Evaluation of the Life History of Native Salmonids in the Malheur River Basin

Cooperative Bull Trout/Redband Trout Research Project

Annual Report
2002 - 2003

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Burns Paiute Tribe

Evaluate the Life History of Native Salmonids in the Malheur Subbasin

Annual Report for 2002-2003

Prepared for

U.S. Department of Energy
Bonneville Power Administration
Division of Fish & Wildlife

Acronyms and Abbreviations

ATS	Advanced Telemetry Systems
BLM	Bureau of Land Management
BPA	Bonneville Power Administration
BPT	Burns Paiute Tribe
BPTFWD	Burns Paiute Tribe Fish and Wildlife Department
°C	Degrees Celsius
cfs	Cubic feet per second
cm	Centimeter
FLIR	Forward Looking Infrared Radiometry
g	Gram
GIS	Geographic Information System
GPS	Global Positioning System
km	Kilometer
LWD	Large Woody Debris
m	Meter
MHz	Megahertz
mm	Millimeter
MWAT	Maximum Weekly Average Temperature
NWPPC	Northwest Power Planning Council
ODFW	Oregon Department of Fish and Wildlife
PIT	Passive Intergraded Transponder
RK	River kilometer
TIR	Thermal Infrared Radiometry
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

Evaluation of the Life History of Native Salmonids in the Malheur River Basin

Annual Reporting April 2002-March 2003
BPA Project #199701900

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GENERAL INFORMATION

The Malheur River is a 306-kilometer tributary to the Snake River, which drains 12,950 square kilometers. The Malheur River originates in the Blue Mountains and flows into the Snake River near Ontario, Oregon. The climate of the basin is characterized by hot dry summers, occasionally exceeding 38 °C, and cold winters that may drop below -29 °C. Average annual precipitation is 30 centimeters in the lower reaches. Wooded areas consist primarily of mixed fir and pine forest in the higher elevations. Sagebrush and grass communities dominate the flora in the lower elevations.

Efforts to document salmonid life histories, water quality, and habitat conditions have continued in fiscal year 2002. Bull trout *Salvelinus confluentus* are considered to be cold water species and are temperature-dependant. Due to the interest of bull trout from various state and Federal agencies, a workgroup was formed to develop project objectives related to bull trout. Table 1 lists individuals that participated in the 2002 work group.

Table 1. List of Participants and Associated Organizations Present for the 2002 Bull Trout Workgroup Meetings.

Organization	Participant
Burns Paiute Tribe	Lawrence Schwabe
	Jason Fenton
	Steve Namitz
Oregon Department of Fish and Wildlife	Wayne Bowers
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This report will reflect work completed during the Bonneville Power Administration contract period starting April 1, 2002, and ending March 31, 2003. All tasks were conducted within this timeframe, and a more detailed timeframe may be referred to in each individual report.

USE OF RADIO TELEMETRY TO DOCUMENT MOVEMENTS OF BULL TROUT IN THE NORTH FORK MALHEUR RIVER, OREGON 2002

By Jason Fenton, Burns Paiute Tribe

Introduction

In 2002, research was conducted on sub-adult bull trout *Salvelinus confluentus* in the North Fork Malheur River above Beulah Reservoir (see Figure 1). Past land management activities, construction of dams, and fish eradication projects (poisoning) in the North Fork Malheur River have reduced the number of native species in the Malheur River basin (Bowers et al. 1993). Survival of remaining bull trout populations is severely threatened (Buchanan et al. 1997).

The North Fork Malheur River bull trout population is currently the largest in the Malheur River drainage (Perkins 2002) and is assumed to be the most secure. Soon after the 1991 ban on bull trout harvest in the Malheur system, research on the life history and distribution of the North Fork Malheur River bull trout began in 1992 with redd counts (Bowers et al. 1993).

In 1998, the Burns Paiute Tribe (BPT) coordinated with state and Federal agencies to collect data on migratory adult bull trout movement. As previous annual reports have indicated, the study identified new spawning and over-wintering locations throughout the North Fork Malheur River.

Currently, there is limited data on sub-adult fluvial bull trout migratory movements. This data is necessary to improve the understanding of Malheur River subbasin bull trout life history and effective population management.

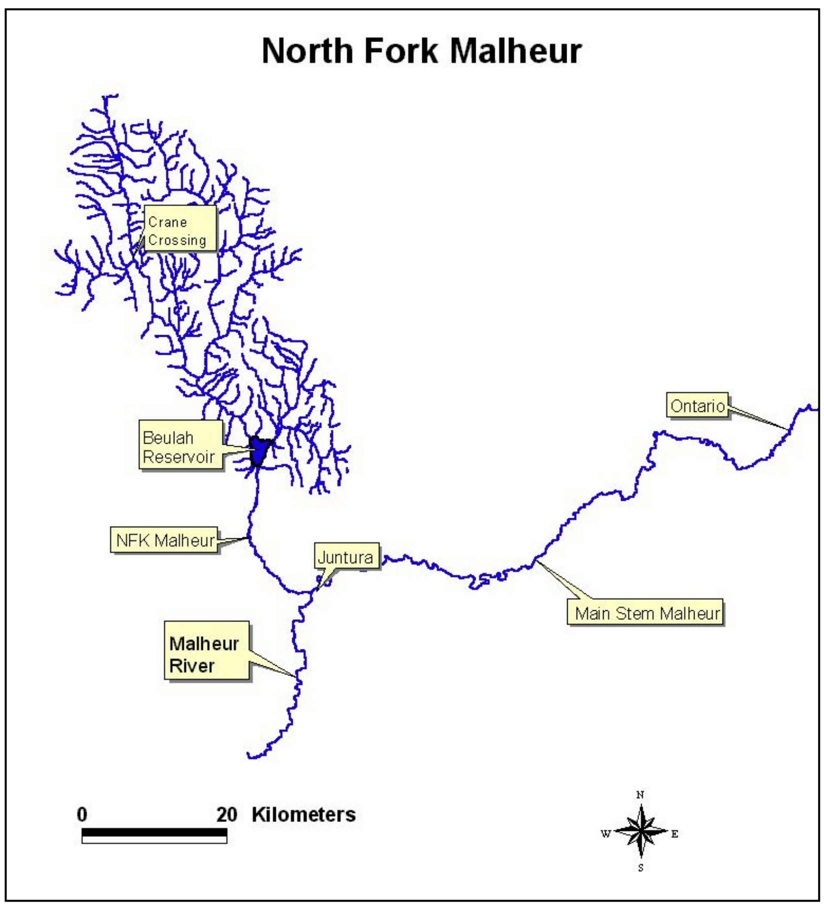

Figure 1. Study area for bull trout migration study in 2002

Research Objectives

- Document the migratory patterns of sub-adult bull trout in the North Fork Malheur River.
- Determine the seasonal sub-adult bull trout use of Beulah Reservoir.

Study Area

The study area includes the Malheur Basin from Beulah Reservoir to the headwaters of the North Fork Malheur River (see Figure 1). Fish collection was conducted in Beulah Reservoir (river kilometer (RK) 29 to RK 33) and in the North Fork Malheur River just above Beulah Reservoir (RK 33) and at Crane Crossing (RK 69). Radio telemetry was conducted from Beulah Reservoir to the headwaters of the North Fork Malheur River. This report reflects all movement data collected from May 9 to October 31, 2002.

Methods

Fish Collection

Bull trout were collected using six fyke nets, two screw traps, and a fish weir with trap boxes. The Oregon Department of Fish and Wildlife (ODFW) analyzed scale samples from captured bull trout.

Reservoir Traps

Six fyke nets were placed in Beulah Reservoir to capture sub-adult bull trout. On March 29, four 2-centimeter fyke nets were deployed. On April 11, two nets were added. Figure 2 shows the location of these nets. Personnel typically checked and reset the nets daily; however, weather conditions sometimes made boat travel unsafe; in these cases, the nets were checked every other day. All fyke nets were removed on May 16.

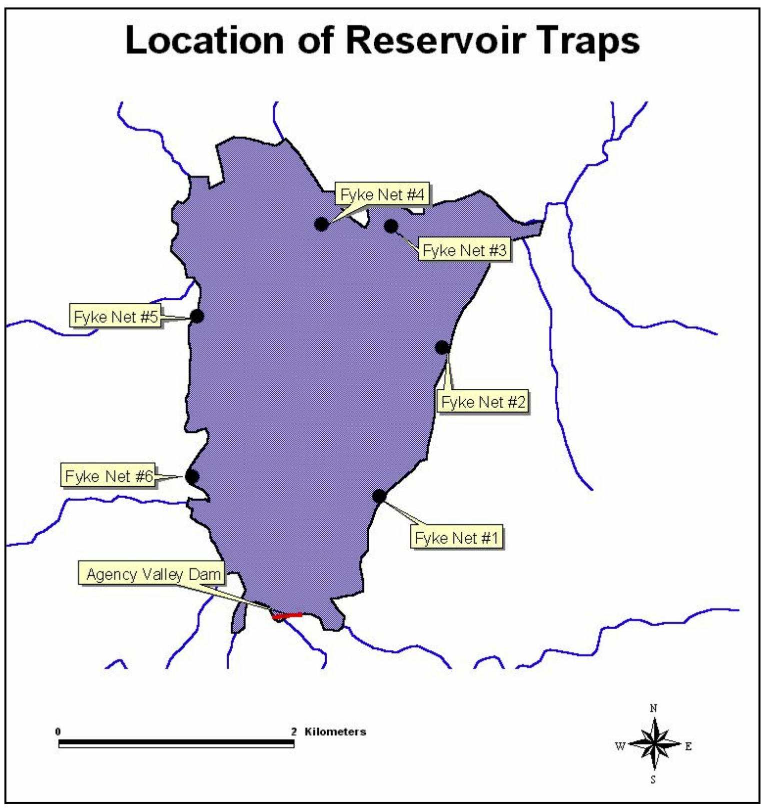

Figure 2. Location of nets in Beulah Reservoir, 2002.

Screw Trap

Two five-foot rotary screw traps were set in the North Fork Malheur River (Figure 3). The first rotary screw trap was set up at RK 33 on March 27, and removed on June 13.

The second screw trap was set up at Crane Crossing (RK 69) on May 8 and removed on July 3. The screw traps were checked daily.

Fish Weir

A fish weir was installed above Beulah at RK 33 near screw trap #1 (see Figure 3) on September 16. The weir trap, designed to span a width slightly larger than the wetted channel, was installed on a slight angle across the channel. The structure used 1/2-inch-diameter conduit rods with 1/4-inch spaces between rods. Fence posts anchored into the streambed stabilized the weir structure. Upstream and downstream trap boxes were placed near opposite stream banks and were interlocked into the weir panels. All fish caught in the upstream trap were released on the downstream side; those caught in the downstream trap were released on the upstream side. The weir was removed on October 31.

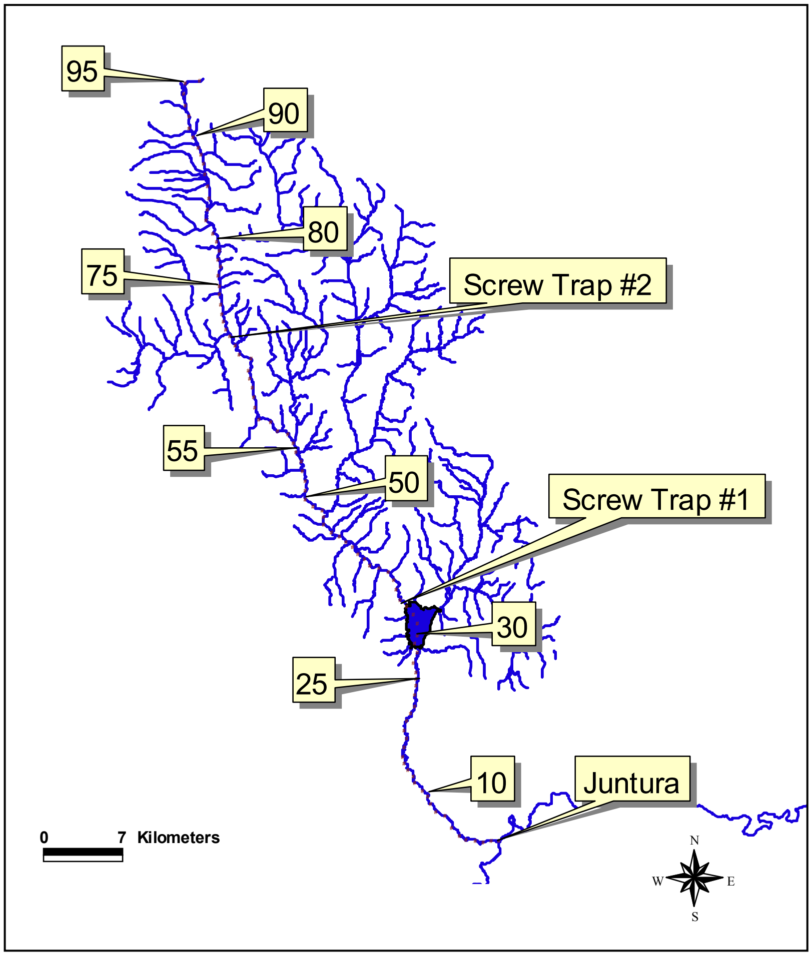

Figure 3. Location of screw traps in North Fork Malheur, 2002.

Radio and Passive Intergraded Transponder (PIT) Tag Implants

Radio transmitters manufactured by Advanced Telemetry Systems (ATS) had external whip antennas that emitted a unique frequency in either the 150 or 151 MHz band. Radios came in two sizes: 2-gram radios guaranteed for up to 78 days, and 3.6-gram radios guaranteed for up to 195 days. Transmitter weight was not to exceed approximately 3 percent of the bull trout body weight. Bull trout weighing less than 50 grams were not implanted.

PIT tags were implanted into the muscle adjacent to the dorsal fin of all bull trout over 150 millimeters using BioMark PIT tag injectors and 1-1/4 inch 12 gauge injector needles.

The Malheur Bull Trout Working Group set the maximum target of 40 radio-tagged sub-adult bull trout to be released into the North Fork Malheur River. Twenty of the sub-adults were to be captured and released just above Beulah Reservoir. The other twenty sub-adults were to be captured and released near Crane Crossing.

Captured bull trout were first anesthetized with MS 222 (tricaine methanesulfonate); they were then measured and weighed. Radio transmitters were inserted internally through a midline internal incision (Ross and Kleiner 1982). The external whip antennas were threaded through the body cavity and exited behind the pelvic fin. Surgeries lasted between 3 and 9 minutes (6 minute mean) during which time the gills were bathed with diluted MS 222 (60 mg/liter). Synthetic absorbable surgical sutures and super glue or surgical staples sealed the incision. After surgery, fish were held in fresh water until equilibrium was achieved; they were then released back into the river. Fish tank aerators were used in all holding buckets to assist with recovery.

Radio Telemetry

Radio telemetry began following the first successful surgery on May 9. Biweekly tracking for tagged bull trout used an ATS receiver, Yagi antenna, and a 12-channel hand-held GPS unit. Tracking primarily used foot and vehicle travel, but boats were used in Beulah Reservoir and aerial surveys were conducted from a fixed-wing aircraft when tagged fish entered roadless or private areas. Visual identification for the fish was preferred but rarely possible. For all positive identifications, personnel recorded the frequency, time, and UTM location. Where applicable, stream temperatures, stream names, redds or pairing fish, and habitat/cover were also recorded.

Results

Fish Collection

Various fish were caught using each of the four methods (see Table 2). In total, 36 bull trout were captured. Table 3 contains information on the sixteen implanted bull trout. All implanted bull trout were captured and released in the Crane Crossing area. Five bull trout caught in the reservoir or just upstream in the screw trap were not within the size guidelines for sub-adults. No bull trout were collected at the weir.

Table 2. Fish Collected in the North Fork Malheur, 2002.

	Fyke Nets in Beulah	Screw Trap Beulah	Screw Trap Crane Crossing	Weir Beulah
Bull Trout	3	2	31	0
Redband/Rainbow Trout	474	791	269	24
Whitefish	2	0	3	59
Northern Pike Minnow	122	41	0	5
Crappie	53	0	0	0
Redside Shiner	359	219	2	171
Bridgelip Sucker	243	1047	1	2
Sculpin	5	21	20	1
Long Nose Dace	2	258	156	23

Table 3. Tagged Bull Trout Captured in Screw Trap at Crane Crossing, North Fork Malheur River, 2002.

Date of Implant	Radio Frequency (MHz)	Weight (g)	Fork Length (mm)	Maximum Distance Traveled Downstream (km)	Maximum Distance Traveled Upstream (km)
May 9	151.570	82	196	0	
May 11	150.073	160	235		18
May 14	151.960	80	198		8
May 15	151.441	61	182	22	
May 15	151.711	76	181		6
May 16	151.462	64	181	8	
May 18	151.803	63	181	10	
May 19	150.183	173	262		21
May 22 [1]	151.470	54	182	.5	
May 29	151.601	62	189		11
June 2	151.581	67	181	1	
June 12	151.482	67	185		2
June 18	151.781	83	208		2.5
June 18	151.793	78	209		2.5
June 22	151.811	66	180		3
July 3 [1]	151.541	64	185	0	

1 Angled near screw trap

Sub-adult movement

In 2002, all methods of tracking documented 63 locations. Table 4 identifies how these bull trout were observed.

All 16 radio-tagged bull trout were implanted at Crane Crossing. One signal was lost due to unknown reasons. Three fish stayed within 1 kilometer of the implant site. Six moved upstream between two to six kilometers. One moved upstream 11 kilometers. Two moved upstream between 18 and 21 kilometers. Two moved downstream between 7 and 10 kilometers. One radio signal, over 20 kilometers downstream, may have been a false reading.

Table 4. Number of Bull Trout Tracking Observations in the North Fork Malheur River during 2002.

Method of Observation	Number of Bull Trout Observed
Foot	47
Vehicle	0
Plane	16
Total	63

Discussion

Migrations patterns of radio-tagged sub-adult bull trout were sporadic after release. Tagged bull trout were documented moving upstream, downstream, and holding at the release site. Though minimal, downstream migration was most evident in May and June. One bull trout migrated downstream as far as 11 kilometers below the upper screw trap site. The capture of two sub-adult bull trout collected at the reservoir screw trap (RK 33) on May 16 and May 18, were estimated to be age 2+ sub-adult bull trout.

By July, upstream migration patterns on tagged bull trout were evident. By July 1, all but one tagged fish were observed above the upper screw trap site. Upstream migration ranged from 0 to 11 kilometers above the upper screw trap site (RK 69) except for two bull trout that migrated between 18 and 21 kilometers above the upper screw trap site. The lengths of these two bull trout suggest they were age 4+ bull trout, more likely adult/spawning fish.

Bull trout tracking was interrupted by an area forest fire. Safety measures prevented tracking between July 15 and August 5. During this 21-day period, the fish moved with no documentation. Limited access was permitted between August 5 and August 21, but only once a week from Crane Creek to the North Fork Malheur headwaters and in very close proximity to the vehicle. No planes were allowed in the area during this period.

From August 15 to September 13, only 4 tagged bull trout were located. The remaining 10 fish could not be found. The BPT scheduled a flight in late August and two in September; however, severe weather conditions prevented these from occurring. By mid-September, no fish could be located, and the radios that had been recovered were no longer functioning. This suggests that battery life of the radio tags were reaching expiration.

Twelve fish did not move more than 11 kilometers from the upper screw trap site. One fish was lost after the radio was installed and no data was obtained. One signal (151.441) was picked up briefly during a flight 22 kilometers below the upper screw trap site. The signal was very weak and only lasted for two seconds. Further attempts by air and foot to locate the fish failed. It was concluded that the signal may have been false and no data was obtained from the fish.

Five fish did not appear to move above the upper screw trap site (RK 69). The first fish (151.441) may have been the false signal detected downstream. Another fish (151.581) was tracked the day after surgery one kilometer below the weir and was not located again. The third fish (151.470) stayed within 0.5 kilometer from the weir, and the radio was then found 200 meters from the stream on the hillside. Eight kilometers below the weir, a transmitter (151.462) was recovered in the river. It is unknown if the transmitter was moved here by the fish or by a predator. The last fish (151.803) was holding 10 kilometers below the weir before the signal was lost. Snorkel attempts failed to recover a radio or locate a bull trout.

