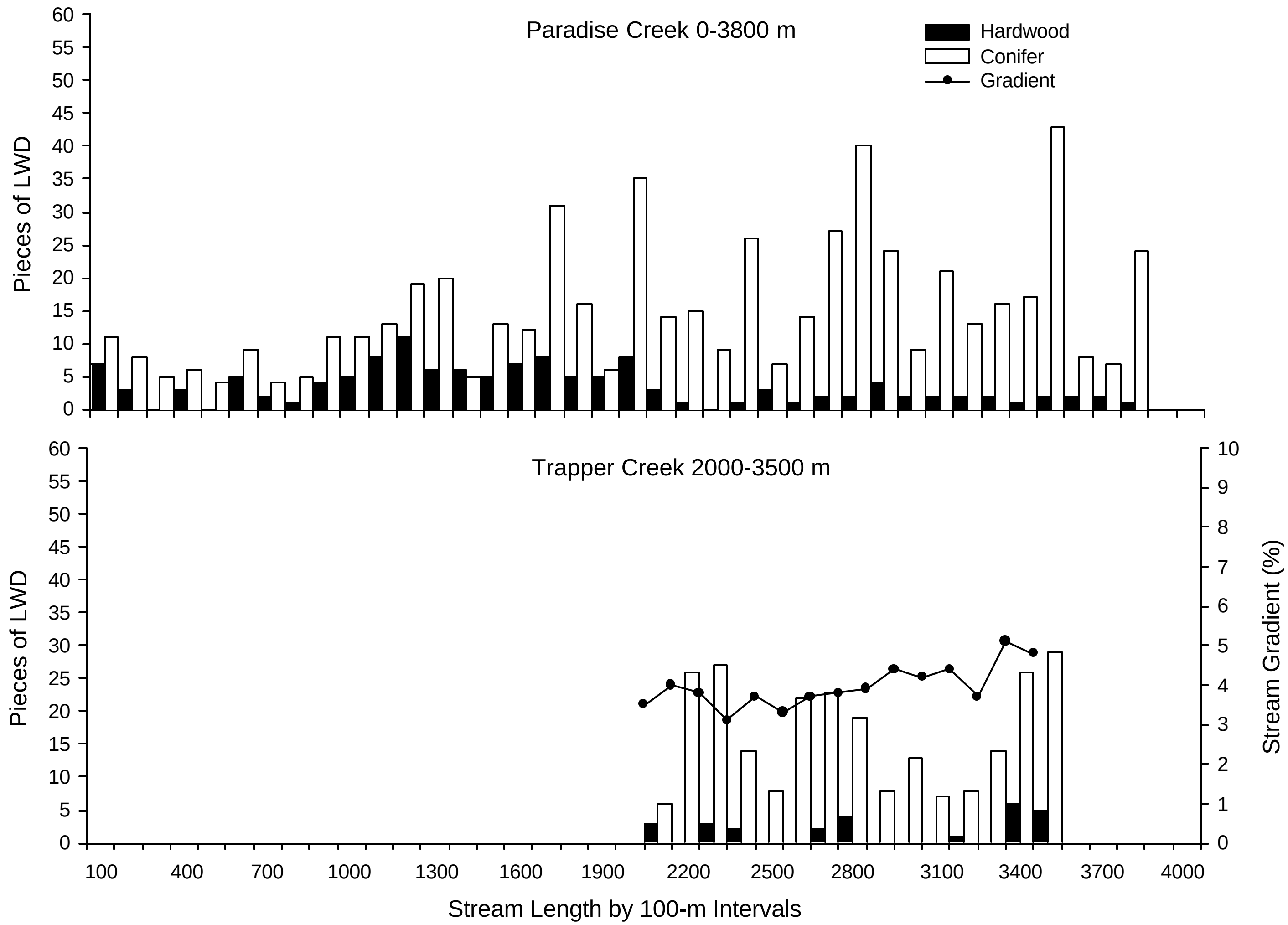


Figure 3. Reach survey data for tributaries of upper Wind River. Shown are counts of hardwood and conifer large woody debris (LWD; length ≥ 1.0 m and diameter ≥ 0.3 m) and stream gradient (%) for 100-m intervals. Stream gradient data are not available for Paradise, Dry, and Big Hollow creeks.

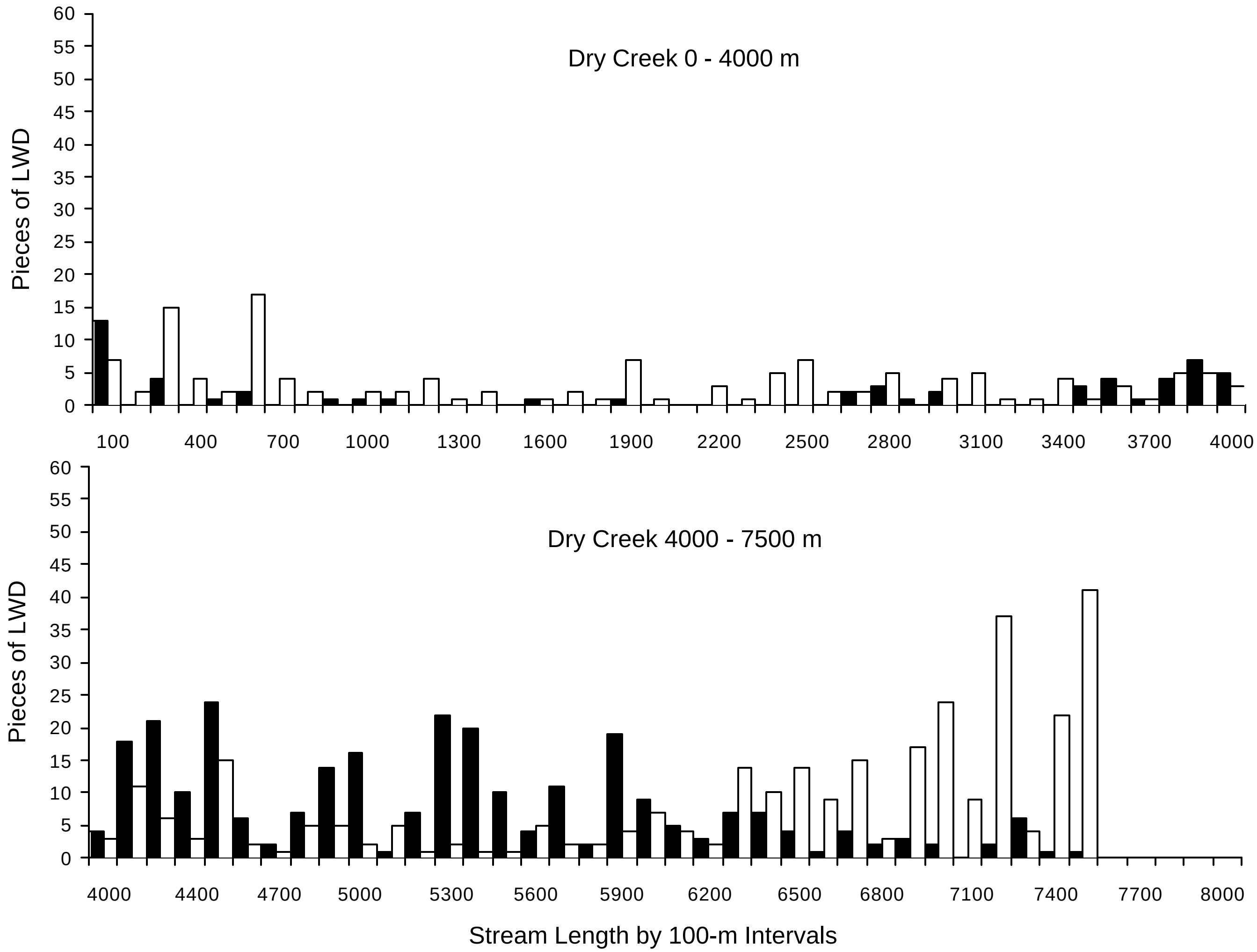


Figure 3. Continued.

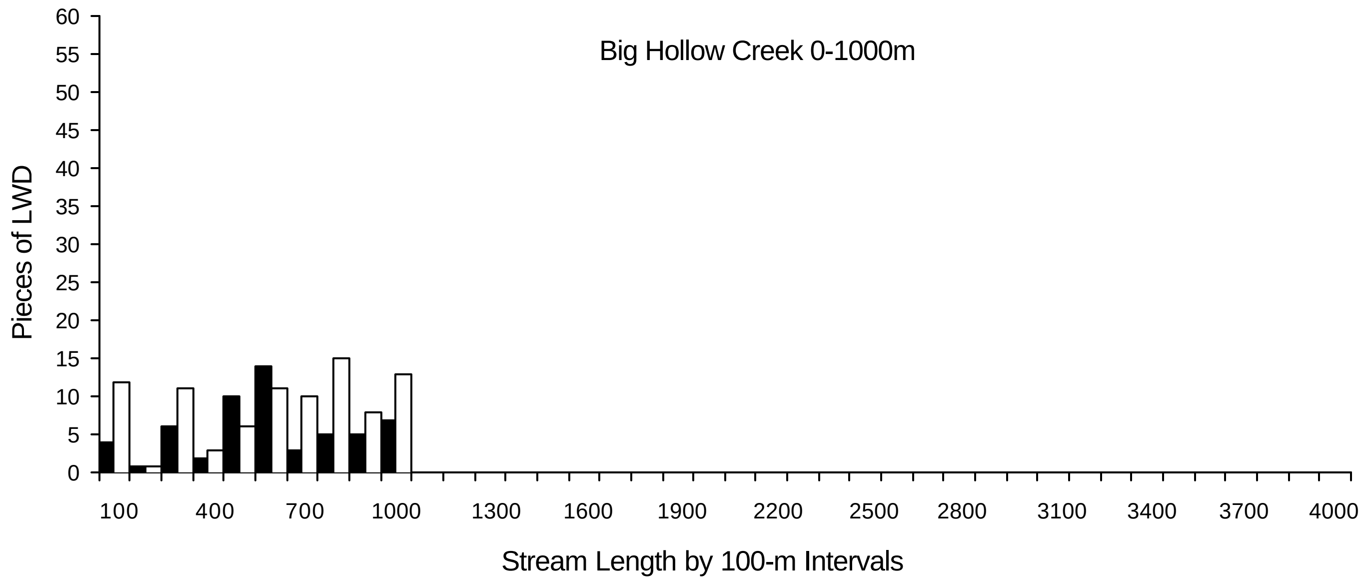


Figure 3. Continued.