Adult bull trout have been found to migrate back into Beulah Reservoir during late October to late November (Schwabe 2000). No fish that were radio tagged in 2002 were documented to use the reservoir. The weir was dismantled on October 31 because ice had built up and caused damage beyond repair. Further research needs to be conducted to determine if juveniles use Beulah Reservoir during the winter months.

Sub-adult bull trout downstream movement from their natal streams more likely occurs during the spring or fall when stream temperatures are cooler. Spring runoff may play a significant role in the movement of sub-adult bull trout. As spring flow decreases, the downstream movement of sub-adult bull trout may also decrease. This is evident in the high catch rates in May and June at the upper screw trap site in 1998, 1999, and 2002.

Seasonal maximum water temperatures tend to peak in July and August in the Malheur River subbasin. Water temperature increases most likely cause sub-adult bull trout to move upstream for cooler water temperatures in the headwaters. Using a 13.9 °C temperature tolerance for bull trout, no cold water refugia exists in Beulah Reservoir and associated inlets from July to September (USBR 2002). Bull trout in the Beulah Reservoir vicinity during these months most likely migrate upstream or perish. Since no reports of large fish kills have been documented at Beulah Reservoir (USBR 2002), sub-adult bull trout collected in the spring likely migrate out of Beulah Reservoir and associated inlets prior to peak reservoir and stream temperatures in search of more suitable water temperature conditions. However, because no sub-adult bull trout were collected in Beulah Reservoir, radio telemetry was not used to test this hypothesis.

Bull trout have been collected by the BPT in stream temperatures up to 23 °C in the Upper Malheur River (Schwabe and Fenton 2001). The population of bull trout in the Malheur River subbasin is on the southern boundary of known bull trout distribution and is susceptible to higher stream temperatures compared to northern populations.

Over-summer distribution of bull trout remains unclear. During the 1998 bull trout trapping effort, bull trout were collected at Crane Crossing (RK 69) at least every other week in June through October (Gonzalez 1999). From the telemetry and trapping data available, sub-adult bull trout tend to oversummer in the mainstem North Fork Malheur River from the confluence of Crane Creek upstream to the North Fork Campground. Collection of sub-adult bull trout for radio implants was limited to the Crane Crossing screw trap site. The extent of sub-adult bull trout distribution downstream of Crane Crossing cannot be fully defined due to the lack of radio-implanted fish from various stream reaches of the North Fork Malheur River. Furthermore, fire closures disrupted the telemetry effort in late July through September. This caused a data gap in the summer distribution of sub-adult bull trout.

There is a need to continue the research on sub-adult bull trout in the North Fork Malheur River. The radio telemetry study of sub-adult bull trout in 2003 is expected to continue on the North Fork Malheur River. Researchers hope to capture sub-adult bull trout in Beulah Reservoir to fill the data gaps from 2002. The unexpected low catch rate of bull trout in Beulah Reservoir may have been influenced by the regional drought conditions in 2001 and 2002. Radio tagging bull trout during drought years is recommended and will provide local agencies critical information and knowledge in making fish and land management decisions.

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Appendix A. Catches of Fish in the North Fork Malheur River, 2002.

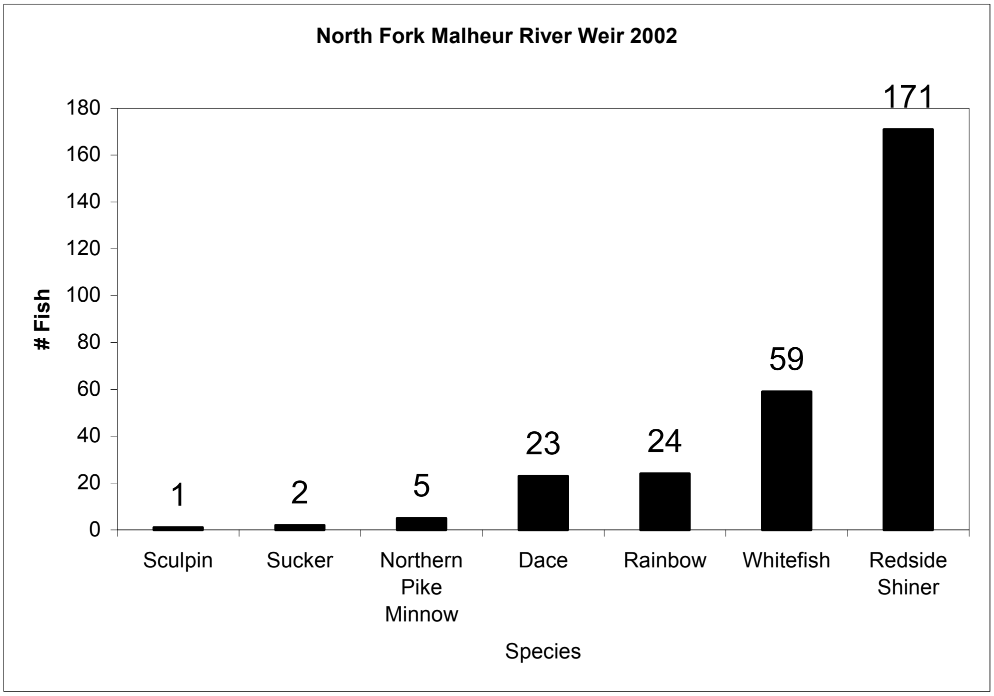

Figure 4. Number and type of fish caught at the North Fork Malheur River weir in 2002.

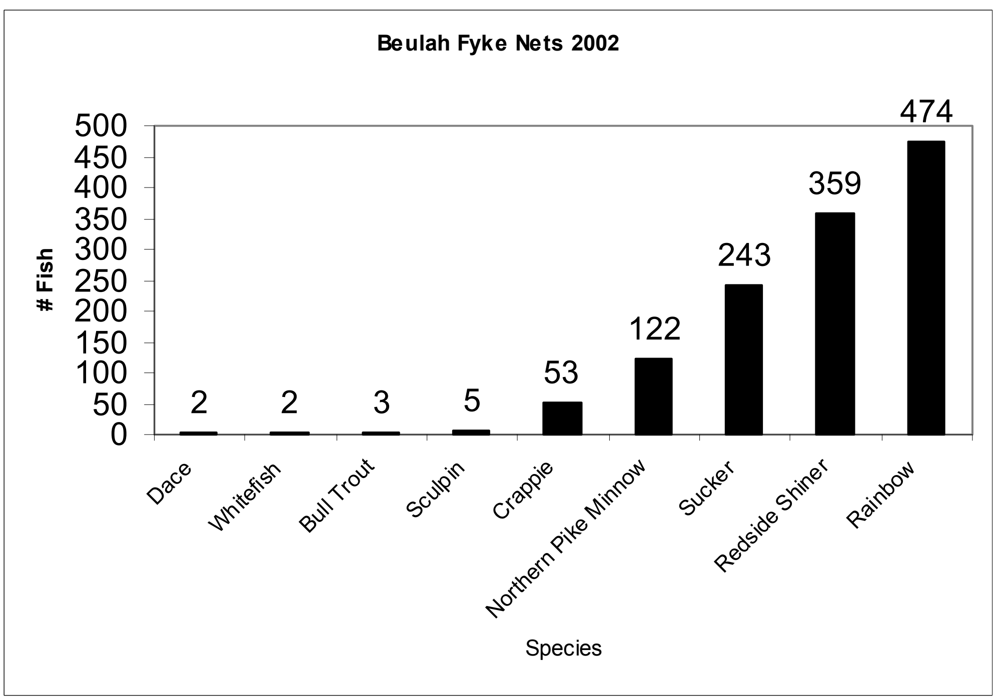

Figure 5. Number and type of fish caught in Beulah Reservoir fyke nets in 2002.

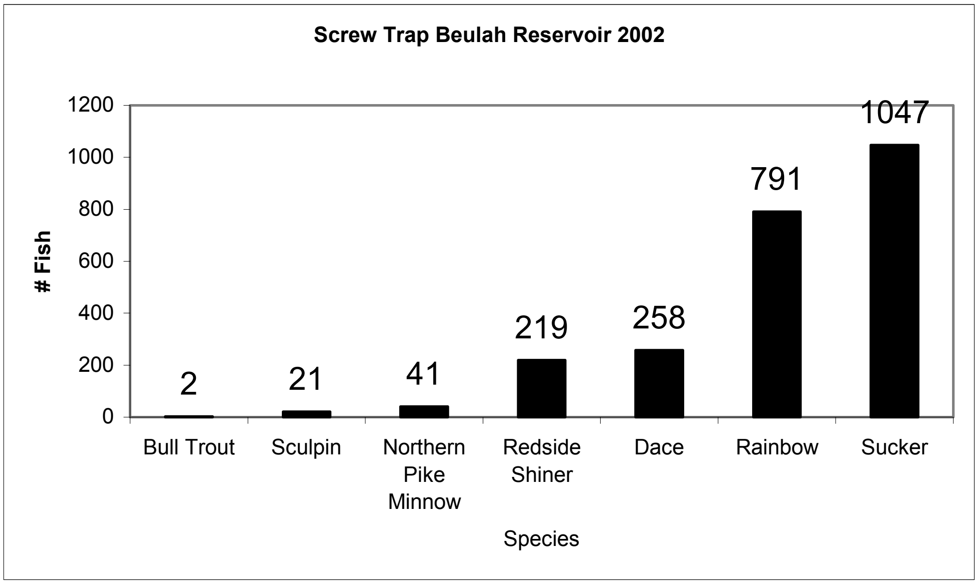

Figure 6. Number and type of fish caught in Beulah Reservoir screw traps in 2002.

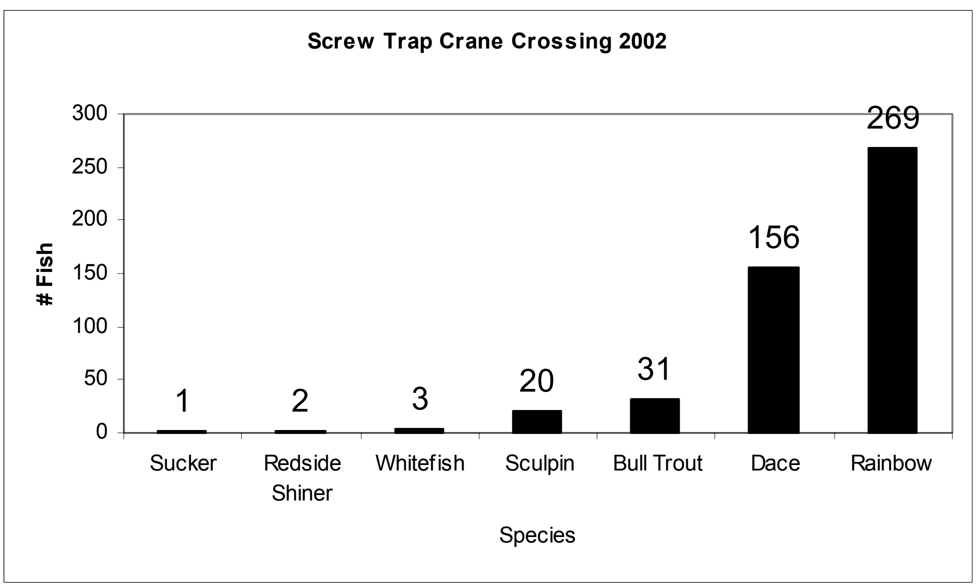

Figure 7. Number and type of fish caught in the Crane Crossing Screw Trap in 2002.

Appendix B. Monthly Observation of Radio-tagged Bull Trout in the North Fork Malheur River, 2002.

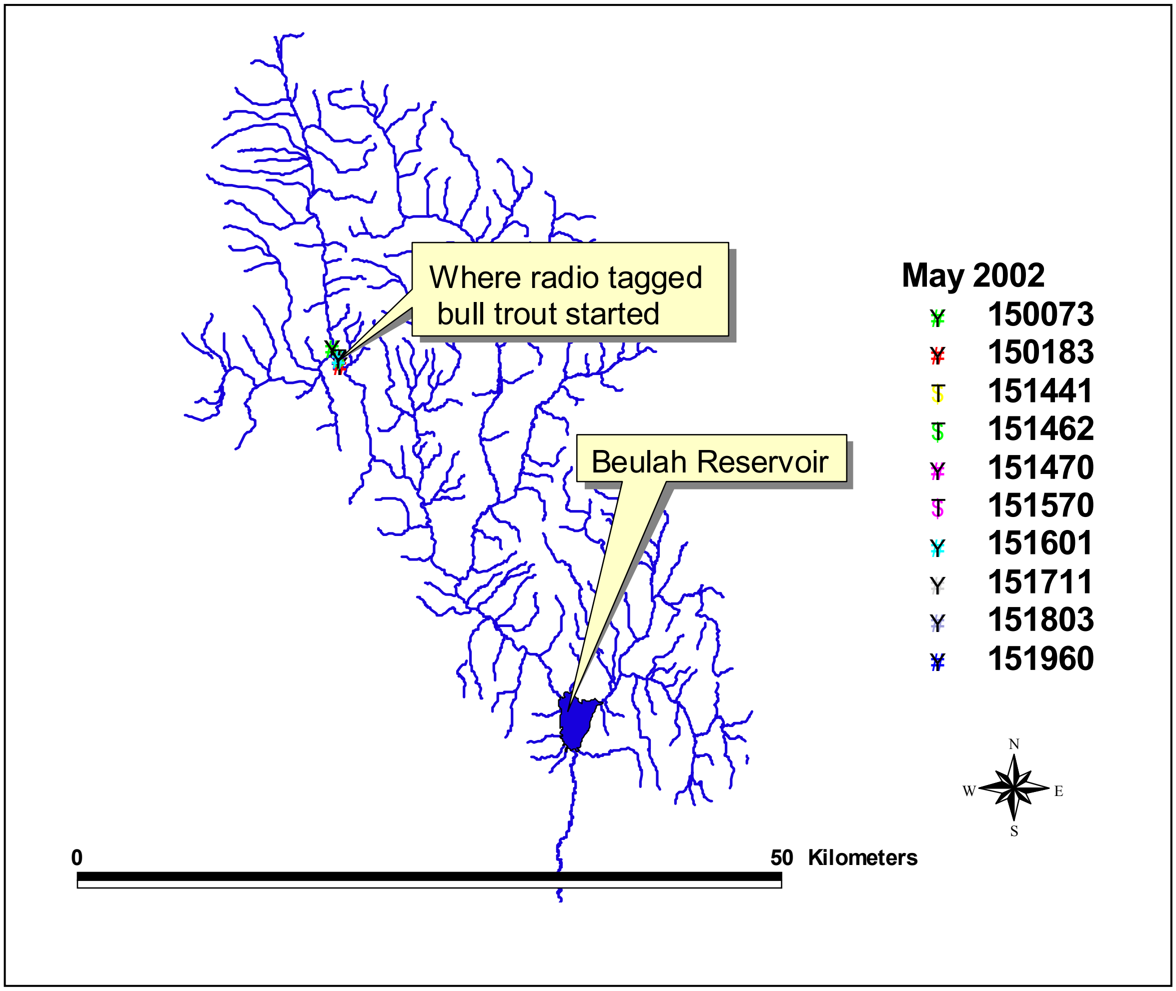

Figure 8. May 2002 observations of radio-tagged bull trout in the Malheur River basin.

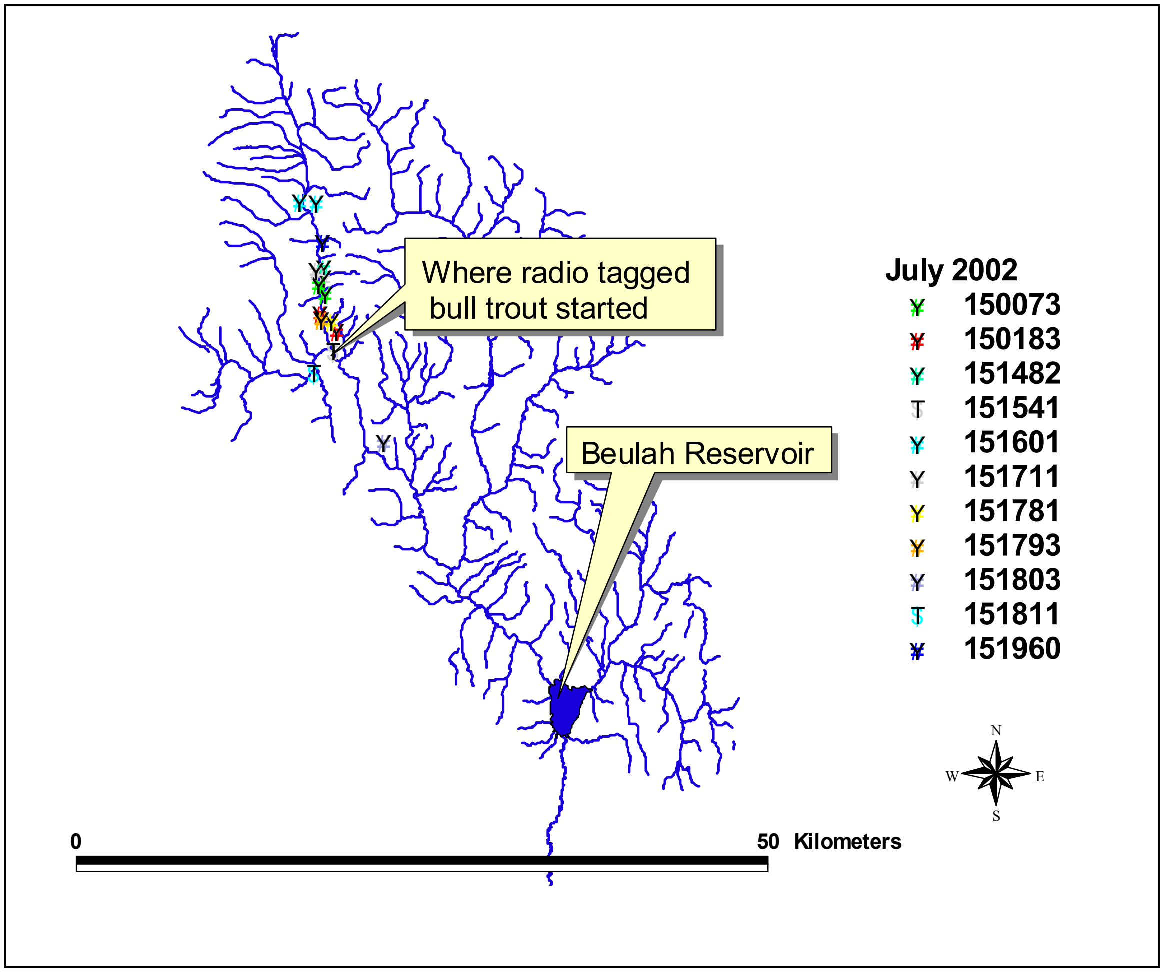

Figure 9. July 2002 observations of radio-tagged bull trout in the Malheur River basin.