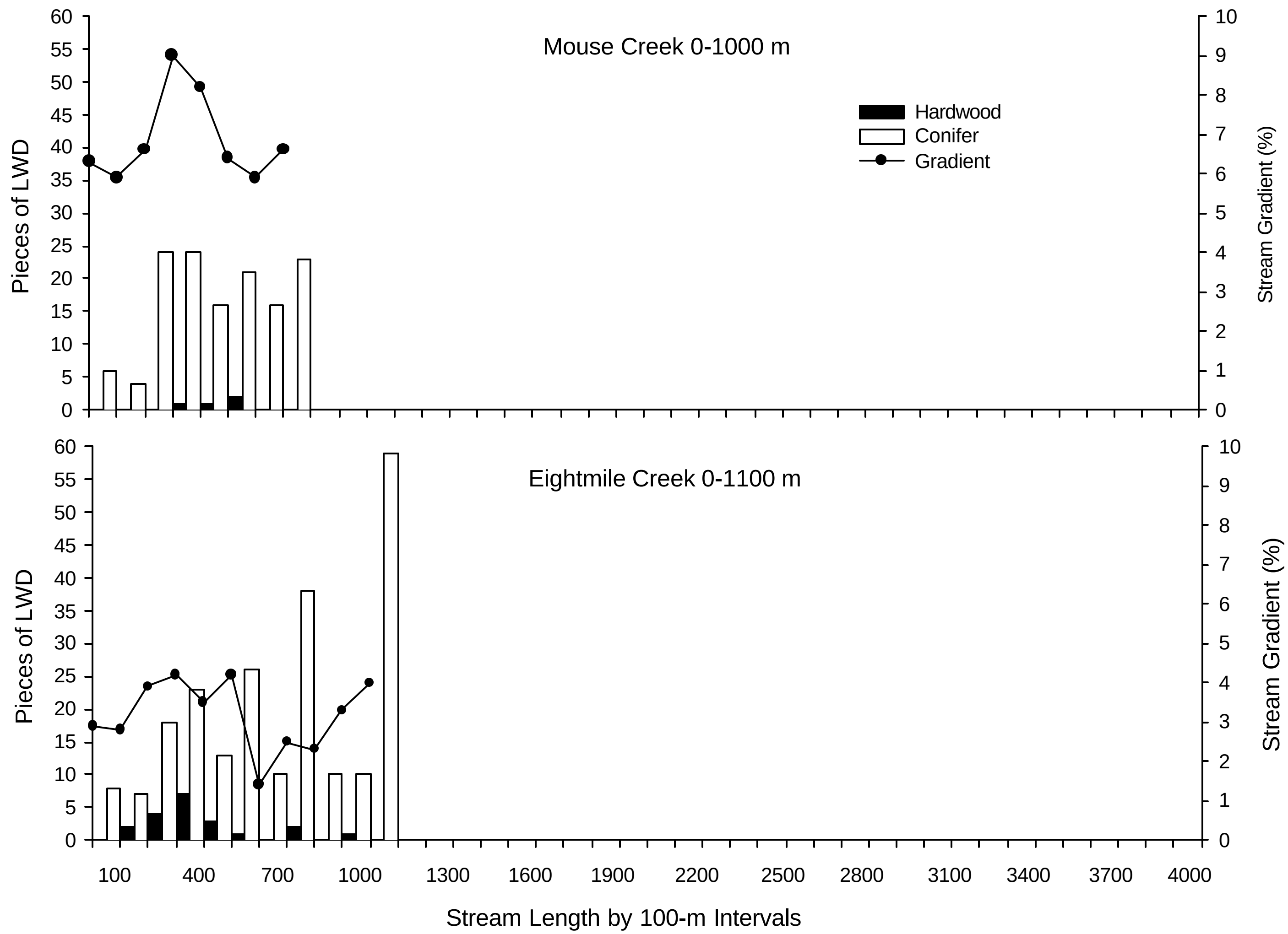


Figure 4. Reach survey data for tributaries of Panther Creek. Shown are counts of hardwood and conifer large woody debris (LWD; length ≥ 1.0 m and diameter ≥ 0.3 m) and stream gradient (%) for 100-m intervals.

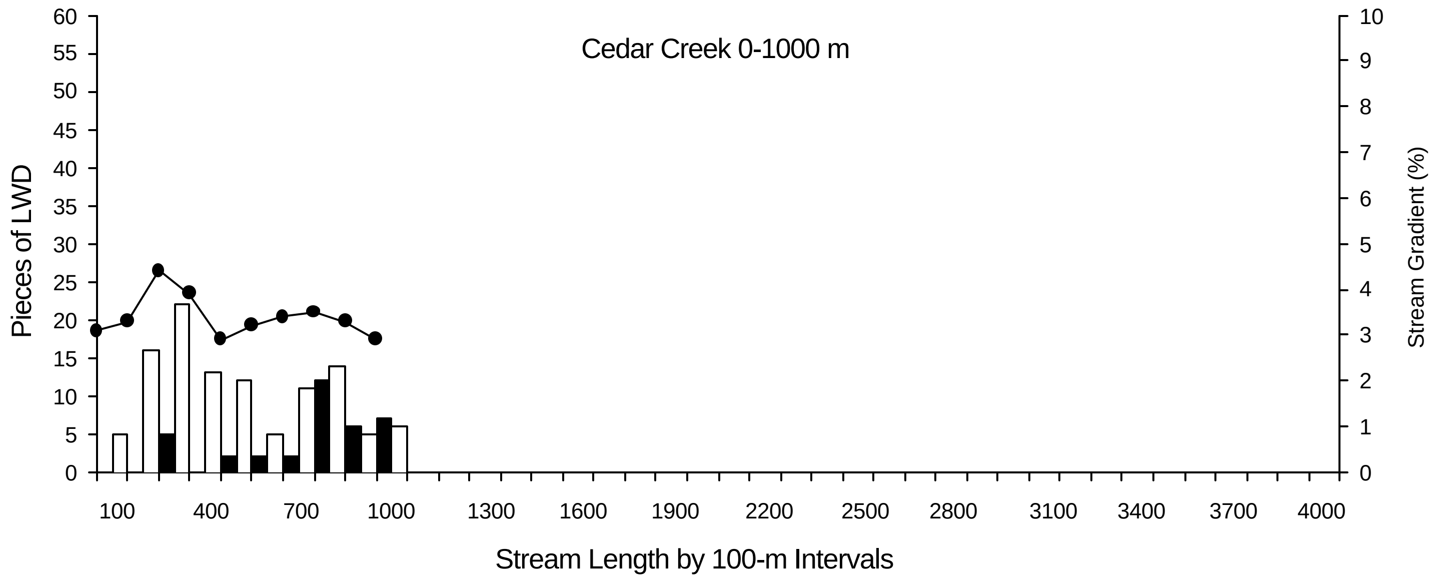


Figure 4. Continued.

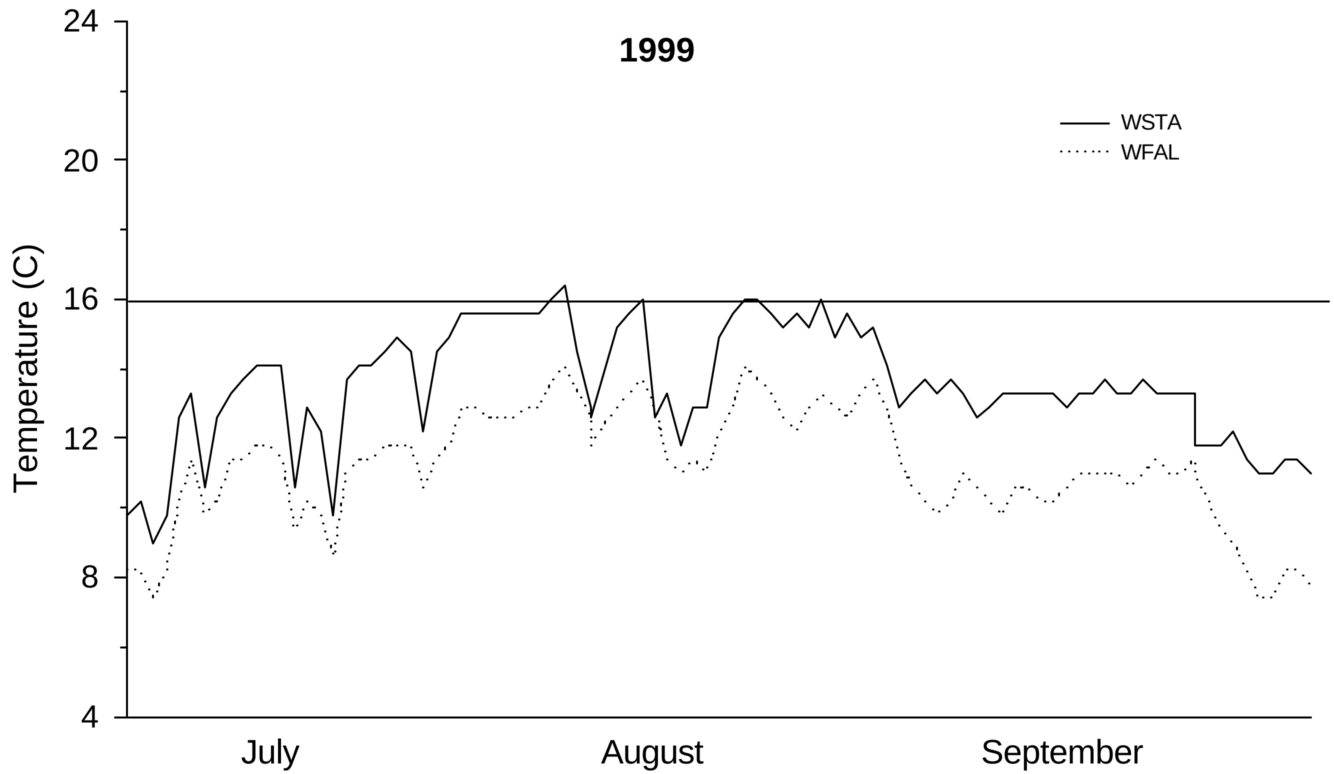


Figure 5. Daily maximum stream temperatures at two sites in the mainstem Wind River for 1 July to 1 October 1999. Sites from downstream to upstream are Wind River at Stabler Bridge Rkm 18.5 (WSTA) and Wind River downstream of Falls Creek Rkm 33.5 (WFAL). The line at 16 °C marks the maximum surface water temperature standard set by the Washington Department of Ecology (Chapter 173-201A, Nov. 18 1997, Water Quality Standards for the Surface Waters of the State of Washington).