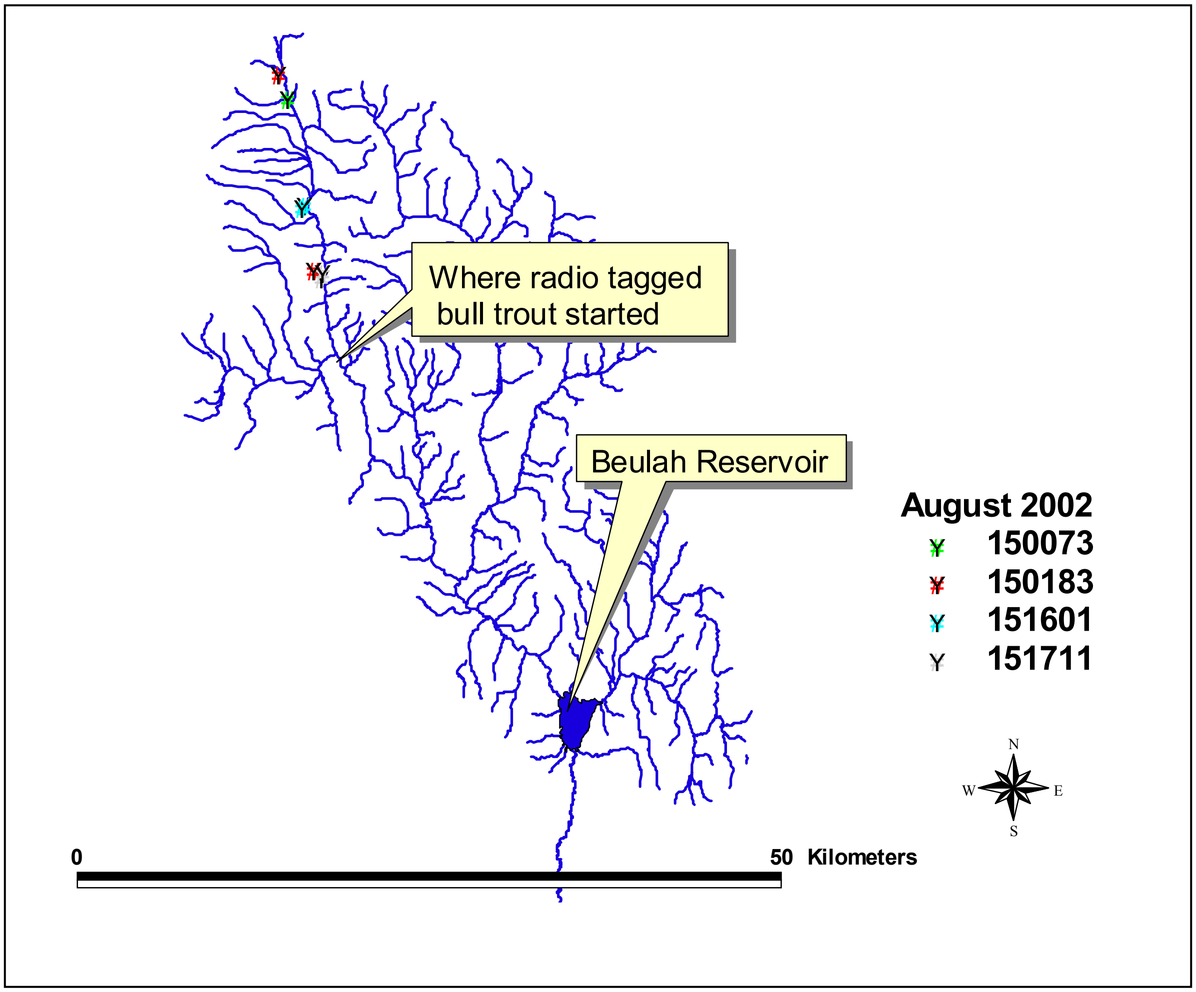

Figure 10. August 2002 observations of radio-tagged bull trout in the Malheur River basin.

DETERMINE THE LENGTH AT AGE FOR BULL TROUT THROUGH THE ANALYSIS OF CYCLOID SCALES TAKEN FROM BULL TROUT IN THE NORTH FORK MALHEUR RIVER, OREGON

By Lawrence T. Schwabe, Burns Paiute Tribe

Introduction

An understanding of bull trout (*Salvelinus confluentus*) life history is critical to develop a defensible recovery plan for the species. Little is known on the age structure and growth rates of the population of bull trout in the North Fork Malheur River drainage (Bowers et al. 1993). Based on a small sample size, the Burns Paiute Tribe (BPT) noted annual growth rates for bull trout range from 0.08 to 0.15 millimeters per day through the recapture of radio-tagged bull trout (BPT 2000). Growth rates for various age classes were unknown.

The rate of growth in diameter of the bones, spines, and scales is proportional to the growth rate (length) of fish. For this reason, scales and otoliths are commonly examined to determine a fish's age at length. Using scales to determine the age of a particular fish is preferred because scale extraction is an easy, less stressful, and non-lethal method.

Research objectives included:

- Continue monitoring age class structure in native salmonids within the Malheur River basin.
- Determine length at-age (fork length) for bull trout collected in the North Fork Malheur River drainage.

Methods

The BPT Fish and Wildlife Department (BPT) has sampled scales from bull trout for age class analysis since 1998 with the cooperation from Oregon Department of Fish and Wildlife (ODFW). This coordination is currently underway.

Before 1998, ODFW periodically collected limited scale samples from bull trout. Data were incorporated into this report to increase the sample size. ODFW collected bull trout scales during five sampling efforts prior to 1998:

- Fyke and trap nets set in Beulah Reservoir on April 3, 1994.
- Fyke and trap nets set in Beulah Reservoir between April 7 and April 14, 1995.
- Backpack electrofishing surveys in Swamp Creek on July 25, 1995.

- Fyke and trap nets set in Beulah Reservoir between April 5 and April 11, 1996.
- Gill nets set in Beulah Reservoir on November 8, 1997.

Since 1998, ODFW and BPT have coordinated efforts in the collection of bull trout scale samples. All bull trout were measured to the nearest millimeter fork length and weighed to the nearest gram. Scale samples were collected from all bull trout over 100 millimeters. Scales were removed from the dorsal surface of bull trout above the median lateral line between the dorsal and adipose fins. ODFW analyzed all BPT-collected scales in 1998, 1999 and 2000. This report presents the 1998, 1999, and 2000 scale analysis results. Fish collection methods include:

- Fyke and trap nets set in Beulah Reservoir March 30 to April 27, 1998.
- Angling in the tailrace of Beulah Reservoir February 1 to June 30, 1998.
- Fyke and trap nets set in Beulah Reservoir March 29 to May 4, 1999.
- Angling in the tailrace of Beulah Reservoir February 1 to June 30, 1999.
- Angling in the tailrace of Beulah Reservoir February 1 to June 20, 2000.
- Screw trap collection in the North Fork Malheur River (RK 69, Crane Crossing) from June 22 to October 15, 1998.
- Angling to capture additional bull trout in near the screw trap from June 22 to July 31, 1998.
- Screw trap collection in the North Fork Malheur River (RK 69, Crane Crossing) from June 2 to October 19, 1999.
- Angling to capture additional bull trout near the screw trap from June 2 to July 31, 1999.

The scales of the fish grow as the fish grows. This growth is usually expressed as scale diameter. Periods of slow growth is determined by closely spaced circuli, or growth rings. Several factors may influence closely spaced circuli: Decreases in metabolic rate and appetite in cold seasons, fasting periods during spawning and/or unavailability of food, and the re-absorption of scales in the development of female sexual gonads. ODFW determined and validated annuli, or annual variations of circuli patterns, for length at age data.

All bull trout scales collected were sent to ODFW in Corvallis, Oregon, for age class analysis. ODFW returned the analysis in two parts: Age of bull trout from scales submitted and associated back calculation estimates for length-at-age. Back-calculation estimates for bull trout collected in the North Fork Malheur River in 1998 were not submitted in the analysis. ODFW determined and validated daily and annular rings. Scales were taken from radio-tagged bull trout in 1998 and 1999. A total of 44 bull trout were radio tagged. Age for these fish has been determined.

All statistical analysis and calculation were performed in Microsoft Excel. T-tests were used to compare average length-at age data for bull trout collected at various sites.

Results

Bull Trout Collection from Beulah Reservoir

ODFW analyzed 81 scale samples from bull trout collected from Beulah Reservoir and the tailrace of the reservoir from 1994 to 2000. These bull trout had fork lengths between 226 to 546 millimeters (see Figure 11). Appendix A contains additional data from ODFW's scale analysis.

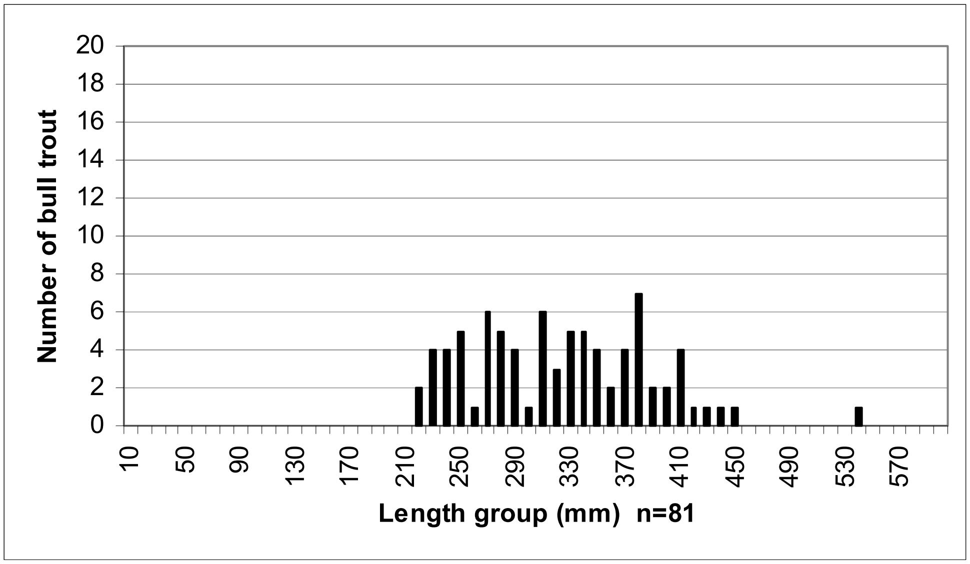

Figure 11. Length frequency histogram for bull trout collected in Beulah Reservoir between 1994 and 2000.

ODFW Efforts from 1994 to 1997

ODFW collected and successfully analyzed scales from 25 bull trout between 1994 and 1997. As Table 5 indicates, the oldest fish was 8 years old when caught (on April 10, 1995); the youngest fish was 3 yeas old when caught (on November 8, 1997).

Table 5. Scale Analysis Results from Bull Trout Collected by ODFW from April 1994 to November 1997.

	Age class									Total
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Undetermined**	
Number of fish	0	0	1	8	10	4	1	1	0	25

1 captured in a trap net on April 3, 1994.
5 captured using fyke and trap nets from April 7 to April 14, 1995.
14 captured using fyke and trap nets from April 5 to April 11, 1996.
5 captured using gill nets on November 8, 1997.

Table 6. Scale Analysis Results from Bull Trout Collected Near Beulah Reservoir by the BPT from March 1998 to May 2000.

	Age class									Total
	1	2	3	4	5	6	7	8	Undetermined	
Number of fish in 1998	0	0	3	7	15	1	0	0	3	29
Number of fish in 1999	0	0	0	15	12	3	1	0	4	33
Number of fish in 2000	0	0	0	0	0	1	0	0	3	4

29 captured using angling, fyke, and trap nets from April 1 to April 21, 1998. Three samples could not be read due to poor scale condition.
33 captured using angling, fyke, and trap nets from March 11 to May 28, 1999. Four samples could not be read due to poor scale condition.
4 captured using angling from May 10 to May 12, 2000. Three samples could not be read due to poor scale condition.

BPT Efforts from 1998 to 2000

BPT collected and ODFW successfully analyzed scales from 56 bull trout between 1998 and 2000. Table 6 presents the number of fish per age class.

Bull Trout Collection from North Fork Malheur River

BPT collected and ODFW successfully analyzed scales from 68 bull trout from the North Fork Malheur River between 1998 and 1999. These bull trout had fork lengths between 148 to 208 millimeters (see Figure 12). Appendix A contains additional data from ODFW's scale analysis. Table 7 presents the number of fish per age class.

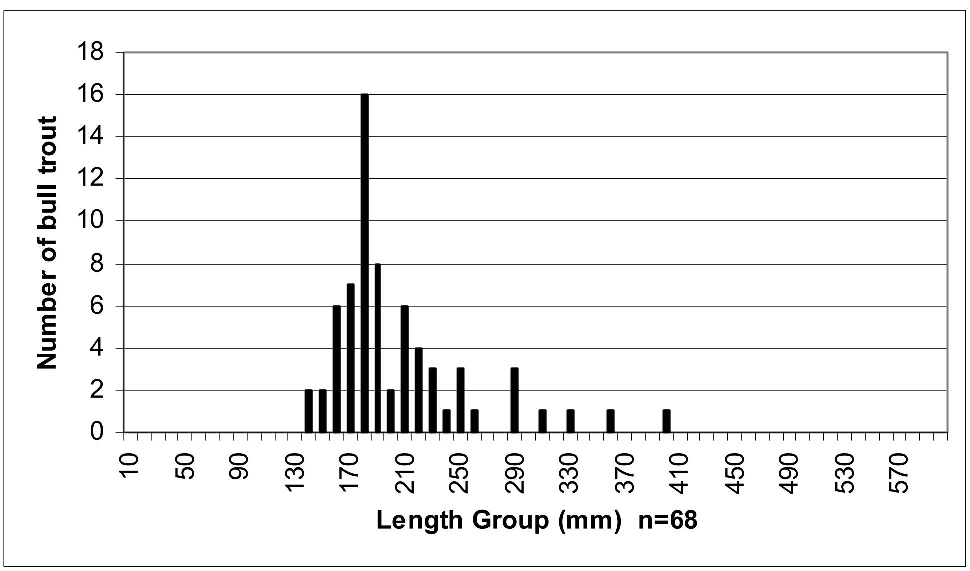

Figure 12. Length frequency histogram for bull trout collected in the North Fork Malheur River (near RK 69) between 1998 and 1999.

Table 7. Scale Analysis Results from Bull Trout Collected in the North Fork Malheur River above RK 69 by the BPT from June 1998 to September 1999.

	Age class									Total
	1	2	3	4	5	6	7	8	Undetermined	
Number of fish in 1998	0	1	15	8	1	1	0	0	2	28
Number of fish in 1999	1	18	19	4	0	0	0	0	3	45

28 captured using the screw trap and angling from June 24 to September 28, 1998. Two samples could not be read due to poor scale condition.
45 captured using the screw trap and angling from June 3 to September 16, 1999. Three samples could not be read due to poor scale condition.

Bull Trout Collection from the North Fork Tributaries

ODFW successfully analyzed scales from 29 bull trout from Swamp Creek on July 25, 1995. These bull trout had fork lengths between 87 and 228 millimeters (see Figure 13). Appendix A contains additional data from ODFW's scale analysis.

Table 8 presents the number of fish per age class.

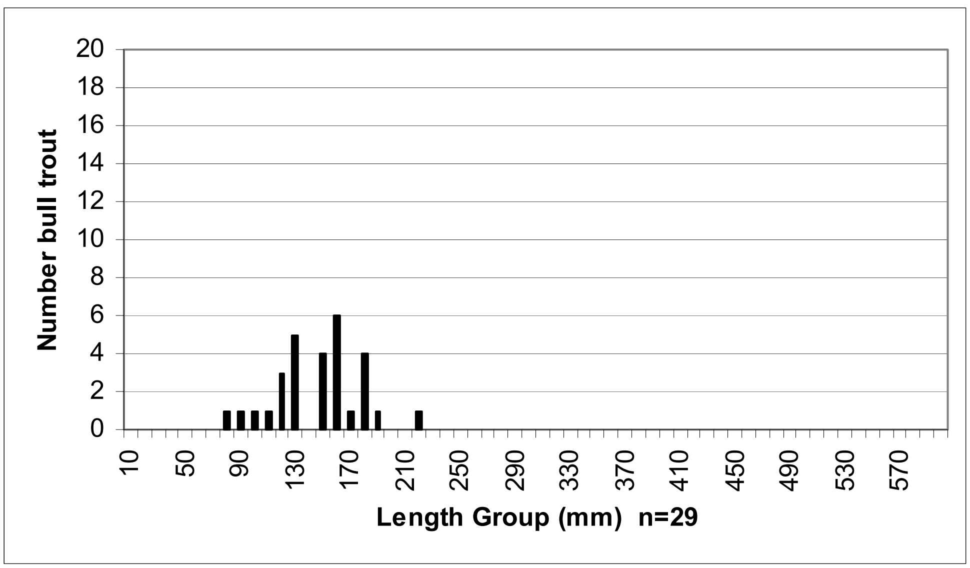

Figure 13. Length frequency histogram for bull trout collected in tributaries to the North Fork Malheur River (Swamp Creek) in 1995.

Table 8. Scale Analysis Results from Bull Trout Collected from Swamp Creek by ODFW in July 1995.

	Age class									Total
	1	2	3	4	5	6	7	8	Undetermined	
Number of fish in 1995	2	9	17	1	0	0	0	0	2	31

33 captured using a backpack electrofisher on July 25, 1995. Two samples could not be read due to poor scale condition.

Pooled Data Analysis

Combining the multiple years of age class analysis data increased the sample size to decrease variance to determine length at age. The ODFW analysis results indicate that bull trout are from age 1 to age 8 (see Figure 14). Table 9 illustrates the standard deviations and associated 95 percent confidence intervals for bull trout age at length from samples collected in the North Fork Malheur River subbasin.

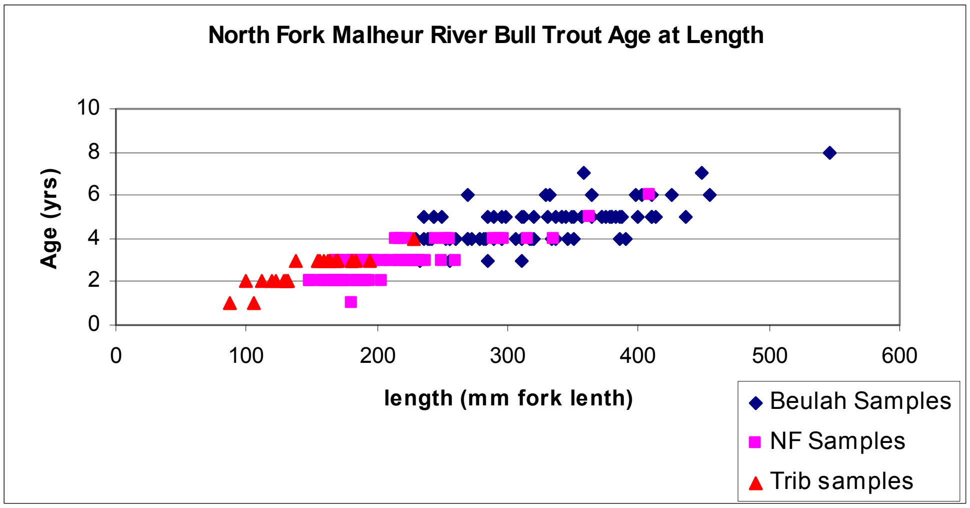

Figure 14. Determined age of bull trout and corresponding length at time of capture for fish collected on the North Fork Malheur River from 1994 to 2000.

Table 9. Scale Analysis Results from All Bull Trout Collected from the North Fork Malheur River Drainage from April 1994 to May 2000.

	Age class							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mean Fork Length (mm)	124	157	195	280	345	371	403	NA
Standard Deviation	49.17	27.76	33.98	45.10	51.81	51.33	63.64	NA
95% confidence interval	68.73 - 179.93	146.93 - 167.14	185.96 - 203.60	266.66 - 293.94	328.21 - 362.06	337.57 - 404.65	314.80 - 491.20	NA

Figure 15 provides average fork lengths for bull trout for three locations. Mean fork length of 2+ (t-test; $p<0.00000001$) and 3+ (t-test; $p<0.00001$) bull trout sampled at Crane Crossing were significantly larger than those sampled in Swamp Creek. Mean fork length of 3+ bull trout sampled in Beulah Reservoir were significantly larger than those sampled at Crane Crossing (t-test; $p<0.05$), though the sample size of age 3+ fish collected in Beulah Reservoir was only 4 bull trout. Mean fork length of 4+ bull trout sampled from Beulah Reservoir was not significantly larger than those 4+ bull trout sampled at Crane Crossing (t-test; $p<0.08$).

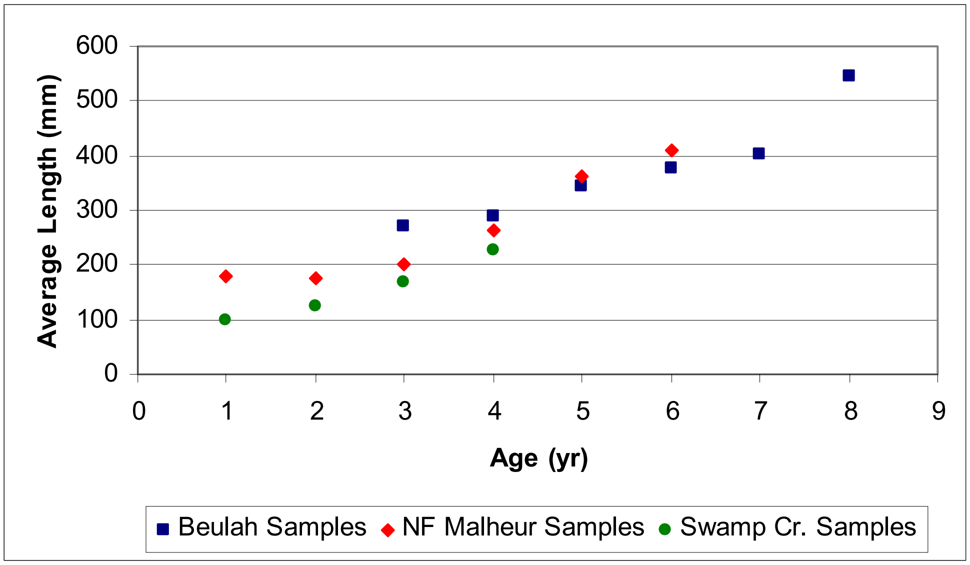

Figure 15. Average fork length of bull trout and age at time of capture for three primary collection sites on the North Fork Malheur River.

Spatial and temporal collection of scales from bull trout in the North Fork Malheur River subbasin varied from early spring to late fall and from low elevation habitats (Beulah Reservoir at elevation 1021 meters) to high elevation habitats (Swamp Creek at elevation 1592 meters). This sampling variation may affect reported growth rates, resulting in a variation of scale ring formation. The data analyzed to this point does not account for fish older than x years of age, meaning the bull trout analyzed are age x+. In validating the annuli patterns of bull trout in the North Fork Malheur River subbasin, various diameters of annuli can be used to determine exact length-at-age. Appendix B, Table 10, and Figure 16 summarize back-calculation data for ODFW-analyzed bull trout in the North Fork Malheur River subbasin.

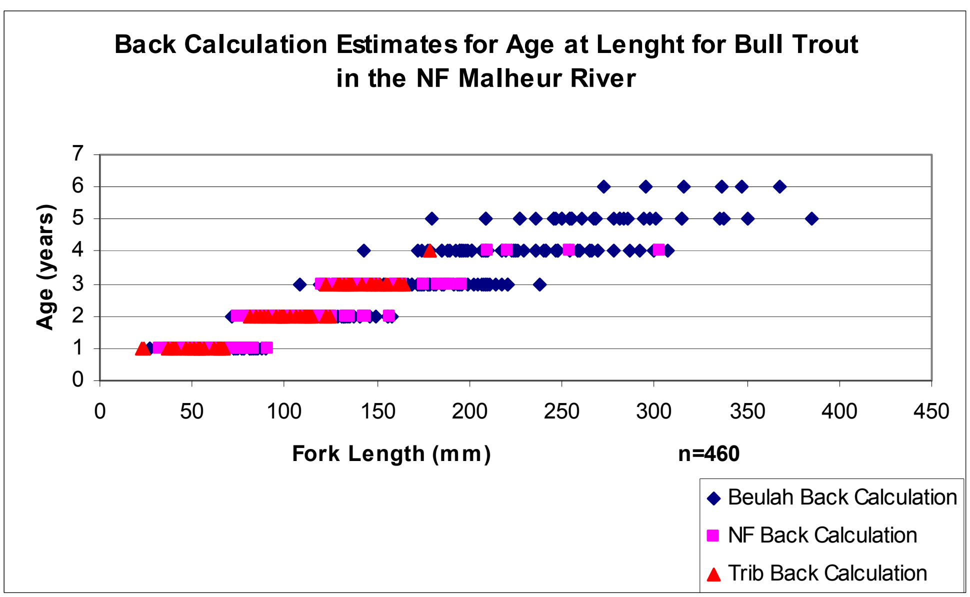

Figure 16. Back-calculation estimates for bull trout collected from the North Fork Malheur River.

Table 10. Back-calculation Length at Age Estimates for Bull Trout in the North Fork Malheur River Drainage.

	Age class							
	1	2	3	4	5	6	7	8
Mean Fork Length (mm)	59	110	163	225	271	322	NA	NA
Standard Deviation	2.68	3.27	27.92	36.00	43.92	35.14	NA	NA
95% confidence interval	56.57 - 61.92	107.15 - 113.7	158.23 - 167.48	216.18 - 233.68	256.11 - 286.54	294.36 - 350.59	NA	NA

Age of Radio-tagged Bull Trout

In 1998, 19 bull trout were implanted with radio tags. Table 11 describes these bull trout. The fork length of these bull trout was from 320 to 451 millimeters with an average length of 365 millimeters. Scale analyses determined that 3 bull trout were age 4, 11 were age 5, and 2 were age 6. The age of 3 bull trout could not be determined due to poor scale condition.

In 1999, 25 bull trout were implanted with radio tags. Table 12 describes these bull trout. The fork length of these bull trout was from 297 to 510 millimeters with an average length of 381 millimeters. Scale analyses determined that 8 bull trout were age 4, 10 were age 5, 2 were age 6, and 1 was age 7. The age of 4 bull trout could not be determined due to poor scale condition.

Table 11. Age of Bull Trout Implanted with a Radio Tag from the North Fork Malheur River Drainage in 1998.

	Frequency	Fork Length (mm)	Age (years)	Comments
1	151.483	320	5	
2	151.453	325	NA	Scales not submitted
3	151.463	333	4	Retagged in 1999 (151.133)
4	151.493	341	5	
5	151.542	342	5	
6	151.513	345	NA	Poor scale condition
7	151.473	346	4	
8	151.582	349	5	Retagged in 1999 (151.192)
9	151.783	351	5	
10	151.653	357	5	
11	151.833	362	5	
12	151.713	364	5	
13	151.603	372	5	
14	151.803	372	5	Retagged in 1999 (150.922)
15	151.793	378	5	
16	151.392	403	6	
17	151.442	408	6	
18	151.402	413	4	

Table 12. Age of Bull Trout Implanted with a Radio Tag from the North Fork Malheur River Drainage in 1999.

	Frequency	Fork Length (mm)	Age (years)	Comments
1	151.753	297	4	
2	151.683	317	4	
3	151.892	319	5	
4	151.872	319	4	
5	151.853	335	4	
6	151.693	337	4	
7	151.862	350	4	
8	151.883	354	5	
9	151.362	365	6	
10	151.192	376	NA	Poor scale condition; re-tagged fish from 1998 (151.582)
11	150.863	380	5	
12	151.173	385	5	
13	151.133	386	4	Re-tagged fish from 1998 (151.463)
14	151.593	387	5	
15	150.803	387	5	
16	151.152	390	4	
17	150.922	400	NA	Poor scale condition, re-tagged fish from 1998 (151.180)
18	151.293	400	5	
19	150.433	410	5	
20	151.023	410	5	
21	151.222	410	5	
22	150.683	424	NA	Poor scale condition
23	150.722	425	6	
24	150.522	448	7	
25	151.182	510	NA	Poor scale condition

Discussion

The back-calculated fork length averages for bull trout in the North Fork Malheur River provide a good baseline estimate for age at length. Using the back-calculation data available, Figure 17 and Table 13 present the percent of bull trout at age per fork length group.

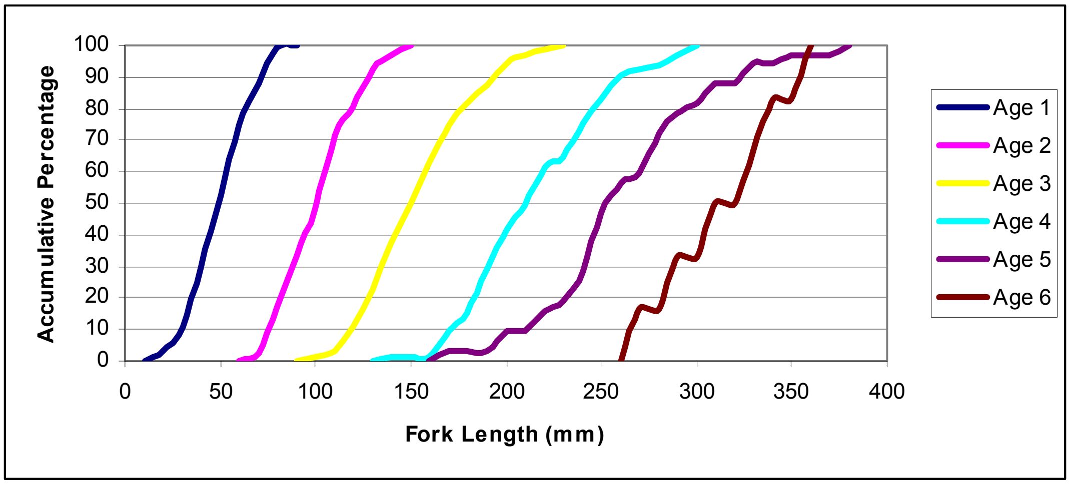

Figure 17. Accumulative percent of bull trout at fork length per age collected in the North Fork Malheur River watershed from 1994 to 2000.

Nevertheless, precise age estimates cannot be determined by fork length alone. Laboratory analysis of scales or otoliths will always provide a more precise age estimate for bull trout. BPT has no documentation of analysis conducted on otoliths from bull trout in the Malheur River subbasin.

Over 75 percent of the bull trout collected from Beulah Reservoir were 4- and 5-year-old fish. Bull trout younger than 3 years have not been documented in Beulah Reservoir. Past sampling methodology in the reservoir may not effectively detect a smaller population of age 2 bull trout. In March 2002, a screw trap less than 1/2-mile upstream from the reservoir pool in the North Fork Malheur River captured two bull trout in May 2002 that had fork lengths of 119 and 162 millimeters. These are potential candidates for age 2+ and 3+ bull trout, but age class analysis on these fish has not been completed.

Dominant age classes for bull trout North Fork Malheur River bull trout are age 2, 3, and 4. Only 3 bull trout sampled from the Crane Crossing area were younger than age 2 or older than 4. The BPT noted a greater 1998 average in bull trout fork length than those captured in 1999 (BPT 2000). The screw trap collection of age 2 went from 3.8 percent of the total catch in 1998 to 42.9 percent in 1999. Furthermore, the catch rate of fish age 4 and older declined from 38.5 percent in 1998 to 9.5 percent in 1999. The greater average in bull trout fork length collected at Crane Crossing in 1998 over that in 1999 is attributed to an increase collection of age 2 bull trout and a decrease in the collection of age 4 and older bull trout in 1999.

Table 13. Percent of Bull Trout at Age per Fork Length Group in the North Fork Malheur River Watershed. Back-calculation Methods Used to Estimate Length at-age. Collection of Samples from 1994 to 2000.

Fork Length (mm)	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6
10						
20	3.3					
30	7.4					
40	18.9					
50	23.0					
60	22.1					
70	13.1	2.3				
80	11.5	14.5				
90	1.0	16.8				
100		14.5	1			
110		23.7	1.9			
120		8.4	7.7			
130		12.2	12.5			
140		4.6	14.4	1.5		
150		3.1	12.5			
160			12.5			
170			12.5	7.7	3.1	
180			6.7	6.2		
190			5.8	13.8		
200			6.7	12.3	6.3	
210			2.9	7.7		
220			1.9	12.3	6.3	
230			1	3.1	3.1	
240				10.8	9.4	
250				7.7	18.8	
260				7.7	9.4	
270				1.5	3.1	16.6
280				1.5	12.5	
290				3.1	6.3	16.6
300				3.1	3.1	
310					6.3	16.6
320						
330					6.3	16.6
340						16.6
350					3.1	
360						16.6
370						
380					3.1	

The greater average in fork length of age 2+ and 3+ bull trout collected at Crane Crossing over those collected at Swamp Creek may be attributed to an increase in forage opportunities or longer foraging periods in lower elevation habitats. Since these samples were collected during various years, annual variation in prey abundance and habitat quality may also have been significant factors. There is no monitoring or trend data on prey availability for bull trout that can be correlated to the greater size of Malheur River fish over those in tributary habitats.

Though existing data suggest a greater average in Beulah Reservoir age 3+ bull trout fork length than those collected at Crane Crossing, a small reservoir sample size (4) make this conclusion weak. It is assumed that more forage opportunities in the reservoir habitat cause greater fork length-at-age for bull trout compared to fluvial or resident populations. Age 4+ bull trout collected at Crane Crossing did not exhibit greater fork length over age 4+ bull trout collected in the reservoir. It is unknown if the age 4+ bull trout collected during the 1998 and 1999 summer months overwintered in Beulah Reservoir. In addition, little is known about the Beulah Reservoir prey base. Recent efforts to analyze stomach contents of Beulah Reservoir bull trout to determine feeding preferences came to a halt due to the lack of bull trout collected in 2002.

Age of Radio-tagged Fish

Table 14. Annual Growth for Bull Trout Using Averages from Back-calculation Length-at-age Estimates.

	Average Growth (mm fork length)	Growth Rate (mm/day)
Age 1 – 2	51	0.14
Age 2 – 3	53	0.15
Age 3 - 4	62	0.17
Age 4 – 5	46	0.13
Age 5 - 6	51	0.14

The average growth in length using back-calculation values can be determined by taking the difference of average fork length at age between years. The average annual growth rates for bull trout in the North Fork Malheur River drainage range from 0.13 to 0.17 millimeters per day (see Table 14). With a limited sample size (n=3), the BPT determined annual growth rates for radio-tagged bull trout that range from 0.08 to 0.15 millimeters per day (BPT 2000). This further illustrates the variation in length-at-age and growth rates for bull trout in the North Fork Malheur River drainage. Cooler water conditions and feeding behavior play a critical role in growth. These estimates provide land and fish managers baseline information for determining age of bull trout by fork length. If more precise measurement of age is needed, scales or otoliths from individual bull trout need to be submitted for age class analysis.

References

Bowers, W., P. Dupee, M. Hanson, and R. Perkins. 1993. Bull trout population summary, Malheur River basin. Unpublished Data. Oregon Department of Fish and Wildlife. Hines, Oregon.

Burns Paiute Tribe (BPT). 2000. Malheur River basin cooperative bull trout/redband trout research project. FY 1999 Annual Report (Unpublished). Burns, Oregon.

Appendix A. Compiled Results of Scale Analyses

ODFW analyzed scales from bull trout to determine age. Scales were taken from bull trout captured at Beulah Reservoir, North Fork Malheur River (RK 69), and Swamp Creek. Table 15 presents the results from the ODFW data analysis.

Table 15. Compiled Results from ODFW Scale Analyses for Bull Trout Captured from the North Fork Malheur River.

	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Average Fork Length (mm)	Number of bull trout
Age 1 Beulah Scales	NA	NA	NA	NA
Age 2 Beulah Scales	NA	NA	NA	NA
Age 3 Beulah Scales	232	310	271	4
Age 4 Beulah Scales	226	390	289	30
Age 5 Beulah Scales	235	436	345	35
Age 6 Beulah Scales	270	455	376	9
Age 7 Beulah Scales	358	448	403	2
Age 8 Beulah Scales	546	546	546	1
Age 1 NFk Malheur Scales	180	180	180	1
Age 2 NFk Malheur Scales	148	204	174	20
Age 3 NFk Malheur Scales	168	260	200	34
Age 4 NFk Malheur Scales	214	335	263	12
Age 5 NFk Malheur Scales	1	362	362	1
Age 6 NFk Malheur Scales	1	408	408	1
Age 7 NFk Malheur Scales	NA	NA	NA	NA
Age 8 NFk Malheur Scales	NA	NA	NA	NA
Age 1 Swamp Scales	87	106	97	2
Age 2 Swamp Scales	99	132	123	9
Age 3 Swamp Scales	137	195	167	17
Age 4 Swamp Scales	228	228	228	1
Age 5 Swamp Scales	NA	NA	NA	NA
Age 6 Swamp Scales	NA	NA	NA	NA
Age 7 Swamp Scales	NA	NA	NA	NA
Age 8 Swamp Scales	NA	NA	NA	NA
Age 1 All Scales	87	180	124	3
Age 2 All Scales	99	204	157	28
Age 3 All Scales	137	310	195	55
Age 4 All Scales	214	390	280	43
Age 5 All Scales	235	436	345	36
Age 6 All Scales	270	425	371	9
Age 7 All Scales	358	448	403	2
Age 8 All Scales	546	546	546	1

Appendix B. Compiled Length-at-age Estimates from Back-calculations

ODFW back-calculated age estimates at length for the bull trout captured at Beulah Reservoir, North Fork Malheur River (RK 69), and Swamp Creek. Table 16 presents the bull trout length-at-age estimates by conducting these back-calculation methods.

Table 16. Compiled Length-at-age Estimates from ODFW Back-calculations for Bull Trout Captured from the North Fork Malheur River.

	Minimum Fork Length (mm)	Maximum Fork Length (mm)	Average Fork Length (mm)	Number of Estimates
Age 1 Beulah Scales	27.0	89.3	61.6	60
Age 2 Beulah Scales	71.9	157.8	115.7	63
Age 3 Beulah Scales	108.0	238.0	172.9	63
Age 4 Beulah Scales	142.8	307.0	224.2	60
Age 5 Beulah Scales	179.2	385.6	271.3	32
Age 6 Beulah Scales	272.5	368.0	322.5	6
Age 7 Beulah Scales	NA	NA	NA	0
Age 8 Beulah Scales	NA	NA	NA	0
Age 1 NFk Malheur Scales	32.5	90.9	60.9	37
Age 2 NFk Malheur Scales	74.8	157.3	107.6	41
Age 3 NFk Malheur Scales	119.8	195.3	149.4	23
Age 4 NFk Malheur Scales	210.3	303.4	247.1	4
Age 5 NFk Malheur Scales	NA	NA	NA	0
Age 6 NFk Malheur Scales	NA	NA	NA	0
Age 7 NFk Malheur Scales	NA	NA	NA	0
Age 8 NFk Malheur Scales	NA	NA	NA	0
Age 1 Swamp Scales	23.2	67.4	51.2	25
Age 2 Swamp Scales	81.5	124.3	102.5	27
Age 3 Swamp Scales	121.8	164.0	144.9	18
Age 4 Swamp Scales	178.8	178.8	178.8	1
Age 5 Swamp Scales	NA	NA	NA	0
Age 6 Swamp Scales	NA	NA	NA	0
Age 7 Swamp Scales	NA	NA	NA	0
Age 8 Swamp Scales	NA	NA	NA	0
Age 1 All Scales	23.2	90.9	59.2	3
Age 2 All Scales	71.9	157.8	110.4	131
Age 3 All Scales	108.0	238.0	162.9	104
Age 4 All Scales	142.8	307.0	224.9	65
Age 5 All Scales	179.2	385.6	271.3	32
Age 6 All Scales	272.5	368.0	322.5	6
Age 7 All Scales	NA	NA	NA	0
Age 8 All Scales	NA	NA	NA	0

ASSESS STREAM HABITAT ON THE NORTH FORK MALHEUR RIVER

By Lawrence T. Schwabe, Burns Paiute Tribe

Introduction

Habitat degradation, migration barriers from irrigation projects, and introduced salmonids have been linked to the decline of bull trout *Salvelinus confluentus* populations (Ratliff and Howell 1992; Rieman and McIntyre 1993; Goetz 1994). The patchy distribution of bull trout in relation to other species suggests that these fish have specific habitat requirements and may be prone to habitat disruption and fragmentation (Fraley and Shepard 1989). Rieman and McIntyre (1993) noted five habitat characteristics that appear to be particularly important: stream channel stability, habitat complexity, substrate composition, temperature, and migratory corridors.

Changes in the forest canopy and riparian shading, water yield, and hydrologic patterns have altered stream temperatures (Anderson 1973; Rishel et al. 1982; Barton et al. 1985; Beschta et al. 1987; McGurk 1989). Although there is no direct evidence that alteration of temperature patterns has influenced the persistence or distribution of bull trout, a strong association between temperature and distribution make such a response likely (Rieman and McIntyre 1993).

The Burns Paiute Tribe (BPT), Oregon Department of Fish and Wildlife (ODFW), Bureau of Reclamation (USBR), and the U.S. Forest Service (USFS) agreed to use collected habitat survey data to identify habitat conditions in the North Fork Malheur River.

Habitat degradation has been identified as a limiting factor for bull trout in the North Fork Malheur River (Bowers et al. 1993). The North Fork Malheur River provides overwinter and migratory habitat for adult bull trout and oversummer habitat for sub-adult and adult bull trout in the upper reaches (BPT 2000). This survey provides land managers a snapshot of the habitat conditions present on the North Fork Malheur River in the summer of 2001.