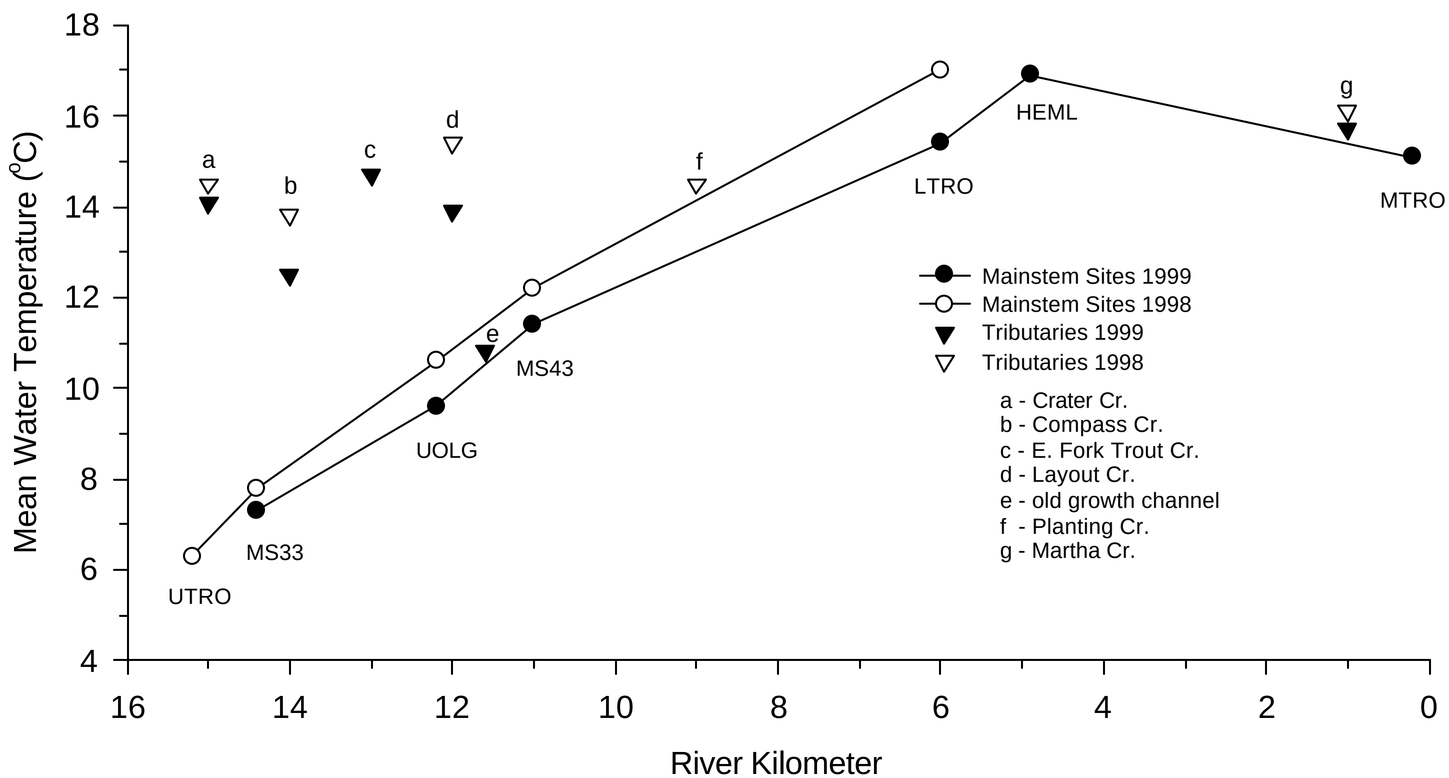


Figure 6. Mean water temperature during August 1998 and 1999 in mainstem Trout Creek and its tributaries. Sites, from left to right, are shown from upstream to downstream. River kilometer zero is the mouth of Trout Creek. Mainstem sites are located at, upper Trout Cr. at Rkm 15.2 (UTRO), 33 Bridge at Rkm 14.4 (MS33), upper old growth channel at Rkm 12.2 (UOLG), 43 Bridge at Rkm 11.0 (MS43), above Hemlock Lake at Rkm 6.0 (LTRO), below Hemlock Dam at Rkm 4.9 (HEML), and the mouth of Trout Creek at Rkm 0.2 (MTRO).

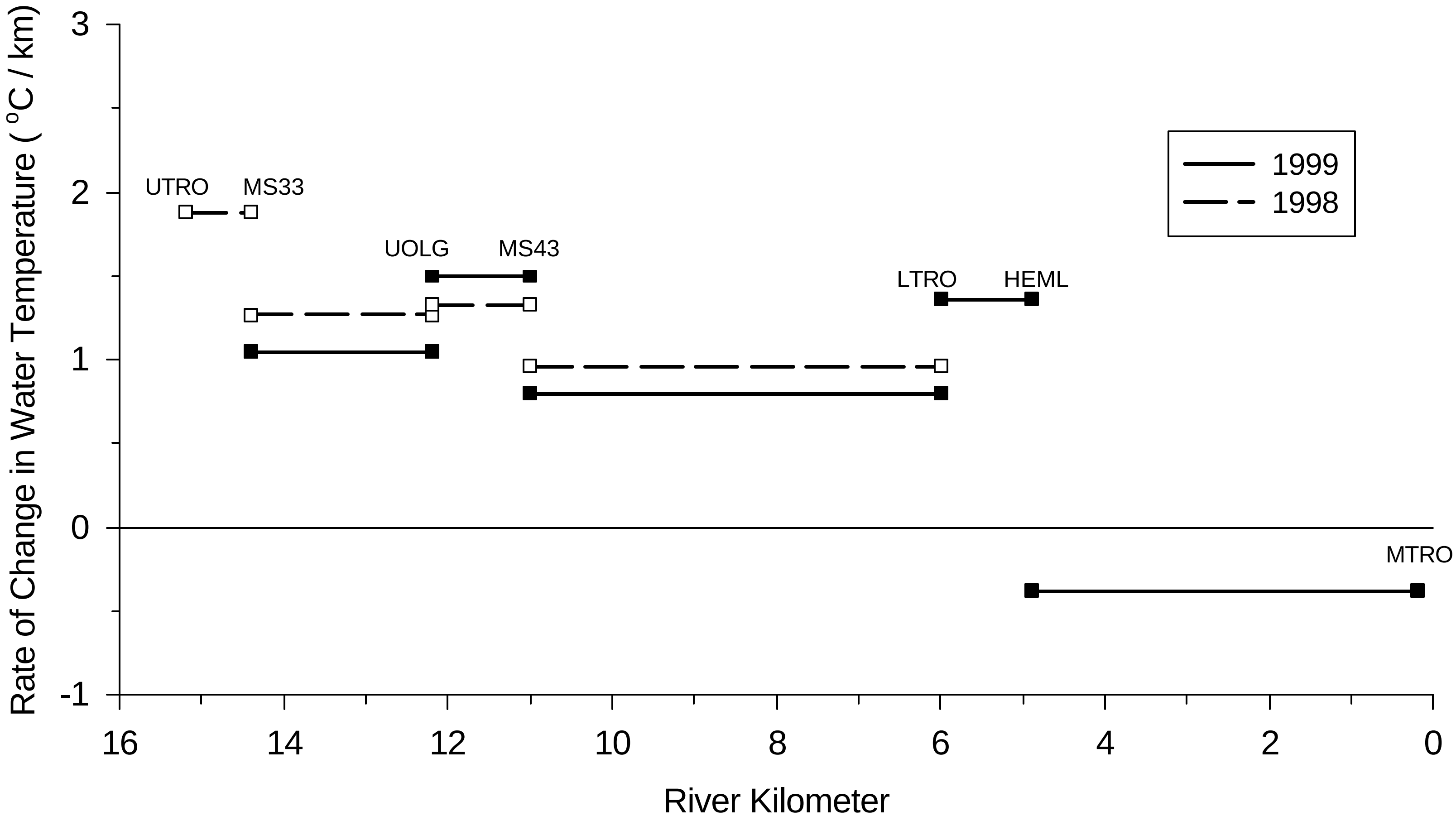


Figure 7. Rate of change (°C/km) of mean temperature for sections of Trout Creek during August 1998 and 1999. River kilometer (Rkm) zero is the mouth of Trout Creek. Thermograph locations at the ends of each section are shown from upstream to downstream: upper Trout Cr. at Rkm 15.2 (UTRO), 33 Bridge at Rkm 14.4 (MS33), upper old growth channel at Rkm 12.2 (UOLG), 43 Bridge at Rkm 11.0 (MS43), lower Trout at Rkm 6.0 (LTRO), below Hemlock Dam at Rkm 4.9 (HEML), and mouth of Trout Cr. at Rkm 0.2 (MTRO).

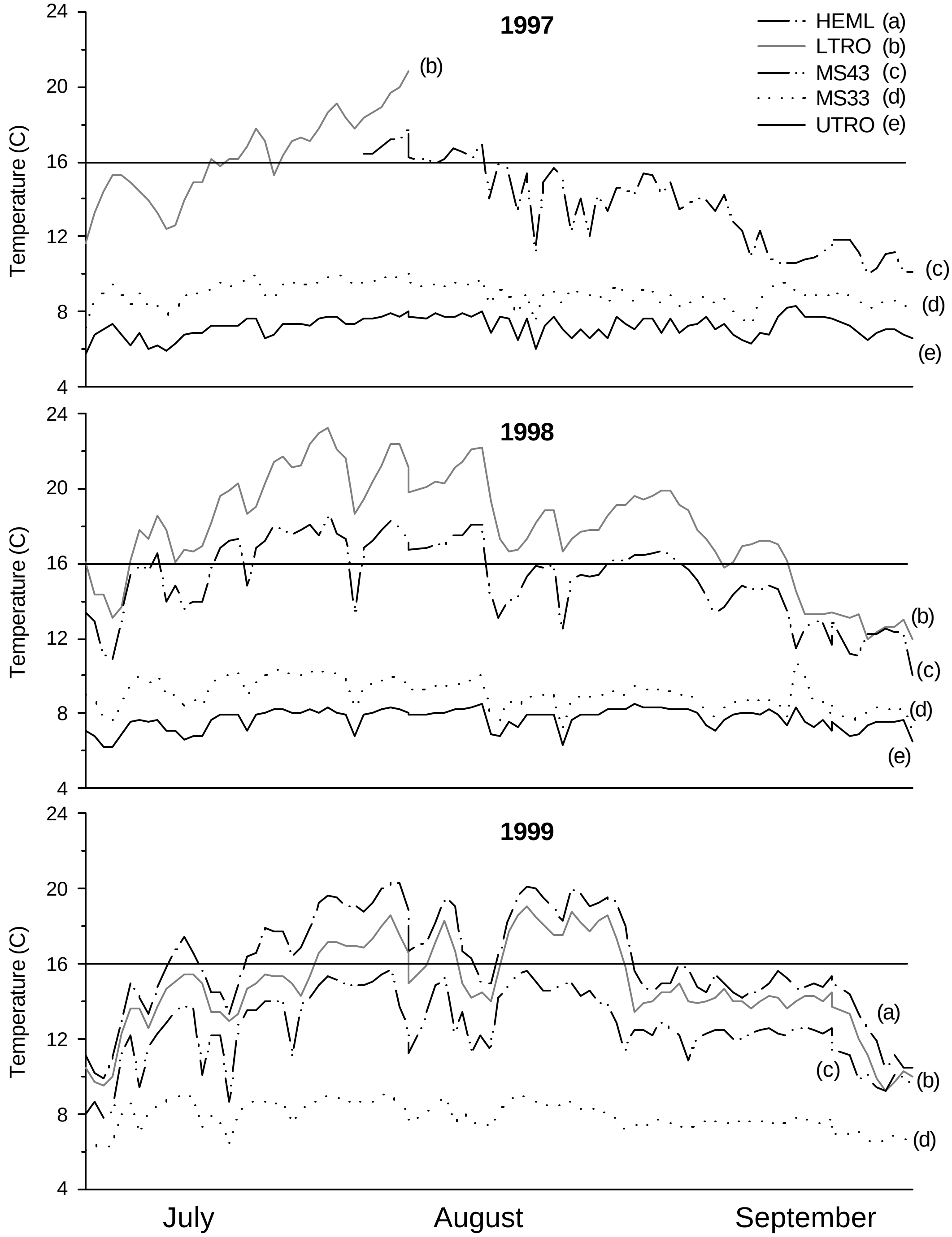


Figure 8. Daily maximum temperatures at five sites in Trout Creek for 1 July to 1 Oct. 1997, 1998 and 1999. Sites from downstream to upstream are a) below Hemlock Dam at Rkm 4.9 (HEML), lower Trout Cr. at Rkm 6.0 (LTRO), 43 Bridge at Rkm 11.0 (MS43), 33 Bridge at Rkm 14.4 (MS33), and upper Trout Cr. at Rkm 15.2 (UTRO). The line at 16^{o}C marks the maximum surface water temperature standard set by the Washington Department of Ecology (Chapter 173-201A, Nov. 18 1997, Water Quality Standards for the Surface Waters of the State of Washington).

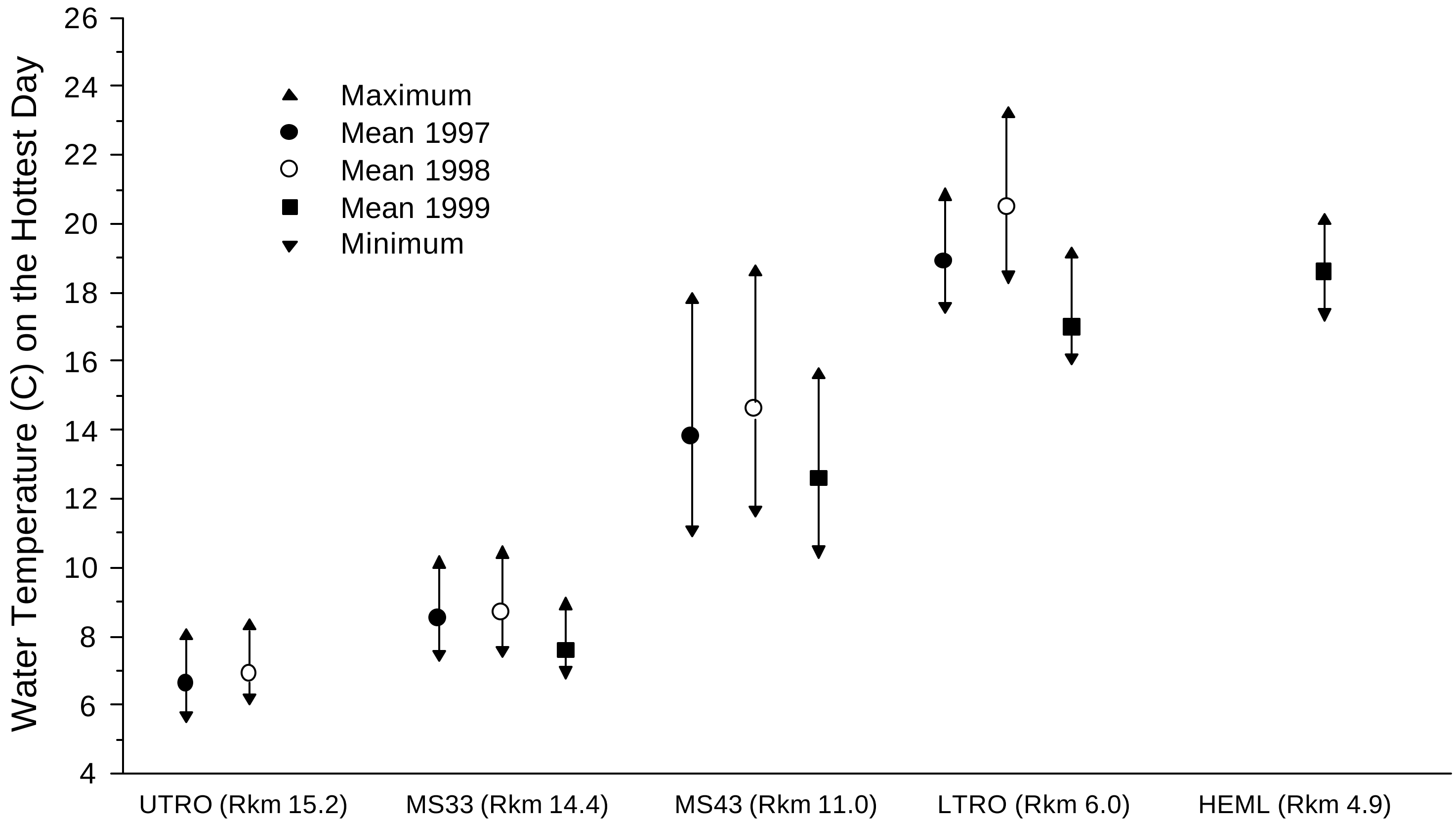


Figure 9. Mean and diel water temperature range for the year's hottest day at five sites in mainstem Trout Creek. Sites from left to right are ordered in an upstream to downstream direction: upper Trout Creek, Rkm 15.2 (UTRO); 33 Road Bridge, Rkm 14.4 (MS33); 43 Road Bridge, Rkm 11.0 (MS43); lower Trout Creek, Rkm 6.0 (LTRO); and below Hemlock Dam, Rkm 4.9 (HEML). Dates chosen had the warmest single day water temperature at the MS43 site within the years 1997 (August 6), 1998 (July 28), and 1999 (August 19).