The North Fork Malheur River is a major tributary to the Malheur River. The North Fork Malheur River originates in the Strawberry Mountains at elevation 2073 meters and approximately 24 kilometers southwest of Prairie City, Oregon. The North Fork Malheur River flows into the Malheur River immediately east of Juntura, Oregon, at river kilometer (RK) 155. The elevation at the confluence is 896 meters.

The North Fork Malheur River once supported a large run of anadromous fish (NWPPC 2001). Irrigation and hydroelectric projects are primary causes of the Malheur River extinction of chinook salmon (*Oncorhynchus tshawytscha*), steelhead trout (*Oncorhynchus mykiss*), pacific lamprey (*Lampertra tridentate*), and probably coho salmon (*Oncorhynchus kisutch*) (USFWS 1950; Pribyl and Hosford 1985; Thompson and Fortune 1967).

Methods

Stream surveys were conducted on the North Fork Malheur River from RK 56 to RK 91 using ODFW intermediate level methods for stream habitat surveys (ODFW 1999). This inventory does not include data on undercut banks, which are critical habitats for juvenile bull trout (Dambacher and Jones 1997). Therefore, undercut banks were measured and recorded during these surveys. Stream survey data was entered and analyzed using Microsoft Excel.

Active channel width, active channel height, and floodplain width were taken every ten habitat units. Actual measurements were used; where floodplain widths exceeded 2.5 times the bank full width, these distances were estimates.

The North Fork Malheur River habitat survey began on July 2, 2001, near the U.S. Forest Service boundary at the confluence with Bear Creek (RK 56). It was completed on October 22, 2001. The surveyed portion of the North Fork Malheur River was broken into 7 reaches, designated based on changes in channel morphology/form and land use:

- Reach 1 begins at the confluence with Bear Creek and ends as the valley floodplain broadens near RK 63.
- Reach 2 begins near RK 63 and ends at the Crane Creek confluence.
- Reach 3 begins at the Crane Creek confluence and ends at the Forest Road 1375 bridge crossing.
- Reach 4 begins at the Forest Road 1375 bridge crossing and ends at the Elk Creek confluence.
- Reach 5 begins at the Elk Creek confluence and ends at the Forest Road 13 bridge crossing.
- Reach 6 begins at the Forest Road 16 bridge crossing and ends at the Swamp Creek confluence.
- Reach 7 begins at the Swamp Creek confluence and ends at a Forest Road 1375 culvert crossing.

Results

Appendix A contains stream survey and riparian data analysis generated from Microsoft Excel.

Reach 1

Access to this reach was primarily by foot trail with road access limited to adjacent ridge tops. The total habitat length was 8159.7 meters with 7327.1 meters of primary channel (00 and 01 represent stream length). Channel gradient was 1.4 percent. Stream habitat was comprised mainly of riffle (55 percent) and riffle with pocket habitat (37 percent). The remaining 8 percent of habitat was either cascade, rapid, glide, lateral pool, or scour pool habitat types. Stream substrate was dominated by cobble (48.1 percent), gravel (34.9 percent), sand (7.3 percent), boulder (6 percent), silt (3.5 percent), and bedrock (0.2 percent). Total large woody debris (LWD) pieces per 100 meters of stream were 1.72. Active erosion estimates for this reach were 3.85 percent. Undercutting was noted on an average of 1.4 percent of both left and right stream banks.

Reach 2

Channel gradient was 1.4 percent. The total length of habitat was 7626.2 meters with 6378.1 meters of primary channel (00 and 01 represent stream length). Stream habitat was comprised of riffle (51.1 percent), riffle with pockets (34.8 percent), and glide (10.6 percent) habitat types. The remaining 3.5 percent of habitat was pool (lateral and straight scour). Stream substrate was dominated by cobble (41.1 percent) and gravel (40.5 percent). Sand (7.9 percent), silt (4 percent), and boulder (6.3 percent) substrates were present in fewer amounts. Total LWD pieces per 100 meters of stream were 3.47. Active erosion estimates were 4.74 percent. Undercutting was noted on an average of 6.0 percent of both left and right stream banks.

Reach 3

Channel gradient was 1.5 percent. The total length of habitat was 8517.4 meters with 6416.1 meters of primary channel (00 and 01 represent stream length). Stream habitat was comprised of riffle (88.1 percent), riffle with pockets (5.5 percent), and lateral pool (3.8 percent) habitat types. The remaining 2.6 percent of habitat was dam pool, plunge pool, and glide habitat types. Stream substrate was dominated by cobble (48 percent) and gravel (39.3 percent). Sand (7 percent), silt (5.2 percent), and boulder (0.4 percent) substrates were present in fewer amounts. Total LWD pieces per 100 meters of stream were 5.2. Active erosion estimates were 10.4 percent. Undercutting was noted on an average of 2.4 percent of both left and right stream banks.

Reach 4

Channel gradient was 1.8 percent. The total length of habitat was 7776.9 meters with 4395.9 meters of primary channel (00 and 01 represent stream length). Stream habitat was comprised of riffle (87.9 percent) and riffle with pockets (8 percent) habitat types. The remaining 4.1 percent of habitat was lateral pool, plunge pool, glide and straight scour habitat types. Stream substrate was dominated by cobble (47.8 percent) and gravel (36.9 percent). Sand (9.9 percent), silt (5.2 percent), and boulder (0.2 percent) substrates were present in fewer amounts. Total LWD pieces per 100 meters of stream were 4.04. Active erosion estimates were 5 percent. Undercutting was noted on an average of 8.5 percent of both left and right stream banks.

Reach 5

Channel gradient was 1.5 percent. The total length of habitat was 3959 meters with 2340 meters of primary channel (00 and 01 represent stream length). Stream habitat was comprised of riffle (81.3 percent), riffle with pockets (9.9 percent), and glide (4.3 percent) habitat types. The remaining 4.5 percent of habitat was dam pool, lateral pool, and straight scour pool habitat types. Stream substrate was dominated by cobble (50 percent) and gravel (32.9 percent). Sand (11.1 percent), silt (5.5 percent), and boulder (0.5 percent) substrates were present in fewer amounts. Total LWD pieces per 100 meters of stream were 4.93. Active erosion estimates were 6.67 percent. Undercutting was noted on an average of 9.8 percent of both left and right stream banks.

Reach 6

Channel gradient was 1.8 percent. The total length of habitat was 3687.1 meters with 3242.4 meters of primary channel (00 and 01 represent stream length). Stream habitat was comprised of riffle (50.9 percent), riffle with pockets (43.6 percent), and glide (4.8 percent) habitat types. The remaining 0.7 percent of habitat was lateral and plunge pool habitat types. Stream substrate was dominated by cobble (44.4 percent) and gravel (40.6 percent). Sand (11.8 percent), silt (2.3 percent), and boulder (0.8 percent) substrates were present in fewer amounts. Total LWD pieces per 100 meters of stream were 9.11. Active erosion estimates were 6.31 percent. Undercutting was noted on an average of 14.6 percent of both left and right stream banks.

Reach 7

Channel gradient was 1.9 percent. The total length of habitat was 4714 meters with 4419 meters of primary channel (00 and 01 represent stream length). Stream habitat was comprised of riffle with pockets (58.4 percent) and riffle (39.2 percent) habitat types. The remaining 2.4 percent of habitat was straight scour, lateral, and plunge pool habitat types. Stream substrate was dominated by cobble (44.8 percent) and gravel (43.3 percent). Sand (8.1 percent), silt (3.5 percent), and boulder (0.3 percent) substrates were present in fewer amounts. Total LWD pieces per 100 meters of stream were 6.09. Active erosion estimates were 8.25 percent. Undercutting was noted on an average of 23.0 percent of both left and right stream banks.

Discussion

Using Rosgen stream classification measurements as a guide (Rosgen 1996), stream reaches can be characterized by the channel measurements taken every ten units during the survey. Stream classification is based on width/depth ratios, entrenchment ratios, and stream slope. Appendix A contains the channel measurements for the North Fork Malheur River.

The dominant Rosgen channel classification type for Reach 1 is a B type channel. Typical characteristics of a B type channel are low/moderate slope, moderate width-to-depth ratios, and moderate entrenchment measurements. Areas of very low entrenchment suggest this reach has some F type channels present. Constraining hillslopes adjacent to the channel in some areas reduce the floodplain width which results in a low entrenchment value, or a more entrenched channel. However, F Type channel characteristics were less dominant than B Type characteristics.

Reach 2's Rosgen classification is a C type channel. C type channels tend to have higher entrenchment values, otherwise described as having a wider floodplain width. Again, areas of very low entrenchment values suggest this reach has some sections of F channel type present. As in Reach 1, adjacent hill slopes constrict the channel in some areas. Lower entrenchment values on the lower units suggest that constraining hillslopes on the channel tend to decrease on the upstream units.

Reaches 3 through 6 have a dominant C type channel. A noticeable decline in the width-to-depth ratios in the North Fork Malheur River above Swamp Creek suggest that Reach 7 transitions into an E type channel. E Type channels are typically described as narrow, deep channels that flow through low, gradient valleys.

Other than the channel measurements, much of the habitat inventory data from the North Fork Malheur River is consistent throughout all reaches. Stream slopes are relatively constant, ranging from 1.4 percent in Reaches 1 and 2 to 1.9 percent in Reach 7. Active erosion ranged from 3.85 percent in Reach 1 to 10.4 percent in Reach 3. A total of 43.5 percent of the total length of habitat in Reach 4 is side channel habitat (secondary channel); this represents the highest ratio for the surveyed sections. A total of 6.3 percent of the total length of habitat in Reach 7 is side channel habitat (secondary channel); this represents the lowest ratio for the surveyed sections. Cobble is the dominant substrate throughout the surveyed stream sections.

Dambacher and Jones (1997) found seven habitat variables that are significant descriptors of the presence of juvenile bull trout (<170 millimeter fork length): shade, undercut banks, LWD volume, LWD pieces, gravel in riffles, low levels of fine sediment in riffles, and bank erosion.

Table 17. Quality of Seven North Fork Malheur River Habitat Variables Described as Significant Descriptors of Bull Trout Habitat.

Habitat Variables [1]	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
Shade	High	High	High	High	High	High	High
Undercut Banks [2]	Low	Mod	Low	Mod	Mod	High	High
LWD (volume)	Low	Low	Low	Low	Low	Low	Low
LWD (count)	Low	Low	Low	Low	Low	Low	Low
Gravel in Riffles	Low	Low	Low	Low	Low	Low	Low
Fine Sediment in Riffles	Mod	Mod	Mod	Mod	Mod	Mod	Mod
Bank Erosion	Mod	Low	Low	Low	Low	Low	Low

[1] Developed by Dambacher and Jones (1997).
[2] Undercut banks were not taken under this survey protocol.

Using the Dambacher and Jones benchmarks for habitat quality, the North Fork Malheur River has low/moderate quality habitat for bull trout (see Table 17).

Surveyors noted extensive cattle grazing, bank slumping, and grazed hardwoods in Reaches 3 through 5. Main channel habitats in these reaches are critical oversummer habitat for sub-adult bull trout. Since C Channel types have higher sinuosity values, some active erosion is expected. Active erosion due to management practices may decrease the amounts of undercut bank. Undercut banks are critical for rearing bull trout populations (Goetz 1994) as well as adult spawning fish (Graham et al. 1982). Reach 3 has a higher incidence of bank erosion than other North Fork Malheur River reaches with the same channel type. Reach 3 has poor habitat quality in respect to undercut banks. Reach management recommendations include improving grazing management and constructing riparian enclosures and fencing to protect the riparian habitat in areas necessary to enhance bank/channel stability and riparian vegetation.

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Appendix A. Stream Survey Results for the North Fork Malheur River

Table 18. Reach 1 Stream Survey Results for the North Fork Malheur River, 2001.

Length	total			total			
	# Units	total len	main len	avg wid	total area	Lg bould	area %
Dam Pool	0	0	0	0	0	0	0
Cascades - Boulders	2	69	69	5	345	69	0.003595271
Glide	8	298.2	238.2	9.3	2773.26	62	0.028900353
Lateral Pool	13	277.6	277.6	9.5	2637.2	79	0.027482462
Plunge Pool	0	0	0	0	0	0	0
Rapids over Boulders	2	89.6	89.6	9	806.4	197	0.008403556
Riffle	51	4143.4	3404.8	12.8	53035.52	221	0.552687189
Riffle with Pockets	42	3135.5	3101.5	11.2	35117.6	2160	0.365963182
Straight Scour Pool	2	146.4	146.4	8.5	1244.4	45	0.012967987
	120	8159.7	7327.1		95959.38	2833	1
% primary channel		0.897961935					

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0	0	0	0	0	0	0
Cascades - Boulders	28	0	4	52	124	166	373
Glide	170	322	804	1101	87	0	2484
Lateral Pool	199	374	1002	996	105	0	2676
Plunge Pool	0	0	0	0	0	0	0
Rapids over Boulders	0	0	58	266	451	0	775
Riffle	1976	3975	23466	31375	2196	1	62989
Riffle with Pockets	1374	3044	12029	17868	3437	31	37784
Straight Scour Pool	74	148	452	454	44	0	1172
Total	3822	7863	37814	52111	6445	198	108252

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0	0	0	0	0	0	0
Cascades - Boulders	0.074	0.000	0.009	0.139	0.333	0.445	1
Glide	0.069	0.129	0.324	0.443	0.035	0.000	0.999995974
Lateral Pool	0.075	0.140	0.374	0.372	0.039	0.000	0.999981317
Plunge Pool	0.000	0.000	0.000	0.000	0.000	0.000	0
Rapids over Boulders	0.000	0.000	0.075	0.343	0.582	0.000	1
Riffle	0.031	0.063	0.373	0.498	0.035	0.000	0.99999746
Riffle with Pockets	0.036	0.081	0.318	0.473	0.091	0.001	1.000001323
Straight Scour Pool	0.063	0.126	0.385	0.387	0.038	0.000	0.999974394
All Habitat Types	0.035	0.073	0.349	0.481	0.060	0.002	1

Table 19. Reach 1 Habitat Summary for the North Fork Malheur River, 2001.

Habitat Summary		Active Erosion	3.85%
All Pools	17	Wood (medium) Total Count	57
Pools >m deep	4	Wood (medium) / 100 m	0.698555094
Residual pool depth (avg)	0.35	Wood (large) Total Count	34
Boulder Count	2833	Wood (large) / 100 m	0.416681986
Boulder / 100m2	2.952290855	Wood (all) Total Count	140
Wood (small) Total Count	49	Wood (all) / 100 m	1.715749354
Wood (small) / 100 m	0.600512274	Average Slope	1.40%
Shade Left	48	Volume sm wood	0.031995053
Shade Right	45	Volume med wood	0.296267699
Shade Total	93	Volume lg wood	1.178140559
Percent Undercut Banks	1.4	Total Volume wood	1.506403312

Table 20. Reach 2 Stream Survey Results for the North Fork Malheur River, 2001.

Length	total			total			
	# Units	total len	main len	avg wid	total area	Lg bould	area %
Dam Pool	0	0	0	0	0.00	0	0.000
Cascades - Boulders	0	0	0	0	0.00	0	0.000
Glide	15	940.7	739	9.4	8842.58	205	0.106
Lateral Pool	10	232.3	225.3	9.3	2160.39	46	0.026
Plunge Pool	0	0	0	0	0.00	0	0.000
Rapids over Boulders	0	0	0	0	0.00	0	0.000
Riffle	56	3925.8	3512.2	10.9	42791.22	2512	0.511
Riffle with Pockets	35	2453.2	1846.4	11.9	29193.08	2182	0.348
Straight Scour Pool	3	74.2	55.2	11.1	823.62	59	0.010
	119	7626.2	6378.1		83810.89	5004.00	1.00
% primary channel		0.83634051					

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0	0	0	0	0	0	0
Cascades - Boulders	0	0	0	0	0	0	0
Glide	613	932	4990	2835	58	0	9428
Lateral Pool	287	310	2822	958	30	46	4453
Plunge Pool	0	0	0	0	0	0	0
Rapids over Boulders	0	0	0	0	0	0	0
Riffle	1595	3281	17156	20768	3460	0	46260
Riffle with Pockets	1155	2684	12316	13176	2277	0	31608
Straight Scour Pool	87	150	238	338	17	0	830
	3737	7357	37522	38075	5842	46	92579

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cascades - Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Glide	0.065	0.099	0.529	0.301	0.006	0.000	1.000
Lateral Pool	0.064	0.070	0.634	0.215	0.007	0.010	1.000
Plunge Pool	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rapids over Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riffle	0.034	0.071	0.371	0.449	0.075	0.000	1.000
Riffle with Pockets	0.037	0.085	0.390	0.417	0.072	0.000	1.000
Straight Scour Pool	0.105	0.181	0.287	0.407	0.020	0.000	1.000
	0.040	0.079	0.405	0.411	0.063	0.000	1.000

Table 21. Reach 2 Habitat Summary for the North Fork Malheur River, 2001.

Habitat Summary		Active Erosion	4.74%
All Pools	13	Wood (medium) Total Count	81
Pools >m deep	1	Wood (medium) / 100 m	1.062127927
Residual pool depth (avg)	0.51	Wood (large) Total Count	71
Boulder Count	5004	Wood (large) / 100 m	0.931001023
Boulder / 100m2	5.970584491	Wood (all) Total Count	265
Wood (small) Total Count	113	Wood (all) / 100 m	3.474862972
Wood (small) / 100 m	1.481734022	Average Slope	1.40%
Shade Left	52	Volume sm wood	0.078553205
Shade Right	45	Volume med wood	0.450464395
Shade Total	97	Volume lg wood	2.632343376
Percent Undercut Banks	6	Total Volume wood	3.161360975

Table 22. Reach 3 Stream Survey Results for the North Fork Malheur River, 2001.

Reach 3							
Length	total			total			
	# Units	total len	main len	avg wid	total area	Lg bould	area %
Dam Pool	1	40	40	11	440.00	5	0.005
Cascades - Boulders	0	0	0	0	0.00	0	0.000
Glide	3	205	18	4	820.00	64	0.013
Lateral Pool	15	357.6	337.5	6.5	2324.40	37	0.038
Plunge Pool	1	33.3	33.3	11.5	382.95	0	0.006
Rapids over Boulders	0	0	0	0	0.00	0	0.000
Riffle	94	7348.4	5818.3	7.4	54378.16	1192	0.881
Riffle with Pockets	8	533.1	169	6.4	3411.84	40	0.055
Straight Scour Pool	0	0	0	0	0.00	0	0.000
	122	8517.4	6416.1		61757.35	1338.00	1.00
% primary channel		0.753293259					

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	66	66	154	154	0	0	440
Cascades - Boulders	0	0	0	0	0	0	0
Glide	135	90	240	85	0	0	549
Lateral Pool	170	215	1209	769	8	0	2372
Plunge Pool	57	57	191	77	0	0	383
Rapids over Boulders	0	0	0	0	0	0	0
Riffle	2724	3820	22232	29176	237	0	58189
Riffle with Pockets	235	262	1355	765	34	0	2651
Straight Scour Pool	0	0	0	0	0	0	0
	3387	4510	25381	31026	279	0	64583

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.150	0.150	0.350	0.350	0.000	0.000	1.000
Cascades - Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Glide	0.245	0.164	0.436	0.154	0.000	0.000	1.000
Lateral Pool	0.072	0.091	0.510	0.324	0.003	0.000	1.000
Plunge Pool	0.150	0.150	0.500	0.200	0.000	0.000	1.000
Rapids over Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riffle	0.047	0.066	0.382	0.501	0.004	0.000	1.000
Riffle with Pockets	0.089	0.099	0.511	0.289	0.013	0.000	1.000
Straight Scour Pool	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.052	0.070	0.393	0.480	0.004	0.000	1.000

Table 23. Reach 3Habitat Summary for the North Fork Malheur River, 2001.