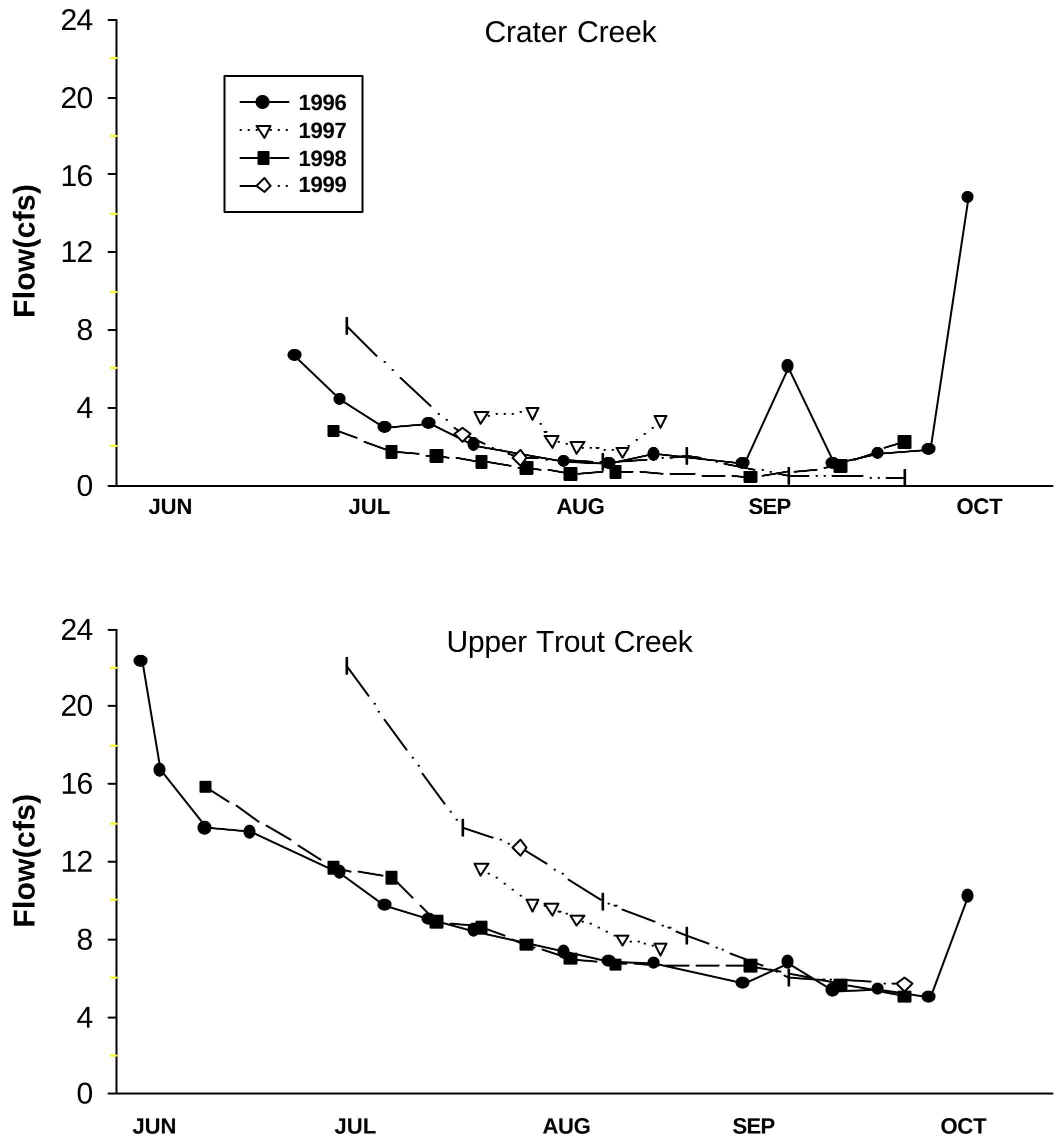


Figure 10. Water flow levels for Crater and upper Trout creeks in the Trout Creek watershed, 1996-1999. For locations of measurement sites, see Table 3 of this report.

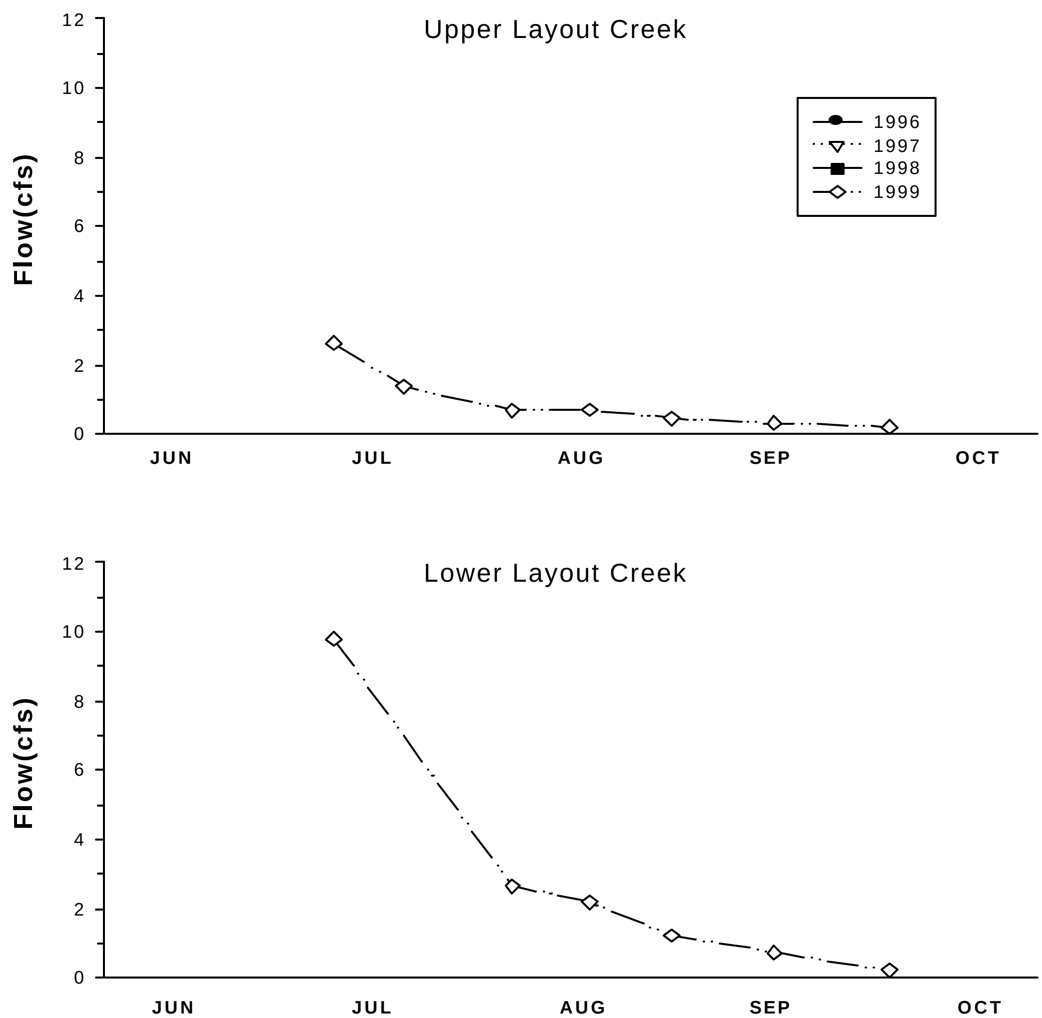


Figure 11. Water flow levels for upper and lower Layout Creeks in the Trout Creek watershed in 1999. For locations of measurement sites, see Table 3 of this report.

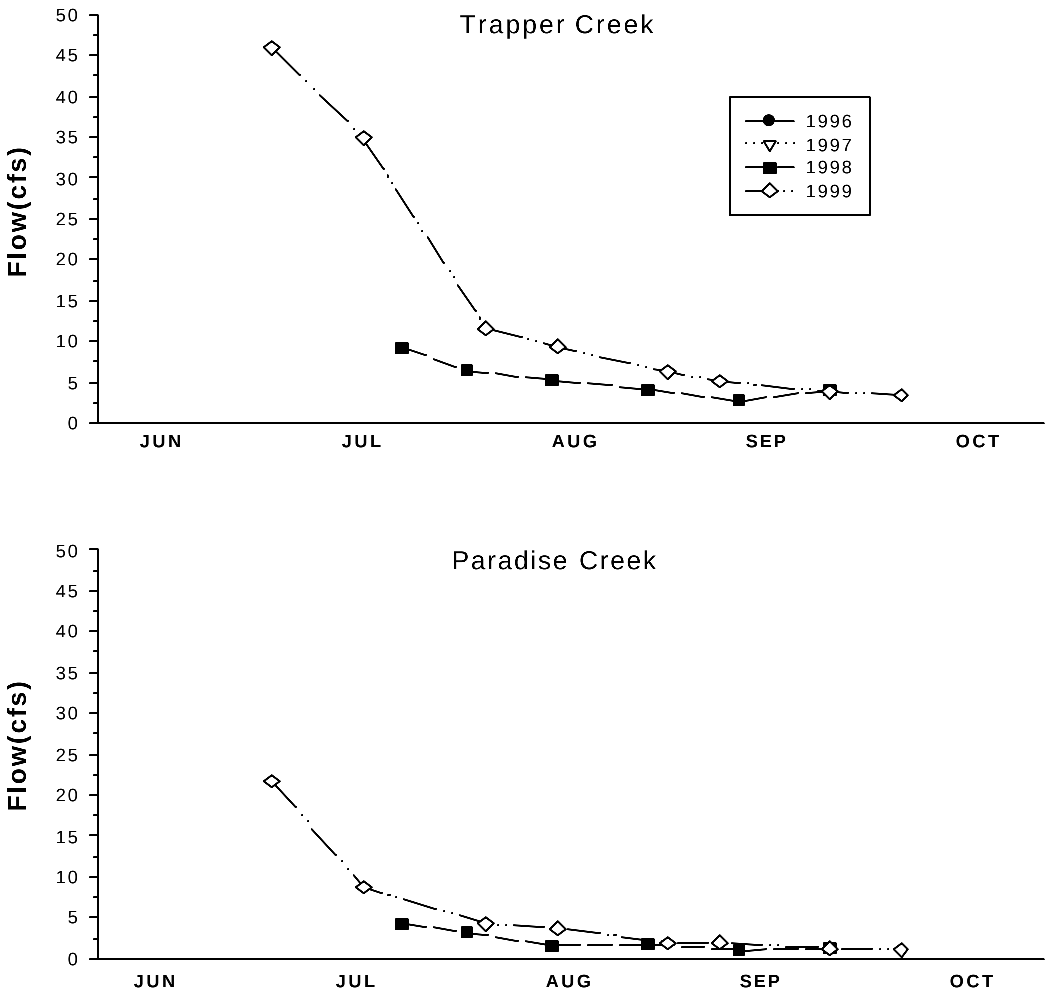


Figure 12. Water flow levels for Trapper and Paradise creeks in the upper Wind River watershed, 1998-1999. For locations of measurement sites, see Table 3 of this report.