Habitat Summary		Percent Active Erosion	10.4
All Pools	17	Wood (medium) Total Count	189
Pools >m deep	0	Wood (medium) / 100 m	2.218987015
Residual pool depth (avg)	0.4	Wood (large) Total Count	62
Boulder Count	1338	Wood (large) / 100 m	0.727921666
Boulder / 100m2	2.166543739	Wood (all) Total Count	443
Wood (small) Total Count	192	Wood (all) / 100 m	5.201117712
Wood (small) / 100 m	2.254209031	Average Slope	1.50%
Shade Left	43	Volume sm wood	0.119505485
Shade Right	47	Volume med wood	0.941105696
Shade Total	90	Volume lg wood	2.058150023
Percent Undercut Banks	2.4	Total Volume wood	3.118761204

Table 24. Reach 4 Stream Survey Results for the North Fork Malheur River, 2001.

Reach 4							
Length	total			total			
	# Units	total len	main len	avg wid	total area	Lg bould	area %
Dam Pool	0	0	0	0	0.00		0.000
Cascades - Boulders	0	0	0	0	0.00		0.000
Glide	2	68.5	68.5	8.2	561.70	2	0.013
Lateral Pool	4	126.9	126.9	7.8	989.82	4	0.022
Plunge Pool	1	29	29	4.3	124.70	3	0.003
Rapids over Boulders	0	0	0	0	0.00	0	0.000
Riffle	61	7039	3658	5.6	39418.40	537	0.879
Riffle with Pockets	6	490	490	7.3	3577.00	37	0.080
Straight Scour Pool	1	23.5	23.5	6.5	152.75	0	0.003
	75	7776.9	4395.9		44824.37	583.00	1.00
% primary channel		0.565250935					

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.00	0.00	0.00	0.00	0.00	0.00	0
Cascades - Boulders	0.00	0.00	0.00	0.00	0.00	0.00	0
Glide	77.20	97.98	259.94	114.69	0.00	0.00	550
Lateral Pool	139.39	139.39	414.54	302.98	0.00	0.00	996
Plunge Pool	12.47	7.48	24.94	62.35	0.00	0.00	107
Rapids over Boulders	0.00	0.00	0.00	0.00	0.00	0.00	0
Riffle	1818.96	3591.40	13573.80	17942.00	86.00	0.00	37012
Riffle with Pockets	149.75	326.70	1277.50	1779.00	0.00	0.00	3533
Straight Scour Pool	15.20	15.20	61.10	61.10	0.00	0.00	153
	2213	4178	15612	20262	86	0	42351

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cascades - Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Glide	0.140	0.178	0.473	0.209	0.000	0.000	1.000
Lateral Pool	0.140	0.140	0.416	0.304	0.000	0.000	1.000
Plunge Pool	0.117	0.070	0.233	0.583	0.000	0.000	1.002
Rapids over Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riffle	0.049	0.097	0.367	0.485	0.002	0.000	1.000
Riffle with Pockets	0.042	0.092	0.362	0.504	0.000	0.000	1.000
Straight Scour Pool	0.099	0.099	0.399	0.399	0.000	0.000	0.997
	0.052	0.099	0.369	0.478	0.002	0.000	1.000

Table 25. Reach 4Habitat Summary for the North Fork Malheur River, 2001.

Habitat Summary		Percent Active Erosion	5.00%
All Pools	6	Wood (medium) Total Count	133
Pools >m deep	0	Wood (medium) / 100 m	1.710193007
Residual pool depth (avg)	0.38	Wood (large) Total Count	58
Boulder Count	583	Wood (large) / 100 m	0.745798454
Boulder / 100m2	1.300631777	Wood (all) Total Count	314
Wood (small) Total Count	123	Wood (all) / 100 m	4.037598529
Wood (small) / 100 m	1.581607067	Average Slope	1.80%
Shade Left	44	Volume sm wood	0.083847912
Shade Right	54	Volume med wood	0.725318521
Shade Total	98	Volume lg wood	2.108695451
Percent Undercut Banks	8.5	Total Volume wood	2.917861884

Table 26. Reach 5 Stream Survey Results for the North Fork Malheur River, 2001.

Reach 5							
Length	total			total			
	# Units	total len	main len	avg wid	total area	Lg bould	area %
Dam Pool	1	17.7	17.7	6.5	115.05	5	0.005
Cascades - Boulders	0	0	0	0	0.00	0	0.000
Glide	3	116.1	116.1	8.6	998.46	82	0.043
Lateral Pool	1	30.7	30.7	8.4	257.88	9	0.011
Plunge Pool	0	0	0	0	0.00	0	0.000
Rapids over Boulders	0	0	0	0	0.00	0	0.000
Riffle	37	3325.5	1706.5	5.7	18955.35	514	0.813
Riffle with Pockets	5	360	360	6.4	2304.00	334	0.099
Straight Scour Pool	3	109	109	6.2	675.80	29	0.029
	50	3959	2340		23306.54	973.00	1.00
% primary channel		0.591058348					

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	34.51	46.02	23.01	11.50	0.00	0.00	115
Cascades - Boulders	0.00	0.00	0.00	0.00	0.00	0.00	0
Glide	71.49	130.31	414.30	355.83	0.00	0.00	972
Lateral Pool	0.00	12.89	64.47	180.51	0.00	0.00	258
Plunge Pool	0.00	0.00	0.00	0.00	0.00	0.00	0
Rapids over Boulders	0.00	0.00	0.00	0.00	0.00	0.00	0
Riffle	998.07	1964.31	5906.99	8495.18	100.00	0.00	17465
Riffle with Pockets	56.70	151.40	537.30	1526.60	0.00	0.00	2272
Straight Scour Pool	38.46	95.28	184.00	274.86	0.00	0.00	593
	1199	2400	7130	10844	100	0	21674

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.300	0.400	0.200	0.100	0.000	0.000	1.000
Cascades - Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Glide	0.074	0.134	0.426	0.366	0.000	0.000	1.000
Lateral Pool	0.000	0.050	0.250	0.700	0.000	0.000	1.000
Plunge Pool	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rapids over Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riffle	0.057	0.112	0.338	0.486	0.006	0.000	1.000
Riffle with Pockets	0.025	0.067	0.236	0.672	0.000	0.000	1.000
Straight Scour Pool	0.065	0.161	0.310	0.464	0.000	0.000	0.999
	0.055	0.111	0.329	0.500	0.005	0.000	1.000

Table 27. Reach 5 Habitat Summary for the North Fork Malheur River, 2001.

Habitat Summary		Percent Active Erosion	6.67%
All Pools	5	Wood (medium) Total Count	74
Pools >m deep	0	Wood (medium) / 100 m	1.869158879
Residual pool depth (avg)	0.32	Wood (large) Total Count	49
Boulder Count	973	Wood (large) / 100 m	1.237686284
Boulder / 100m2	4.174793856	Wood (all) Total Count	195
Wood (small) Total Count	72	Wood (all) / 100 m	4.925486234
Wood (small) / 100 m	1.818641071	Average Slope	1.50%
Shade Left	48	Volume sm wood	0.096414122
Shade Right	47	Volume med wood	0.792738333
Shade Total	95	Volume lg wood	3.499475524
Percent Undercut Banks	9.8	Total Volume wood	4.388627979

Table 28. Reach 6 Stream Survey Results for the North Fork Malheur River, 2001.

Reach 6							
Length	total			total			
	# Units	total len	main len	avg wid	total area	Lg bould	area %
Dam Pool	0	0	0	0	0.00	0	0.000
Cascades - Boulders	0	0	0	0	0.00	0	0.000
Glide	4	202.4	202.4	5.9	1194.16	106	0.048
Lateral Pool	1	32	32	4	128.00	0	0.005
Plunge Pool	1	10	10	5	50.00	20	0.002
Rapids over Boulders	0	0	0	0	0.00	0	0.000
Riffle	26	2138.7	1694	5.9	12618.33	334	0.509
Riffle with Pockets	17	1304	1304	8.3	10823.20	414	0.436
Straight Scour Pool	0	0	0	0	0.00	0	0.000
	49	3687.1	3242.4		24813.69	874.00	1.00
% primary channel		0.879390307					

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.00	0.00	0.00	0.00	0.00	0.00	0
Cascades - Boulders	0.00	0.00	0.00	0.00	0.00	0.00	0
Glide	62.99	216.05	652.83	240.41	0.00	0.00	1172
Lateral Pool	19.20	25.60	44.80	38.40	0.00	0.00	128
Plunge Pool	2.50	2.50	22.50	22.50	0.00	0.00	50
Rapids over Boulders	0.00	0.00	0.00	0.00	0.00	0.00	0
Riffle	171.55	1855.60	6420.81	6324.26	0.00	0.00	14772
Riffle with Pockets	361.86	1042.91	3682.90	5203.05	223.75	0.00	10514
Straight Scour Pool	0.00	0.00	0.00	0.00	0.00	0.00	0
	618	3143	10824	11829	224	0	26637

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cascades - Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Glide	0.054	0.184	0.557	0.205	0.000	0.000	1.000
Lateral Pool	0.150	0.200	0.350	0.300	0.000	0.000	1.000
Plunge Pool	0.050	0.050	0.450	0.450	0.000	0.000	1.000
Rapids over Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riffle	0.012	0.126	0.435	0.428	0.000	0.000	1.000
Riffle with Pockets	0.034	0.099	0.350	0.495	0.021	0.000	1.000
Straight Scour Pool	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.023	0.118	0.406	0.444	0.008	0.000	1.000

Table 29. Reach 6Habitat Summary for the North Fork Malheur River, 2001.

Habitat Summary		Percent Active Erosion	6.31%
All Pools	2	Wood (medium) Total Count	152
Pools >m deep	0	Wood (medium) / 100 m	4.122481083
Residual pool depth (avg)	0.3	Wood (large) Total Count	91
Boulder Count	874	Wood (large) / 100 m	2.468064332
Boulder / 100m2	3.52224921	Wood (all) Total Count	336
Wood (small) Total Count	123	Wood (all) / 100 m	9.11285292
Wood (small) / 100 m	3.335955087	Average Slope	1.80%
Shade Left	51	Volume sm wood	0.133718559
Shade Right	52	Volume med wood	1.748406098
Shade Total	103	Volume lg wood	6.978287497
Percent of Undercut banks	14.6	Total Volume wood	8.860412154

Table 30. Reach 7 Stream Survey Results for the North Fork Malheur River, 2001.

Reach 7							
Length	total			total			
	# Units	total len	main len	avg wid	total area	Lg bould	area %
Dam Pool	0	0	0	0	0.00	0	0.000
Cascades - Boulders	0	0	0	0	0.00	0	0.000
Glide	0	0	0	0	0.00	0	0.000
Lateral Pool	3	51	51	3.1	158.10	4	0.008
Plunge Pool	2	59	59	3.6	212.40	4	0.011
Rapids over Boulders	0	0	0	0	0.00	0	0.000
Riffle	23	1617	1382	4.8	7761.60	129	0.392
Riffle with Pockets	32	2962	2902	3.9	11551.80	253	0.584
Straight Scour Pool	1	25	25	4.3	107.50	1	0.005
	61	4714	4419		19791.40	391.00	1.00
% primary channel		0.93742045					

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.00	0.00	0.00	0.00	0.00	0.00	0
Cascades - Boulders	0.00	0.00	0.00	0.00	0.00	0.00	0
Glide	0.00	0.00	0.00	0.00	0.00	0.00	0
Lateral Pool	4.06	41.56	97.34	52.24	0.00	0.00	195
Plunge Pool	26.99	26.99	106.95	58.98	0.00	0.00	220
Rapids over Boulders	0.00	0.00	0.00	0.00	0.00	0.00	0
Riffle	309.30	662.30	3362.10	3677.80	0.00	0.00	8012
Riffle with Pockets	348.21	876.29	5075.10	5201.85	65.50	0.00	11567
Straight Scour Pool	16.13	16.13	53.75	21.50	0.00	0.00	108
	705	1623	8695	9012	66	0	20101

Substrate	s/o	sand	gravel	cbl	bldr	bdrk	Total
Dam Pool	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cascades - Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Glide	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lateral Pool	0.021	0.213	0.499	0.268	0.000	0.000	1.001
Plunge Pool	0.123	0.123	0.486	0.268	0.000	0.000	1.000
Rapids over Boulders	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Riffle	0.039	0.083	0.420	0.459	0.000	0.000	1.000
Riffle with Pockets	0.030	0.076	0.439	0.450	0.006	0.000	1.000
Straight Scour Pool	0.149	0.149	0.498	0.199	0.000	0.000	0.995
	0.035	0.081	0.433	0.448	0.003	0.000	1.000

Table 31. Reach 7Habitat Summary for the North Fork Malheur River, 2001.

Habitat Summary		Percent Active Erosion	8.25%
All Pools	6	Wood (medium) Total Count	84
Pools >m deep	0	Wood (medium) / 100 m	1.781926177
Residual pool depth (avg)	0.43	Wood (large) Total Count	33
Boulder Count	391	Wood (large) / 100 m	0.700042427
Boulder / 100m2	1.975605566	Wood (all) Total Count	287
Wood (small) Total Count	170	Wood (all) / 100 m	6.088247773
Wood (small) / 100 m	3.606279168	Average Slope	1.90%
Shade Left	60	Volume sm wood	0.191184638
Shade Right	60	Volume med wood	0.755741635
Shade Total	120	Volume lg wood	1.979323331
Percent Undercut Banks	23	Total Volume wood	2.926249603

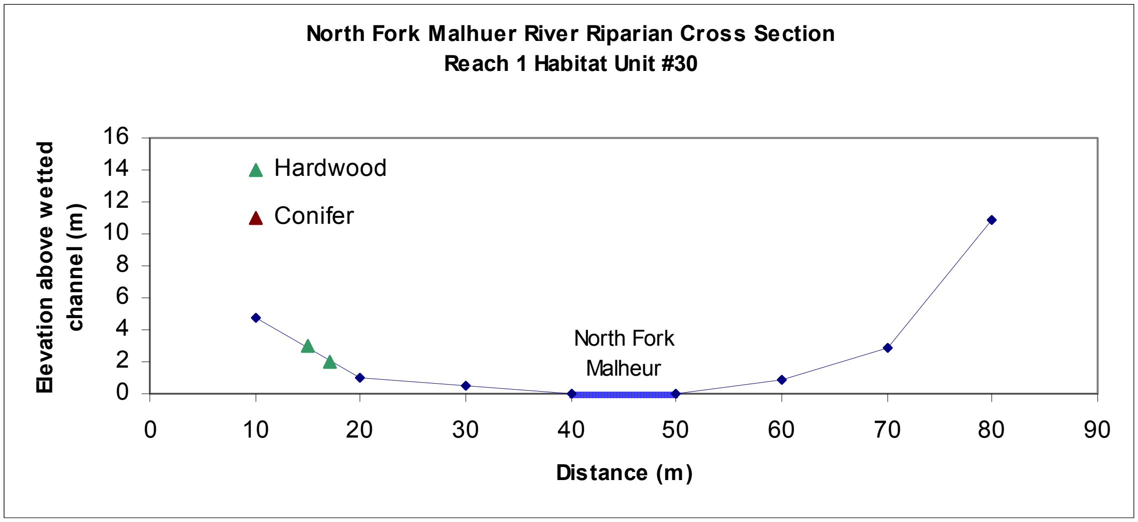

Figure 18. North Fork Malheur River Riparian Cross Section, Reach 1 Habitat Unit #30.

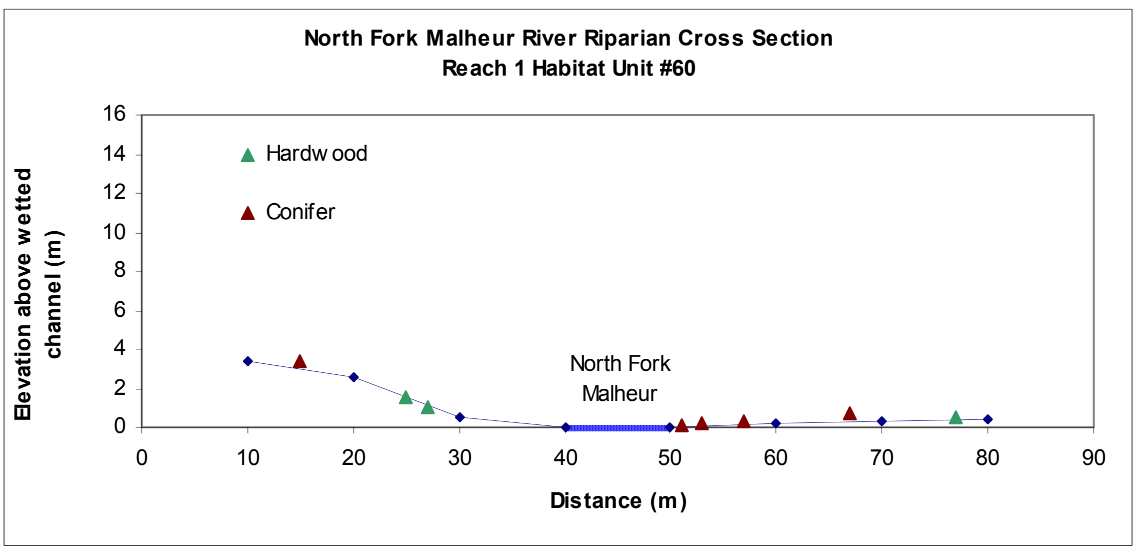

Figure 19. North Fork Malheur River Riparian Cross Section, Reach 1 Habitat Unit #60.

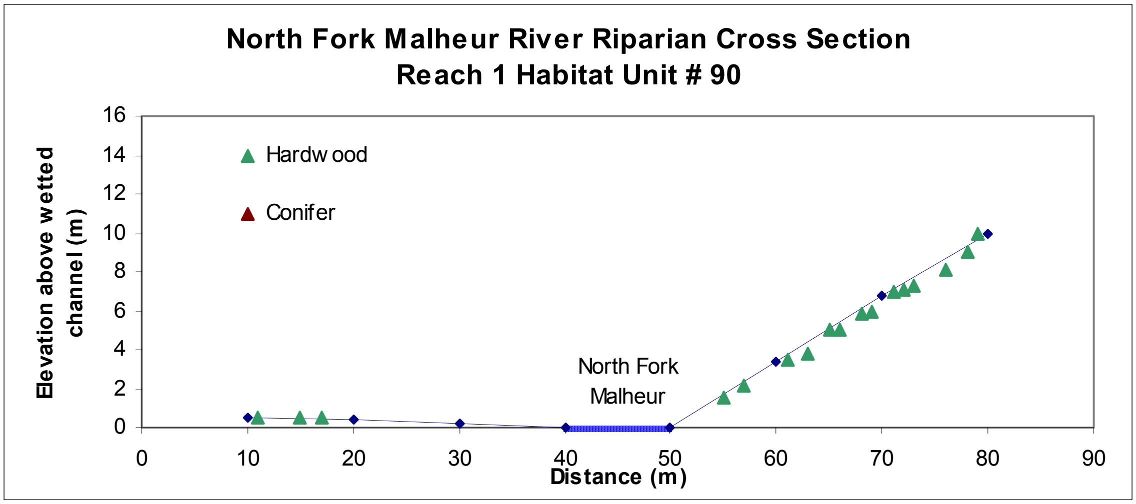

Figure 20. North Fork Malheur River Riparian Cross Section, Reach 1 Habitat Unit #90.

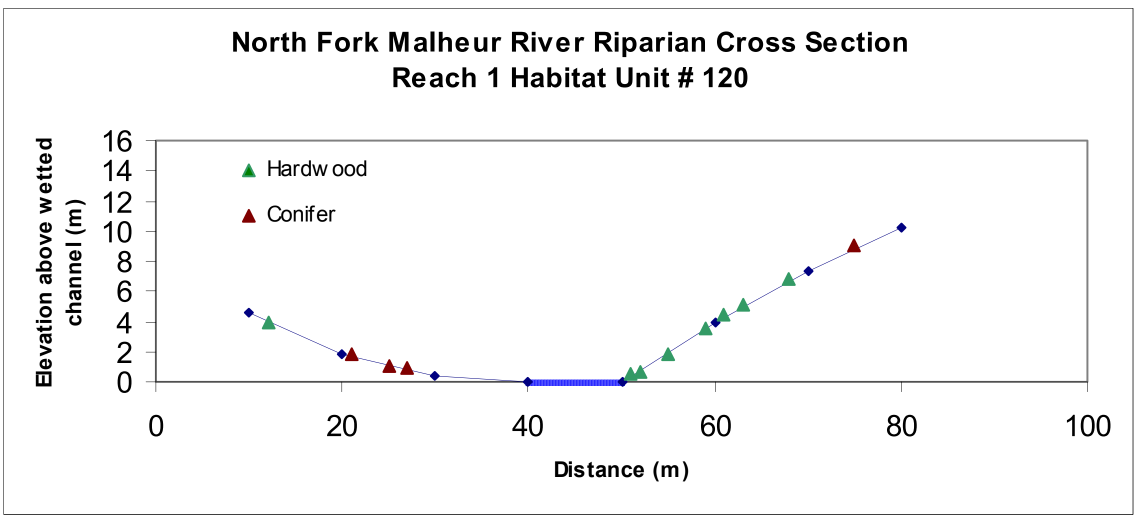

Figure 21. North Fork Malheur River Riparian Cross Section, Reach 1 Habitat Unit #120.