Appendix Table 1. Reach survey data for streams within the Wind River watershed. Sites are listed from upstream to downstream within a subbasin.

Watershed / Subwatershed / Subdrainage	Rosgen (1994) channel type	Accessible length (m)	Surveyed length (m) Start – End	Surveyed length (m) Length	Mean width (m)	Survey date (mm/yy)	Number per 100 m in reach length[a] Pools	Boulders	CLW	HLW	KEY	Stream gradient (%)
Wind River												
Paradise Cr.[b]	B	3800	0-3800	3800	7.0	7/99	3.5	52.7	15.2	3.5	6.2	2.4[c]
Dry Cr.												
Reach 1[b]	C	1200	0-1200	1200	11.0	6/99	1.9	4.0	5.1	1.9	1.0	0.8[c]
Reach 2[b]	B	1300	1200-2500	1300	8.9	6/99	2.7	-	2.4	0.2	1.1	2.4[c]
Reach 3[b]	C	3400	2500-5900	3400	11.6	6/99	2.4	-	3.4	7.4	2.0	1.2[c]
Reach 4[b]	B	220	5900-6120	220	8.5	6/99	2.7	5.0	5.0	6.4	3.2	2.6[c]
Reach 5[b]	B,A	1380	6120-7500	1380	7.3	6/99	4.3	15.0	16.0	3.1	7.1	2.0[c]
Big Hollow Cr. 98[b,d]	B	1200	0-500	500	6.2	6/98	3.4	35.0	16.8	9.6	5.8	2.1
Big Hollow Cr. 99[b,d]	B	1000	0-1000	1000	6.9	6/99	3.9	35.0	9.0	5.7	3.3	-
Trapper Cr.[b]	B,A,D	3850	2350-3850	1500	6.9	8/99	4.7	115.7	16.7	1.7	6.8	4.0
Panther Creek												
Mouse Cr[b].	B	1176	0-800	800	4.6	6/96	7.8	288.0	16.8	0.5	0.5	6.9
Eightmile Cr.[b]												
Reach 1[e]	B	580	0-580	580	4.2	6/96	4.5	297.0	13.4	2.8	1.2	3.6
Reach 2[e]	B	500	580-1080	500	4.3	6/96	3.8	113.0	25.4	0.8	1.2	2.7
Cedar Cr.[b,e]	B	1823	0-1000	1000	4.6	7/96	3.9	173.0	10.9	3.6	0.6	3.4

Appendix Table 1. Continued.

Watershed Subwatershed Subdrainage	Rosgen (1994) channel type	Accessible length (m)	Surveyed length (m) Start – End	Surveyed length (m) Length	Mean width (m)	Survey date (mm/yy)	Number per 100 m in reach length[a] Pools	Boulders	CLW	HLW	KEY	Stream gradient (%)
Trout Creek												
Reach 1	B	2897	0-2897									
Reach 2 [c]	B,C	874	2897-3771	874		6/95	1.2					3.0
Reach 3 [c]	B,C	611	3771-4382	669		6/95	0.6					2.0
Reach 4 [c]	B	1345	4382-5727	1392		6/95	1.1					4.0
Reach 5 [c]	B,C	4592	5727-10319	4592		6/95	1.4					2.0
Reach 6 [c]	C,F	3578	10319-13897	3678		6/95	1.5					1.0
Upper Trout (above Crater Cr.)[b,e]	C,B,A	1353	0-1000	1000	5.8	6/96	3.6	8	16.2	0.2	4.9	2.2
Crater Cr [b]	C,B	2600	0-2600	2600	4.7	7/99	5.2	32	16.1	2.1	4.9	3.4
Compass Cr .[b,e]	B	3175	0-500	500	4.2	7/96	5.4	0	14.2	0.6	1.2	1.5
East Fork Trout Cr.[b,e]	B	1823	0-540	540	4.7	7/96	4.3	7	31.6	0.0	1.6	1.0
Layout Cr												
Reach 1[b,e]	C,B	2840	0-2840	2840	6.4	7/99	3.4	0	19.3	1.5	6.0	1.8
Reach 2 [b]	B	1160	2840-4000	1160	4.3	7/99	4.1	4	9.8	1.6	3.7	3.1
North Fork Layout Cr. [b,e]	B	800	0-800	800	4.1	7/99	4.0	23	8.1	3.3	1.4	4.0
Planting Cr. [b,e]	B	1000	0-1000	1000	4.3	6/96	5.4	147	13.9	1.8	1.5	3.7
Martha Cr.[b]	B,A	3352	1052-3352	2300	3.6	6/98	4.2	43	6.4	4.1	1.9	2.6

[a] CLW = Conifer large woody debris ≥1 m length and ≥ 0.3 m diameter; HLW = Hardwood large woody debris ≥ 1 m length and ≥ 0.3 m diameter; KEY = "Key pieces" Conifer and Hardwood large woody debris ≥ 5 m length and ≥ 0.6 m diameter.

[b] Data from USGS habitat survey.

[c] Data from USFS habitat survey.

[d] During winter 98/99 Big Hollow Cr. shifted into a new channel just above it's confluence with Bourbon Cr. Big Hollow and Bourbon now flow into Dry Cr. separately. The 500 m of Big Hollow surveyed in 1998 is now Bourbon Cr.

Report I: Baseline Water Quality Monitoring in the Wind River Watershed

Wind River Watershed Project

1999 Annual Report

September 2001

Prepared by:

Susan J. James and Steve Stampfli

Underwood Conservation District
P.O. Box 96
White Salmon, WA 98672

Introduction

Water temperature, turbidity (sediment), and fecal coliform were recognized as potential parameters of concern to the beneficial uses of the watershed in the 1996 Wind River Watershed Analysis (USFS 1996). This analysis indicates that elevated levels of water temperature occur throughout the basin and recognizes particular sub-watersheds as being at high risk for sediment production. However, specific impacts to the river, riparian systems, and fish habitat are incompletely understood consequent to a lack of sufficient baseline data and diagnostic assessment work. The objective of the Wind River Water Quality Monitoring Plan is to collect existing and new water quality data throughout the watershed in order to identify current condition and establish a baseline for comparing historic and future data. Such evaluation is intended to allow general correlation of the impacts of timber harvests, transportation/utility corridors, residential development, and natural processes. It is also intended to provide a base for evaluating the success of restoration efforts. The information will be used by the Wind River Watershed Council to identify voluntary and cooperative strategies to improve water quality in the watershed.

In 1997, the Underwood Conservation District (UCD) and cooperating agencies initiated a broad-scale watershed restoration project in the Wind River Basin. This water quality monitoring plan represents a portion of this effort and will be conducted by the UCD with support from cooperating agencies.

Historical Information

There are many beneficial uses in the watershed that rely on clean water, including a source of drinking water for the towns of Carson and Stabler. Additionally, there is a remaining run of wild steelhead that were recently listed as a “threatened” species under the Endangered Species Act. Snorkel surveys organized by the Washington Department of Fish and Wildlife (WDFW) have identified adult steelhead returns of less than 50 during the last two years, down from an estimated 2000-5000 historic adult returns.

Bear Creek, Eightmile Creek, and Trout Creek are listed on Washington Department of Ecology’s (WDOE) 1999 303d list for water temperature exceedences. High temperatures have been documented elsewhere in the watershed by the USFS (1996), most notably in the Trout Creek system and mainstem Wind River. Elevated levels of instream sediment have also been identified by the USFS (1996) and by empirical evidence from various sources. Sediment deposition at the mouth of the Wind has long been a concern for the Port of Skamania County and private interests who use the mouth for log shipping and fishing. Due to concerns of historic high recorded surface water temperatures in the basin, a separate continuous temperature monitoring plan was implemented by the UCD, US Geological Survey’s Columbia River Research Laboratory (CRRL), and USFS (see Report H in this Volume IV).

To assess basin water quality, the USFS has conducted baseline sampling in the upper Wind River basin for the past decade. Additionally, temperature data have been collected by CRRL personnel for the past two years. Other water quality information is available in limited amounts from the Yakama Nation, the Skamania PUD (city water supply intake on Bear Creek), and the US Fish and Wildlife Service's Carson National Fish Hatchery (Tyee Springs). Although this information has been useful to resource managers in the basin, the data is spotty and incomplete. Significant water quality data gaps remain throughout the basin, especially in the lower watershed.

Design

As an initial step in determining the monitoring parameters, the Wind River Technical Advisory Committee identified land-use activities potentially affecting water quality in the basin. They are the following:

- Forest harvest
- Forest chemicals (low intensity in Wind basin)
- Road building and maintenance
- Crop production (low intensity)
- Recreation (dispersed and developed)
- Residential development
- Mining (low intensity)
- Grazing (low intensity)

Table 1 lists watershed activities that may influence specific water quality parameters. Based on the major sub-basin divisions, the information in Table 1, and the location of existing baseline monitoring stations, a monitoring plan was devised (Table 2). Budgetary considerations did not allow monitoring of all parameters. For instance, herbicide / pesticide sampling was eliminated due to the expense and the relatively low level of use in the watershed. Other parameters were considered as well, such as invertebrates and nitrogen/carbon stable isotopes, but were also eliminated due to unidentified current need and financial considerations.

Table 1. Sensitivity of water quality monitoring parameters to management activities, assuming average management practices: 1=directly affected and highly sensitive; 2=moderately affected and somewhat sensitive; 3=indirectly affected and not very sensitive; 4 = largely unaffected.