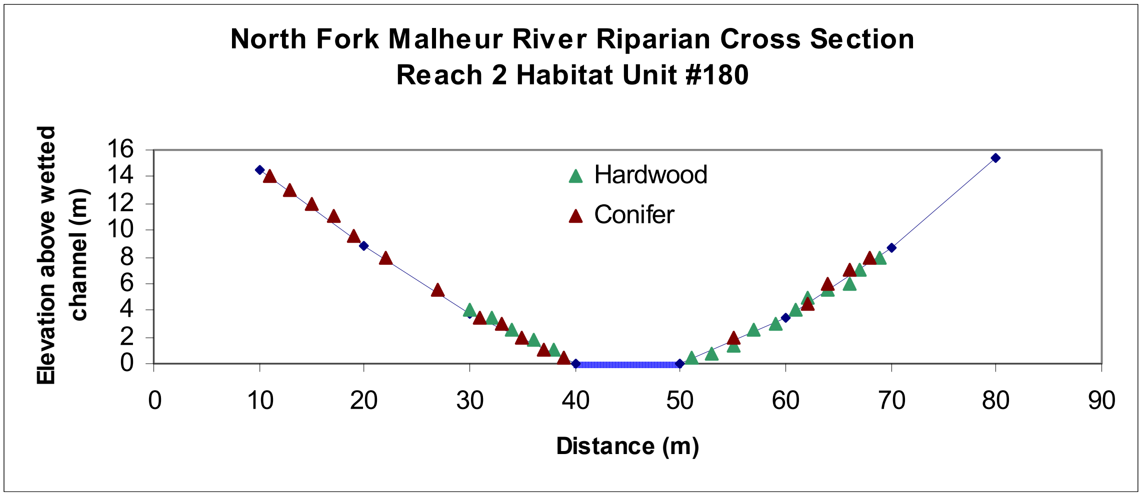

Figure 22. North Fork Malheur River Riparian Cross Section, Reach 2 Habitat Unit #180.

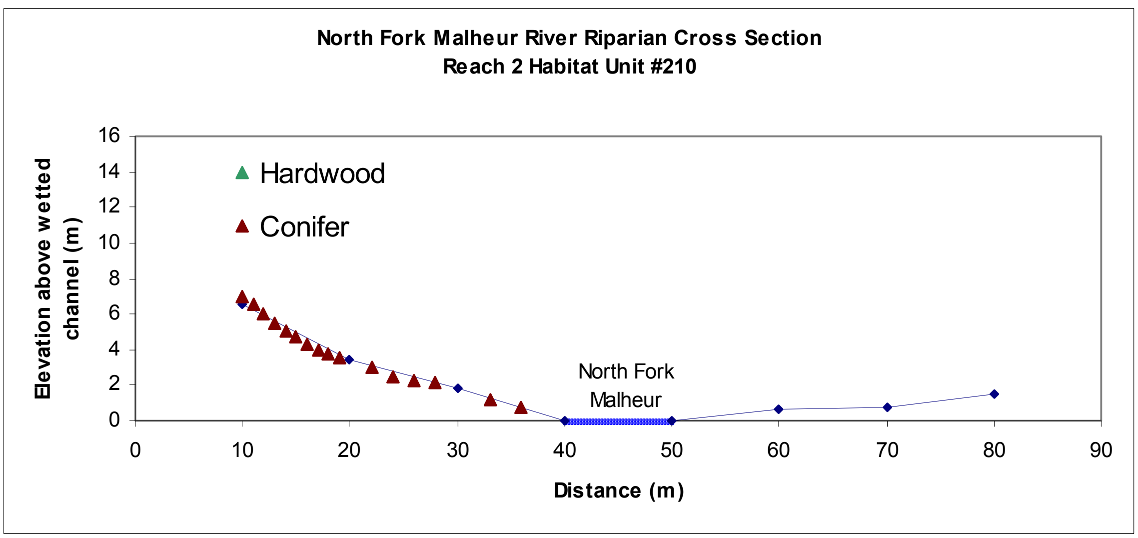

Figure 23. North Fork Malheur River Riparian Cross Section, Reach 2 Habitat Unit #210.

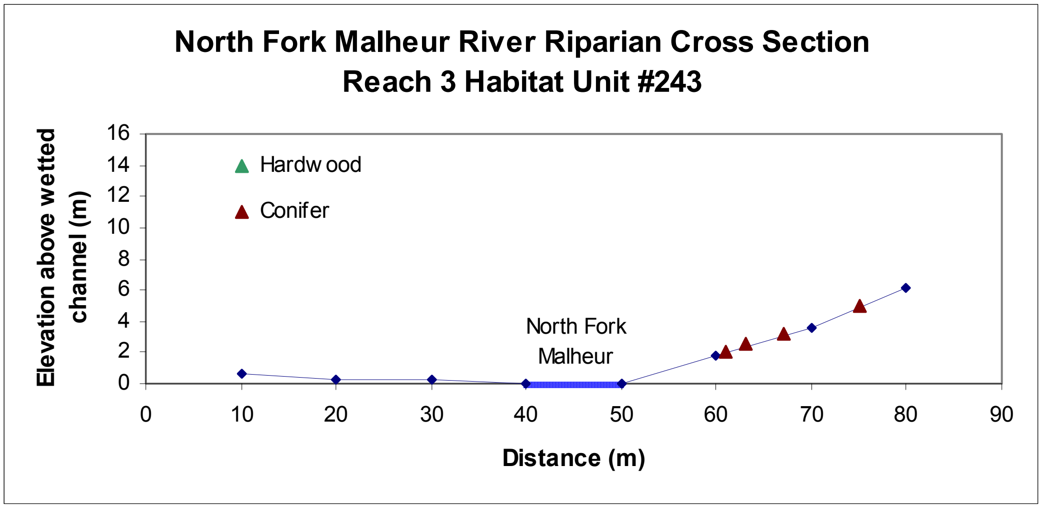

Figure 24. North Fork Malheur River Riparian Cross Section, Reach 3 Habitat Unit #243.

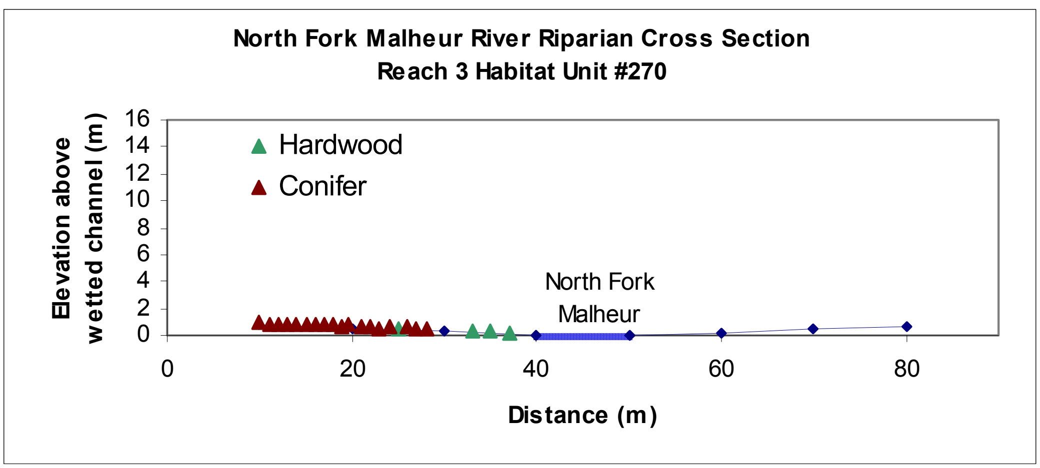

Figure 25. North Fork Malheur River Riparian Cross Section, Reach 3 Habitat Unit #270.

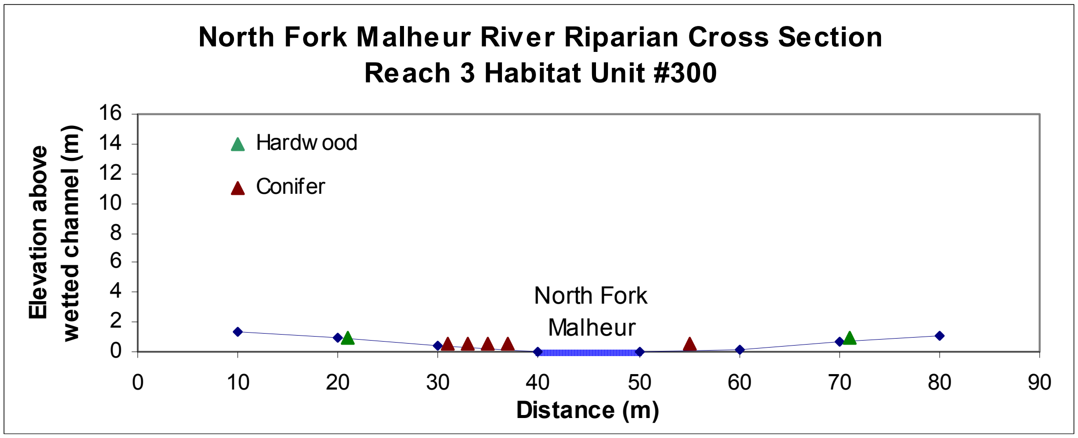

Figure 26. North Fork Malheur River Riparian Cross Section, Reach 3 Habitat Unit #300.

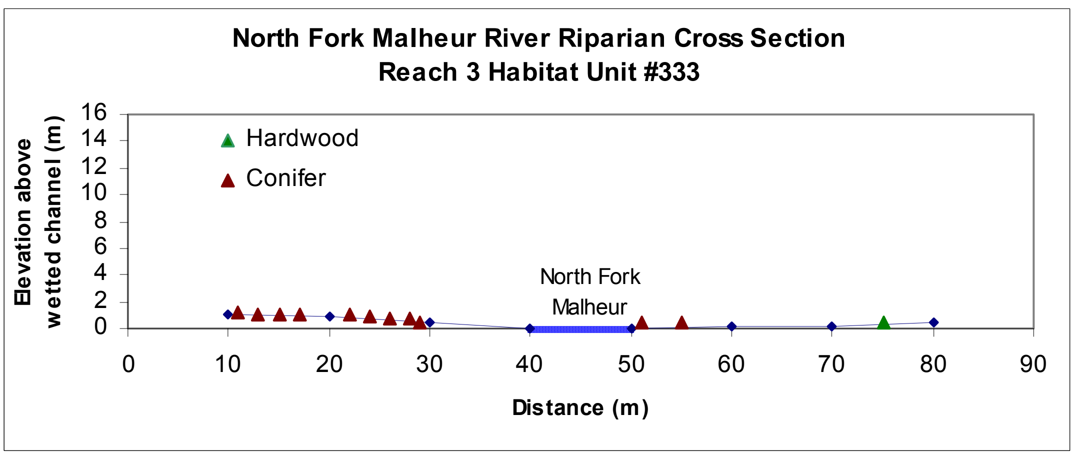

Figure 27. North Fork Malheur River Riparian Cross Section, Reach 3 Habitat Unit #333.

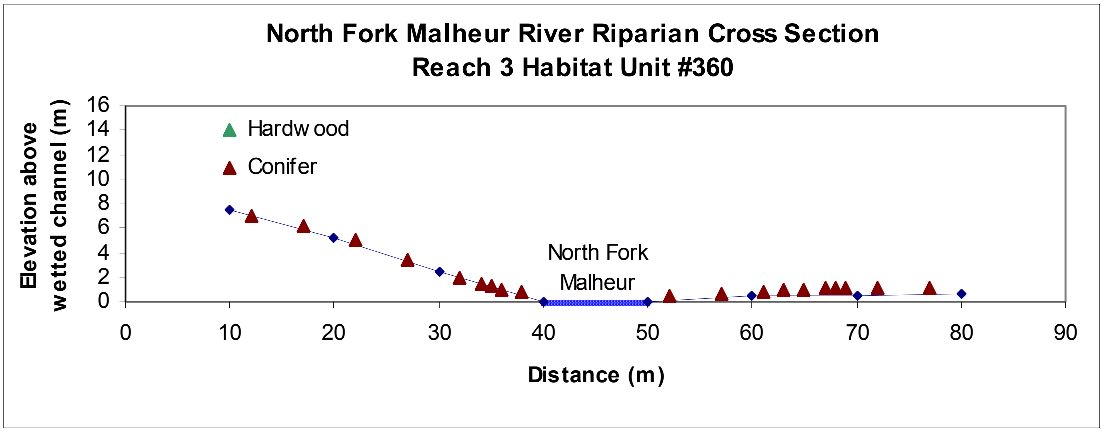

Figure 28. North Fork Malheur River Riparian Cross Section, Reach 3 Habitat Unit #360.

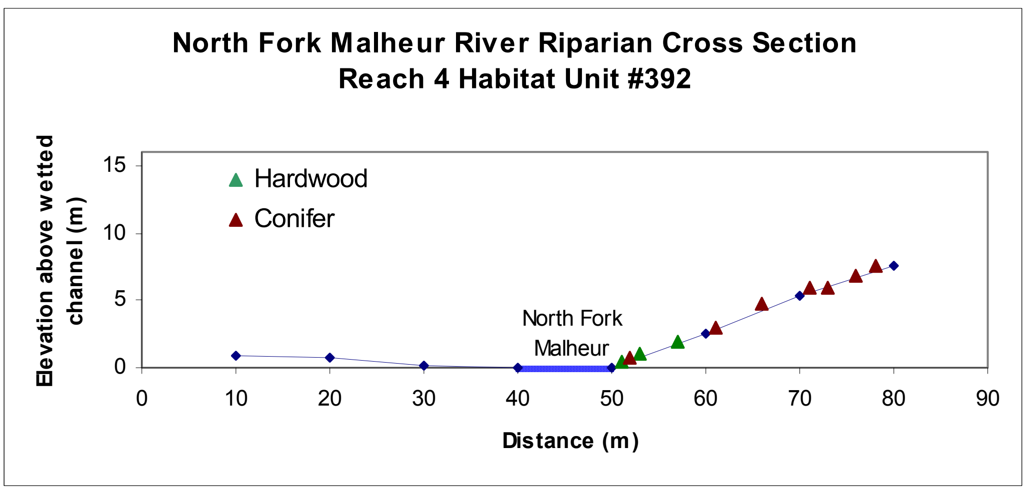

Figure 29. North Fork Malheur River Riparian Cross Section, Reach 4 Habitat Unit #392.

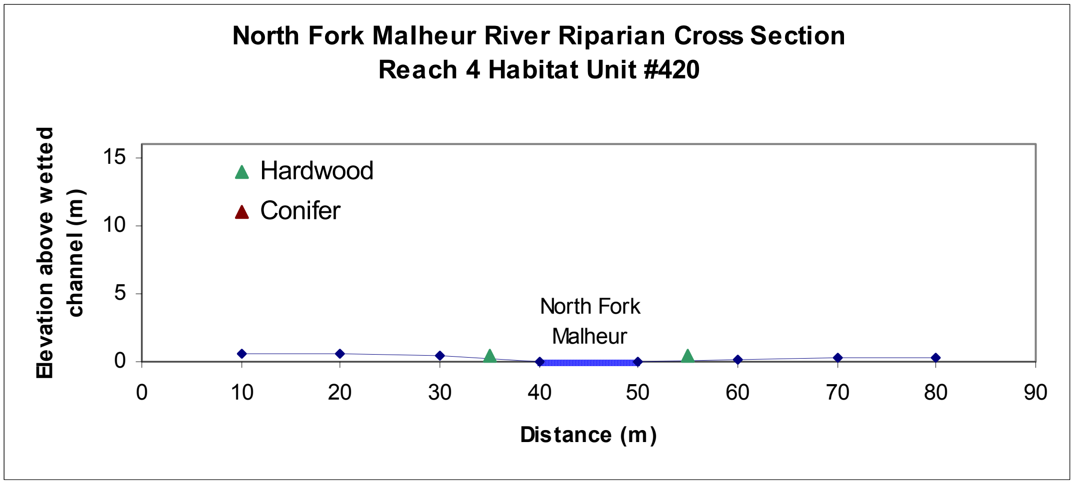

Figure 30. North Fork Malheur River Riparian Cross Section, Reach 4 Habitat Unit #420.

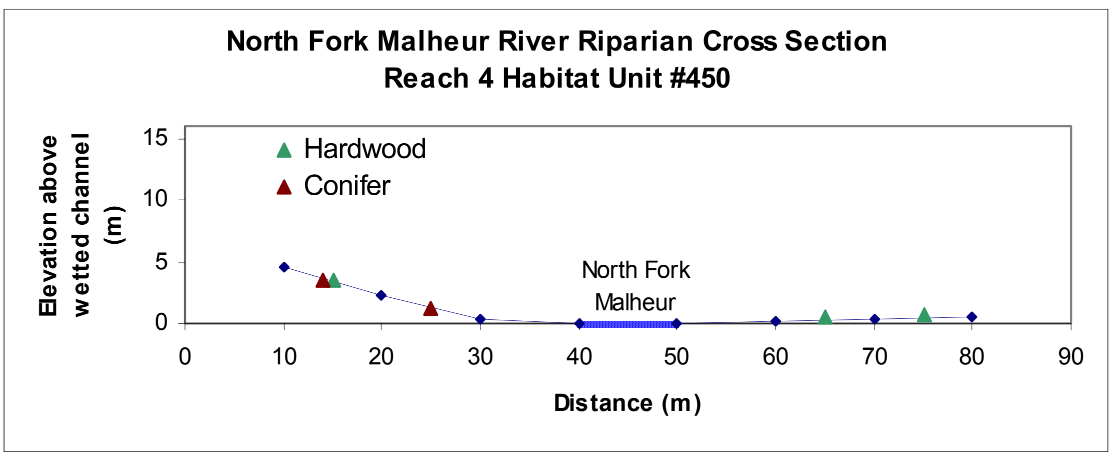

Figure 31. North Fork Malheur River Riparian Cross Section, Reach 4 Habitat Unit #450.

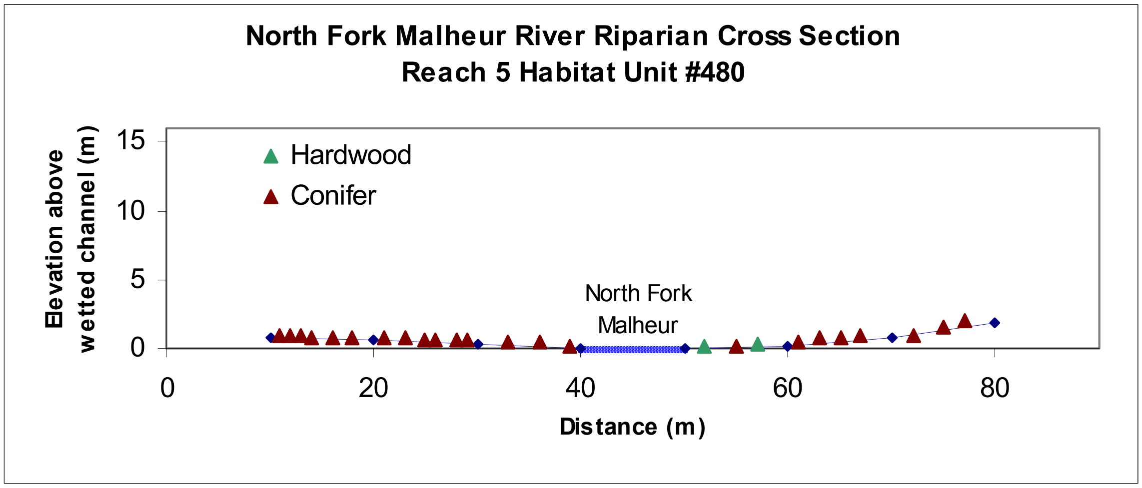

Figure 32. North Fork Malheur River Riparian Cross Section, Reach 5 Habitat Unit #480.