	Land-use activities							
	High intensity in Wind Basin				**Lower intensity in Wind Basin**			
Parameters	Forest harvest	Roads	Resi-dential	Recre-ation	Crops	Forest chem.	Mining	Grazing
Temperature	1	3	2	4	2	3	3	2
pH	3	4	3	4	3	2	1	3
Conductivity	3	3	3	4	3	3	1	3
Sediment	1-2	1	1	2	2	3	2	1-2
Dissolved O_2	2	4	3	4	3	2	3	2
Nitrogen	3	3	2	2	1	1	3	2
Phosphorous	3	3	2	2	1	2	3	2
Coliform bacteria	4	4	1	1	3	4	4	1
Flow	1-2	1-2	2	4	3	4	4	3
Herbicides & pesticides	4	3	2	4	1	1	4	4

Adapted from Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska, US Environmental Protection Agency 1991.

Table 2. Baseline stations and monitoring parameters.

Station I.D.	Baseline Stations	temperature	conductivity	dissolved oxygen	pH	turbidity	nitrate+nitrite nitrogen	total phosphorous	fecal & total coliform
WR-1	Wind (base)	X	X	X	X	X	X	X	X
WR-2	Little Wind (base)	X	X	X	X	X	X	X	X
WR-3	Panther (bear cr rd)	X	X	X	X	X	X	X	X
WR-4	Trout (base)	X	X	X	X	X	X	X	X
WR-4a	Upper Trout (at 43 rd. bridge)	X	X	X	X	X	X	X	X
WR-5	Middle Wind (Stabler bridge)	X	X	X	X	X	X	X	X
WR-6	Trapper (base)	X	X	X	X	X	X	X	X
WR-6a	Upper Trapper (abv cabins)	X	X	X	X	X	X	X	X
WR-7	Dry (base)	X	X	X	X	X	X	X	X
WR-8	Upper Wind (below Falls Cr)	X	X	X	X	X	X	X	X
WR-9	Paradise (base)	X	X	X	X	X	X	X	X

*USGS gauging stations allow discharge readings at WR-1 and WR-4a.

Schedule

Baseline monitoring of all sub-basins was accomplished four times during the project year (Spring 1999 to Spring 2000) on a quarterly basis. One of these sampling rounds was planned to correlate with the period of low summer flow. Additionally, two discretionary sampling rounds were planned during the wet season. Wet season discretionary sampling was conducted with the goal of measuring peak concentrations of pollutants being carried from the land during "initial flush" (rising limb of hydrograph) in fall or early winter of 1999 and 2000 (Table 2). Only one discretionary flush flow was captured, during December 1999. A second flush flow measurement round is planned, pending stream conditions, for Fall 2000.

Quarterly Sampling
1st quarter sampling – June 1999
2nd quarter sampling – Oct 1999 (to correlate with base flow)
3rd quarter sampling – Dec 1999
4th quarter sampling – Apr 2000

Flush Flow Sampling
1 flush flow event was sampled during winter (Dec 15, 1999)

Data Quality

The overall data quality objective is to provide data of known and acceptable accuracy. Specific objectives and procedures for precision, accuracy, completeness, representativeness and comparability are identified in Johnson's (1999) QA/QC document.

Careful adherence to established procedures for instrument calibration, sample collection, preservation, transportation, and storage was followed to eliminate most sources of bias. However, discretionary (flush flow) sampling was not aimed at attaining unbiased representation. Instead, discretionary samples were intentionally taken during the upslope of the hydrograph, and designed to detect runoff of peak concentrations of materials/pollutants.

Results

During June 1999 to April 2000, four quarterly and one flush flow rounds were taken according to the objectives and methods set out in the QA/QC (Table 4). All of the requirements in the QA/QC were met with the exception of a diagnosis of fallibility in the pH probe after some odd readings were recorded in the December rounds. After consulting with the WDOE and others, who have had similar problems with excessive cold air temperatures affecting the measurements with older probes, a different pH probe was purchased for future use.

Preliminary results indicate that the water in the Wind River is relatively clean, and typical of similar cascade ecosystems. However, a full analysis must wait for collection of more data.

Sampling Procedures

Field sampling was conducted in accordance with the standard procedures described in WDOE (1994). This document generally describes the procedures for water sample collection, decontamination, field notes, sample container preparation / identification, sample size, preservation, storage, and sample transport / chain-of-custody.

Water samples were collected at the locations and frequency identified in the Project Description. When possible, monitoring stations were sampled in a generally downstream direction to track the flow of water and improve comparability of results.

Field analysis was conducted *in situ* for stream temperature, pH, conductivity, dissolved oxygen and turbidity. Lab analysis will be conducted by a DOE accredited laboratory for nitrate + nitrite nitrogen, total phosphorous, and total and fecal coliform bacteria. Samples for lab analysis will be collected by submerging cleaned, pre-preserved and pre-labeled sample containers below the water surface in a standard, free flowing, homogeneously mixed, representative section of the stream channel.

Field and laboratory analytical methods, instruments, and reporting limits are presented in Table 3. Methods used are described in the Handbook for Analytical Quality Control in Water and Wastewater Laboratories (EPA 1979). We used standard methods, which are described by the American Public Health Association (1985).

Table 3. Equipment and methods used for water quality assessments.

Analyte	**Equipment or method used**	**Reporting limit**
Field Temperature	HB Digital thermometer model 2000	NA
Field Temperature	Onset - HOBO Temp H8 Data Logger (UCD)	**NA**
Field pH	Orion model 250A	NA
Field Conductivity	Orion model 126	NA
Field D.O.	YSI model 55	NA
Field Turbidity	Hach model 2100P	NA
Fecal Coliform	Most probable number [Standard method # 9221]	2/100 ml
Total Phosphorous	Auto ascorbic [EPA method # 365.3]	0.01 mg/l
Nitrate + Nitrite Nitrogen	Auto Cd reduction [EPA method # 353.2]	0.05 mg/l

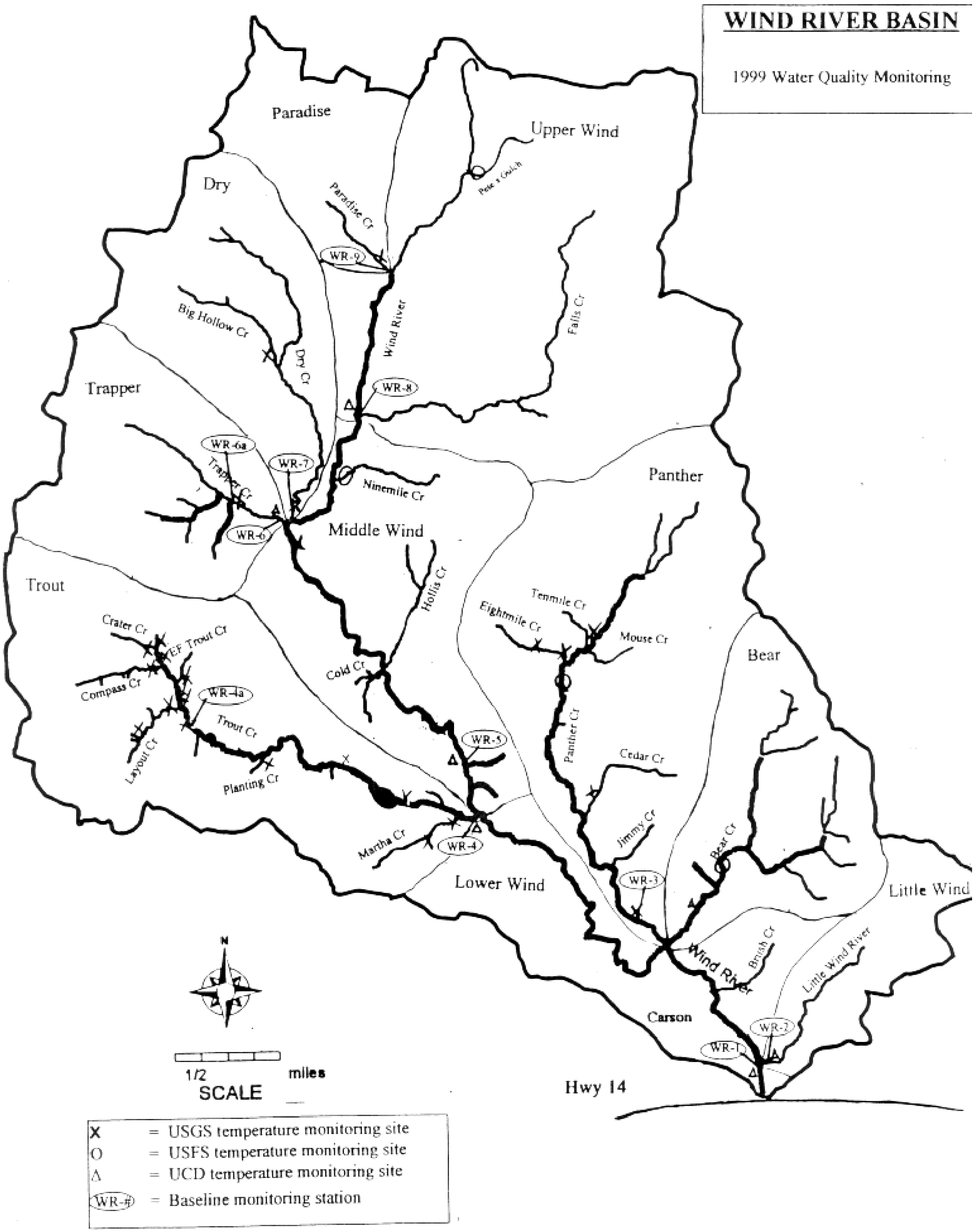


Figure 1. Map of the Wind River watershed water quality monitoring station locations.

Table 4. Water quality data from nine sites in the Wind River watershed, 1999-2000.

Station description	Date	Time	Air Temp. Celsius	Water Temp. Celsius	pH	Cond-uctivity (uS)	Dissolved Oxygen ppm	Turbidity ntu	Fecal Coliform n/100ml	Total Coliform n/100ml	Nitrate NO_3 & NO_2 N (mg/L)	Total Phosphorus (mg/L)
WR-1	21-Jun-99	14:35	16	10.5	7.24	37.8	11.72	0.835	4	14	0.08	0.02
Wind River	05-Oct-99	14:45	19	9.8	6.97	56.2	11.24	0.39	<18	20	nd	0.03
at Base	07-Dec-99	15:30	5.5	6	6.08	34	12.11	5.11	11	80	nd	0.03
	15-Dec-99	15:37	10	6.7	6.01	39	12.7	12.8	nd	17	nd	0.04
	17-Apr-00	17:17	23.8	8.4	7.64	35	9.08	1.87	13	500	0.06	0.02
WR-2	21-Jun-99	13:57	17	13.2	6.98	54.5	10.55	1.98	13	33	0.03	0.04
Little Wind	05-Oct-99	14:10	16.5	11.5	7.01	57.2	10.43	0.65	<18	130	0.08	0.05
at Base	07-Dec-99	15:15	5.5	7.1	7.2	42	10.44	9.1	8	27	nd	0.06
	15-Dec-99	15:22	10	8.4	6.94	44	11.65	13	2	7	nd	0.07
	17-Apr-00	16:52	20	11.3	7.73	48.7	10.17	2.06	nd	21	0.07	0.04
WR-3	21-Jun-99	13:28	15	9	7.05	46.5	11.36	0.86	4	70	0.03	0.03
Panther Cr.	05-Oct-99	13:40	13	7.7	7.14	48.5	10.82	0.44	<18	78	nd	0.04
at Bear Cr.	07-Dec-99	14:35	4.5	6	7.28	39	11.4	3.25	11	130	nd	0.04
Rd. Bridge	15-Dec-99	14:47	9	6.6	6.79	41	10.2	10.3	2	7	nd	0.05
	17-Apr-00	16:00	15	8.8	7.74	32	8.88	1.12	2	17	0.05	0.03
WR-4	21-Jun-99	12:47	16	8.9	7.11	24.9	11.44	0.565	2	14	0.04	nd
Trout Cr.	05-Oct-99	12:55	13.5	9.7	7.43	28.8	10.86	0.4	<18	68	nd	0.01
at Base	07-Dec-99	13:45	3.5	4.8	6.26	21	9.61	1.81	30	30	nd	0.02
	15-Dec-99	13:40	10	5.5	6.74	23	12.28	7.39	13	23	nd	0.02
	17-Apr-00	14:30	12	6.6	7.47	22.8	11.57	1.51	nd	240	0.06	0.01

Continued.

Table 4. Continued.

Station description	Date	Time	Air Temp. Celsius	Water Temp. Celsius	pH	Cond-uctivity (uS)	Dissolved Oxygen (ppm)	Turbidity (ntu)	Fecal Coliform n/100ml	Total Coliform n/100ml	Nitrate NO_3 & NO_2 N (mg/L)	Total Phosphorus (mg/L)
WR-4a	21-Jun-99	12:10	18.5	7.8	7.1	23	10.83	0.585	2	9	0.04	nd
Trout Cr.	05-Oct-99	11:00	12	7.7	7.2	27.6	10.42	0.47	<18	78	0.06	nd
at 43 Rd.	07-Dec-99	8:30	0	3.7	5.01	19	11.65	1.06	14	22	nd	0.01
Bridge	15-Dec-99	12:45	7	4.2	5.95	20	11.58	4	7	17	nd	0.01
	17-Apr-00	13:15	18	7.07	5.7	21.8	9.01	1.04	23	130	0.07	nd
WR-5	21-Jun-99	11:33	15.9	8.8	7.22	34.4	10.8	0.595	11	27	0.03	nd
Middle Wind	05-Oct-99	12:10	14	9.1	7.49	50.3	10.24	0.43	<18	<18	nd	0.02
at Stabler Br.	07-Dec-99	12:35	3.5	5.1	5.92	32	11.02	2.69	nd	14	nd	0.02
	15-Dec-99	14:20	9	5.3	6.76	34	12.35	7.08	13	50	nd	0.03
	17-Apr-00	12:30	15	6.2	7.17	34.5	7.84	1.43	nd	80	0.06	0.02
WR-6	21-Jun-99	10:20	13.5	7.3	7.28	33.6	11.19	0.443	2	8	0.04	nd
Trapper Cr.	05-Oct-99	8:45	9	9	7.52	93.8	9.85	0.16	<18	20	0.07	nd
at Base	07-Dec-99	12:10	2.5	4.7	5.55	32	11.14	0.61	2	30	nd	0.02
	15-Dec-99	12:10	2.3	4.5	6.17	31	12.48	1.26	nd	nd	nd	0.01
	17-Apr-00	11:55	14	5.5	7.19	33.9	11.09	0.38	nd	8	0.06	nd
WR-6a	21-Jun-99	10:57	17	6.4	7.09	30.4	11.54	0.84	nd	7	0.03	nd
Upper Trapper	05-Oct-99	9:15	13	8.7	6.98	86.4	9.59	0.6	<18	18	0.08	0.01
Cr. above	07-Dec-99	11:00	1.5	4.2	6.95	30	11.15	0.37	nd	4	nd	0.01
cabins	15-Dec-99	11:45	1	4	6.42	29	12.06	0.83	8	17	nd	nd
	17-Apr-00	10:35	8	4.5	7.36	31.6	9.19	0.385	nd	2	0.06	nd

Continued.

Table 4. Continued.

Station description	Date	Time	Air Temp. Celsius	Water Temp. Celsius	pH	Cond-uctivity (uS)	Dissolved Oxygen (ppm)	Turbidity (ntu)	Fecal Coliform (n/100ml)	Total Coliform (n/100ml)	Nitrate NO_3 & NO_2 N (mg/L)	Total Phosphorus (mg/L)
WR-7	21-Jun-99	9:50	16	7.9	7.05	34	11.19	0.373	17	17	0.03	nd
Dry Creek	*05-Oct-99	dry!										
at Base	07-Dec-99	11:45	2	4.8	6.05	33	9.81	1.39	nd	11	nd	0.02
	15-Dec-99	11:05	2	4.6	6.07	37	12.31	2.33	nd	4	nd	0.02
	17-Apr-00	11:25	10	5.7	7.37	34.3	11.98	1.085	nd	2	0.06	0.01
WR-8	21-Jun-99	9:10	12	7.6	7.17	29.6	11.91	0.866	30	50	0.03	nd
Upper Wind	05-Oct-99	8:55	9	7.6	7.27	40.5	10.69	0.3	<18	<18	nd	nd
below	07-Dec-99	10:15	0	3.9	5.85	30	11.25	1.24	11	50	nd	0.01
Falls Creek	15-Dec-99	10:35	3.2	3.6	6.59	36	12.55	2.18	4	13	nd	0.01
	17-Apr-00	9:30	9	4.7	6.51	30.9	10.32	1.75	30	50	0.06	0.01
WR-9	21-Jun-99	8:30	12	7.4	7.27	35.3	11.63	1.23	nd	4	0.04	nd
Paradise Cr.	05-Oct-99	7:00	8	8.8	7.32	58.8	10.19	0.14	<18	18	0.08	nd
at Base	07-Dec-99	9:50	0	4	6.33	36	11.53	1.34	nd	11	nd	0.02
	15-Dec-99	10:00	2	3.6	7.6	32	12.52	2.72	8	8	nd	0.01
	17-Apr-00	8:30	7.5	4.1	6.59	34.2	11.65	2.12	4	8	0.05	0.01

*Note: On 5 October 1999, there was no water in Dry Creek, hence, no measurements were taken.

Discussion

While a complete analysis of the data must wait for a more complete data set and the attention of an analyst, much use has been made of the data gathered so far. This data was shared with WDOE, WDFW, USDA Forest Service, USGS, and other interested parties and used as part of the Ecosystem Diagnosis and Treatment analysis (in progress), the Wind River Watershed Analysis 2000 update (also in progress) and WDOE's Total Maximum Daily Load model.

It is the intent of the UCD to gather data from another flush flow in 2000-2001 and plan for future measurements over a period of years to compare with the data gathered thus far. Troubleshooting of technical problems with the equipment (such as the pH probe) will continue as needed as even the best QA/QC plan can be hung up by faulty equipment. Our goal is for gathering repeatable, quality data that document the current level of water quality in the Wind River, which appears to be good and fairly clean at this time. These data will allow comparison with future measurements to show changes in response to watershed restoration activities.

Acknowledgements

Many thanks for assistance with planning and support go to: The Wind River Watershed Council and Technical Advisory Committee; Bengt Coffin, Hydrologist, USFS; and Bill Ehinger, Bernard Strong, and Robert Plotnikoff, WDOE.

Figure 2. Measuring conductivity at Paradise Creek on the Wind River, June 1999.

References

American Public Health Association. 1985. Standard methods for the examination of water and wastewater. 18th Ed. APHA, AWWA, WEF.

EPA (United States Environmental Protection Agency). 1979. Handbook for analytical quality control in water and wastewater laboratories. EPA-600/4-79-019 (plus 1983 update). U.S. EPA, National Environmental Research Center, Cincinnati, OH.

EPA (United States Environmental Protection Agency). 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. EPA/910/9-91-001. US EPA, Center for Streamside Studies, and University of WA. Seattle, WA.

Johnston, G. J. 1999. Wind River watershed project water quality monitoring and quality assurance plan. Underwood Conservation District, White Salmon, WA.

Stampfli, S. M. 1994. White Salmon WQ report. Underwood Conservation District, White Salmon, WA.

USFS (USDA Forest Service). 1996. Wind River Basin watershed analysis. Wind River Ranger District, Carson, WA.

WDOE (Washington Department of Ecology). 1991. Guidelines and specifications for preparing quality assurance project plans. Report 91-16. Ecology, Environmental Investigations and Laboratory Program, Quality Assurance Section, Manchester, WA. 17 pp + appendices.

WDOE (Washington Department of Ecology). 1994. Technical guidance for assessing the quality of aquatic environments. Report 91-78. Ecology, Environmental Investigations and Laboratory Program, Watershed Assessments Section, Olympia, WA.