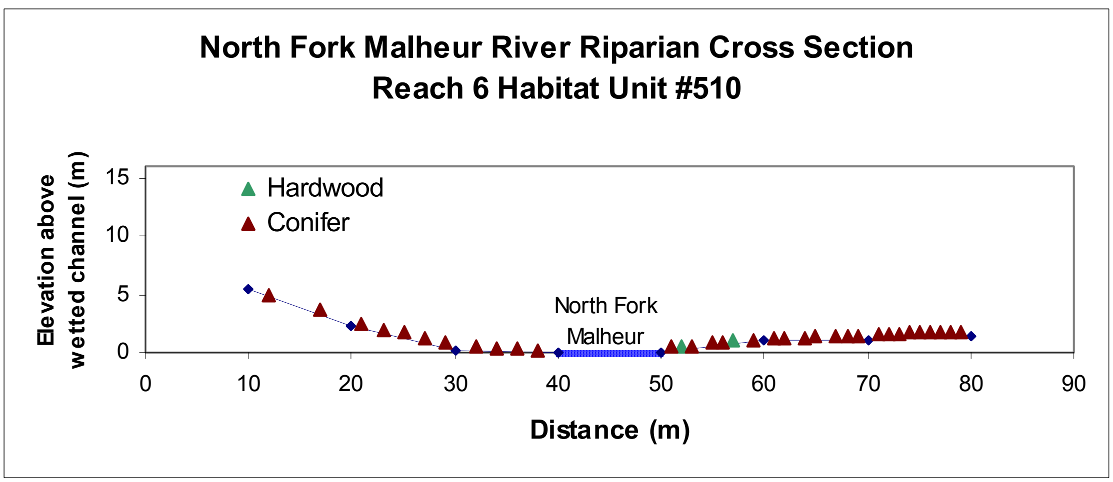

Figure 33. North Fork Malheur River Riparian Cross Section, Reach 6 Habitat Unit #510.

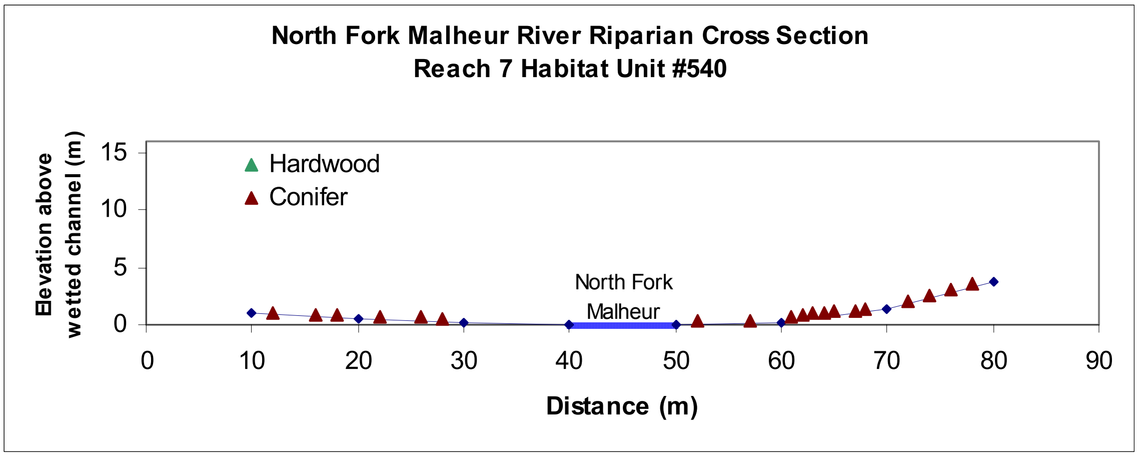

Figure 34. North Fork Malheur River Riparian Cross Section, Reach 7 Habitat Unit #540.

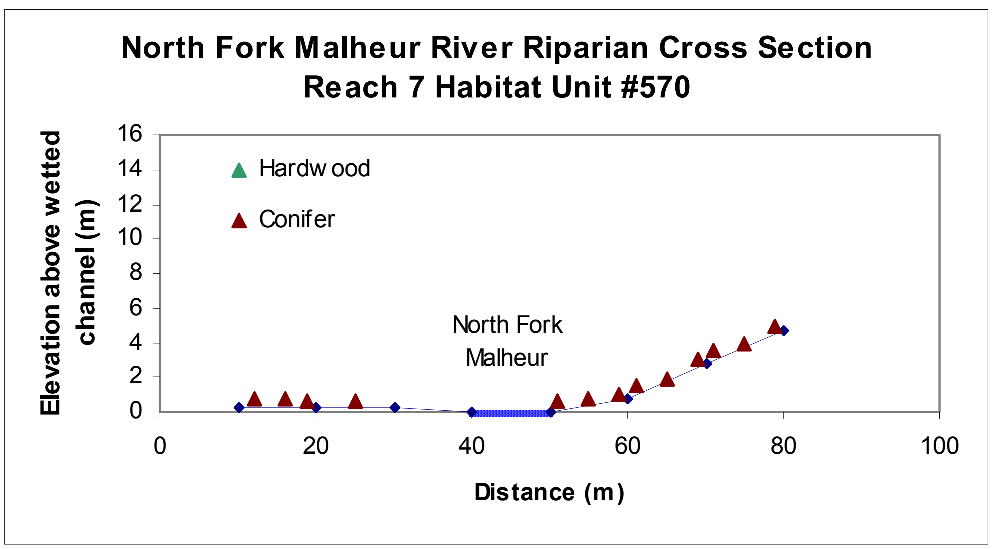

Figure 35. North Fork Malheur River Riparian Cross Section, Reach 7 Habitat Unit #570.

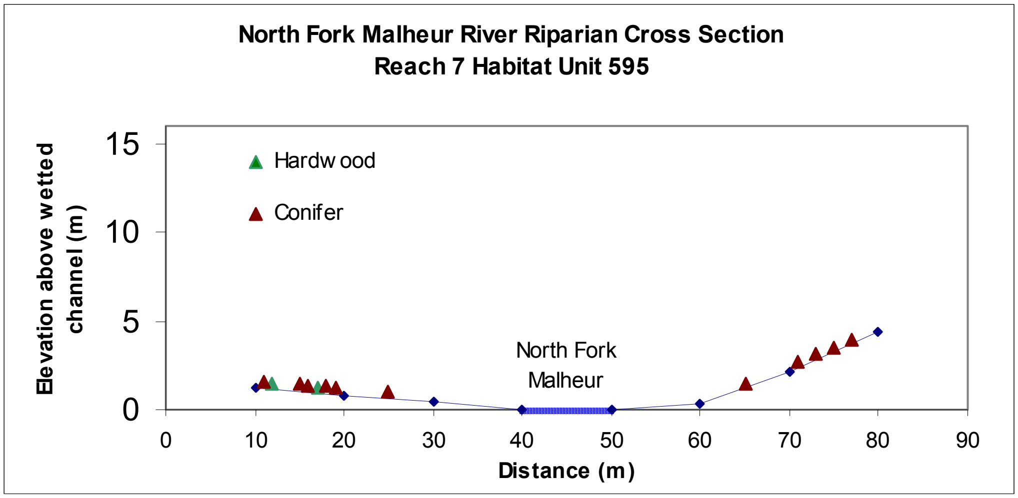

Figure 36. North Fork Malheur River Riparian Cross Section, Reach 7 Habitat Unit #595.

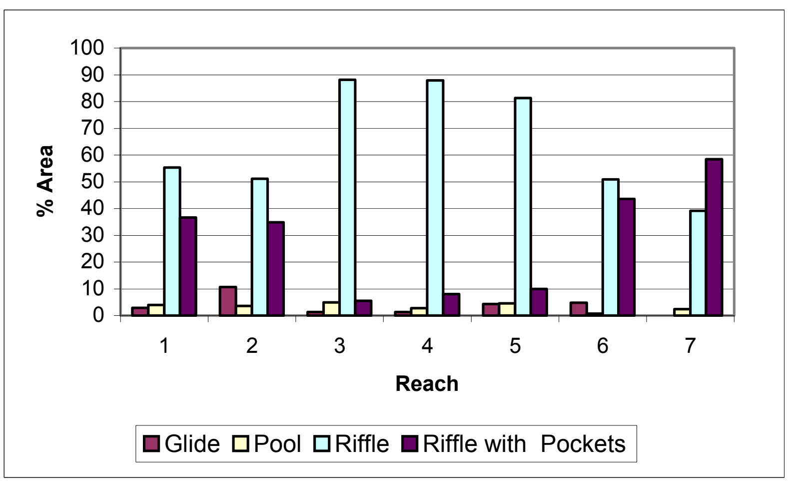

Figure 37. Stream habitat types (percent area) in the seven North Fork Malheur River reaches.

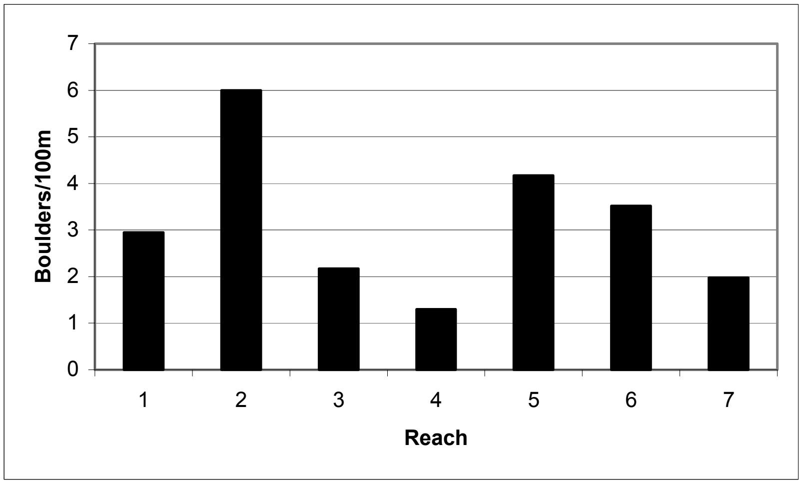

Figure 38. Number of boulders per 100 meters in the North Fork Malheur River seven reaches.

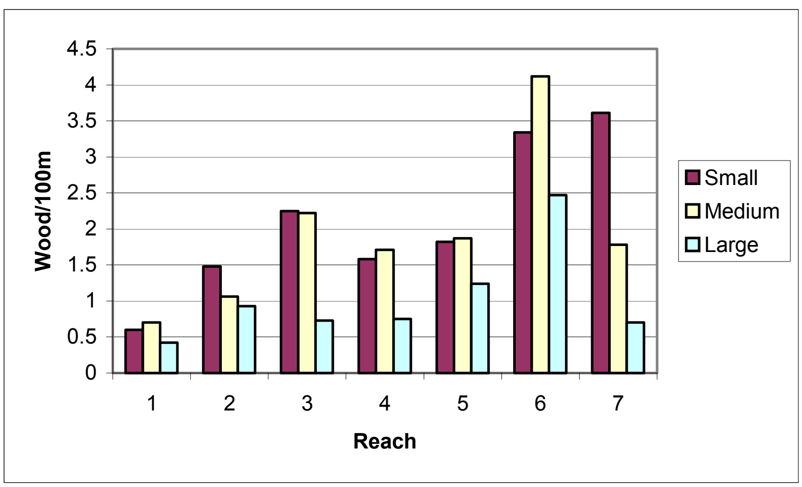

Figure 39. Number of LWD per 100 meters in the North Fork Malheur River seven reaches.

ENTRAINMENT OF BULL TROUT AT AGENCY VALLEY DAM, 2002

By Jason Fenton, Burns Paiute Tribe

Introduction

Bull trout are listed as a threatened species due to past land management activities, which include the construction of dams and fish eradication projects by poisoning (Bowers et al. 1993). The Bureau of Reclamation (USBR), Oregon Department of Fish and Wildlife (ODFW), and the Burns Paiute Tribe (BPT) have determined that bull trout entrainment occurs over the Agency Valley Dam spillway (Schwabe 2000).

In 1998 and 1999, a migration study on bull trout was conducted. In both years, radio-tagged bull trout were observed in Beulah Reservoir and the North Fork Malheur River from mid-April to late May (Schwabe 2000). The Vale Irrigation District began releasing water from the reservoir in mid-March for flood control. During this release, there was a risk of bull trout entrainment through Agency Valley Dam. Bull trout were still being observed in the reservoir from mid-March through June. In previous research, bull trout have been documented leaving the reservoir during these periods of irrigation withdrawals and returning from spawning/ migration activities before the end of the water releases.

Currently, there are no fish passage facilities at Agency Valley Dam for upstream migrating or entrained fish. During 1998 and 1999, water was released over the spillway. This resulted in the entrainment of radio-tagged bull trout from the reservoir. Changes in the 2000 irrigation season resulted in the release of water through the flow valves rather than over the spillway in an effort to reduce the number of entrained bull trout. The Burns Paiute Tribe and partners developed these study objectives:

- Identify bull trout entrainment in response to water management activities.
- Determine if the release of water from the flow valves will reduce the rate of entrainment of radio-tagged fish in comparison to traditional water management practices.

This report consists of cumulative data since the water release practices have changed.

Methods

Creel surveys for all survey years were conducted three times a week in the spring from mid-March to mid-July and in the fall from August to October. All anglers within 1/4-mile below the dam were surveyed. The surveys consisted of recording catch per effort (number of fish per hour) for the total hours fished per angler. BPT employees angled while they surveyed other fishermen. Any bull trout that were angled by employees were placed in a bucket with an aerator and transported above the dam to be released in the reservoir.

Results

In the spring of 2002, 73 rainbow trout *Oncorhynchus mykiss* and no bull trout were angled below Beulah Reservoir (see Table 32). Other species angled below the reservoir include: Sucker *Catostomus spp*., Chiselmouth Chub *Acrocheilus alutaceus*, Northern Pike Minnow *Ptychocheilus oregonensis,* White Crappie *Pomoxis annularis*, and Mountain Whitefish *Prosopium williamsoni*.

In the fall of 2002, no bull trout were angled below the reservoir. Rainbow trout catch decreased to 36.

Table 32. Catch Rate and Fish Types below Beulah Reservoir between 1999 through 2002.

	Fish Angled in Spring			**Fish Angled in Fall**	
	Bull Trout	**Rainbow Trout**		**Bull Trout**	**Rainbow Trout**
1999	20	150		na[1]	na[1]
2000	5	107		0	4
2001	0	13		0	34
2002	0	73		0	36
	Spring Catch Rate (catch per hour)			**Fall Catch Rate (catch per hour)**	
	Bull Trout	**Rainbow Trout**		**Bull Trout**	**Rainbow Trout**
1999	0.05	0.34		na[1]	na[1]
2000	0.01	0.21		0.00	0.02
2001	0.00	0.08		0.00	0.59
2002	0.00	0.44		0.00	0.43

[1] No creel in fall of 1999.

Discussion

In 2000, 2001, and 2002, water was released from the reservoir through the flow valves at the bottom of the dam. In the fall of 2001, BPT employees observed unknown species of fish exiting the flow valves below the dam. Because the reservoir was lowered to near 2000 acre-feet, it is assumed fish became concentrated near the upper opening of the tubes; here, they had a greater chance to become entrained than they did in 2000. As a result, the rainbow trout catch rate in the fall of 2001 increased. The spring 2002 catch had greater rainbow trout numbers than the previous years; this may indicate an increased entrainment in the fall of 2001.

In 2002, the reservoir was drawn down to running river only. The catch rate for the fall of 2002 was not as high as the fall of 2001 and could have been due to poor water quality conditions. No bull trout were observed to be angled in the spring or the fall of 2002. Previous studies

(Schwabe 2000) suggest that adult bull trout migrate into Beulah Reservoir in November and December. Since water releases cease in mid-October, adult bull trout may not be present during late summer and early fall releases. This may explain why no bull trout were observed below the dam in 2002.

It is unknown if juvenile bull trout reside in the reservoir year-round. Since angling is size-selective, small bull trout that were entrained most likely would not be caught with hook and line. The BPT and partners are currently conducting a study of juvenile bull trout to help managers determine the best water management practices for the survival of bull trout. Creel surveys will be conducted in the spring of 2003 to continue monitoring salmonid catches below Agency Valley Dam.

References

Bowers, W., P. Dupee, M. Hanson, and R. Perkins. 1993. Bull trout population summary, Malheur River basin. Unpublished Data. Oregon Department of Fish and Wildlife. Hines, Oregon.

Schwabe, L.T. 2000. Use of radio telemetry to document movements of bull trout in the Malheur basin in Oregon. In: Malheur River basin cooperative bull trout/redband trout research project. FY 1999 Annual Report (Unpublished). Burns Paiute Tribe. Burns, Oregon.

STREAM TEMPERATURE MONITORING ON STREAMS FLOWING THROUGH THE LOGAN VALLEY WILDLIFE MITIGATION PROPERTY, 2002.

By Lawrence T. Schwabe, Burns Paiute Tribe

Introduction

The Burns Paiute Tribe (BPT), U.S. Forest Service (USFS), Bureau of Land Management (BLM), and Oregon Department of Fish and Wildlife (ODFW) have coordinated efforts to maintain stream temperature sites in the Upper Malheur River. The information collected provides land and fish management agencies stream temperature trend data.

The BPT acquired the Logan Valley Oxbow Ranch in April 2000. The land purchase, funded by the Bonneville Power Administration, is intended to benefit fish and wildlife resources. One of the primary goals stated in the Logan Valley Wildlife Mitigation Plan is to restore stream channel morphology and natural function (Wenick 2000).

The lower reaches of Big and Lake Creeks flow through the deeded land. These drainages support a population of threatened bull trout *Salvelinus confluentus*. The current status of this population of bull trout is at a "high risk of extinction" (Buchanan et al. 1997). Thermal barriers on many Logan Valley tributaries may limit bull trout production in the Upper Malheur River watershed (Bowers et al. 1993).

Changes in the composition, vigor, and density of riparian vegetation produce corresponding changes in water temperature (Rosgen 1996). The Logan Valley Management Plan will encourage the restoration of both native riparian vegetation and stream channel morphology. The area will be managed for fish and wildlife populations native to the area.

In 2000, stream temperature sites on the property were installed to monitor stream temperature trends associated with the management of Logan Valley. The current and future management of Logan Valley should reduce the seasonal, maximum stream temperatures and the daily low and high stream temperatures.

Methods

The BPT, ODFW, BLM, and USFS have coordinated the effort to strategically place thermographs throughout the Malheur River subbasin. Five temperature sites on the Logan Valley property have been monitored since 2000 (see Table 33 and Figure 40).

Continuous data recorders are commonly used to gather water temperature data. StowAway and hobo XT data loggers, manufactured by Onset Computer, were used at stream temperature monitoring sites. Loggers were calibrated for accuracy using methods recommended by Oregon's Water Quality Monitoring Guide Book (Oregon Plan for Salmon and Watersheds 1999).

Temperature data were analyzed using rolling daily maximum temperatures averaged over a seven day period (Maximum Weekly Average Temperature; MWAT).

Table 33. Five stream temperature sites that have been maintained since 2000.

Site Number	Location
1	Lake Creek below McCoy Creek
2	Lake Creek below Crooked Creek
3	Malheur River below Lake and Big Creek
4	Big Creek approximately one mile below the 16 road
5	Big Creek below the 16 road

Results

2002 Stream Temperature Data

In 2002, four stream temperature sites were activated with a 100 percent success rate of data retrieval. Data from sites 1 and 2 were collected by the Agricultural Research Service in Burns, Oregon. Data were compiled using Microsoft Excel. Table 34 displays the maximum temperature characteristics for the sites.

Table 34. BPT Stream Temperature Probe Sites in the Upper Malheur River Subbasin, 2002.

Site	Maximum Temperature (°C)	Date Maximum Temperature Occurred	MWAT (°C)	Week MWAT Occurred
Site 1 - Upper Lake Creek	28.72	7/11/02	26.91	7/9/02 to 7/15/02
Site 2 - Lower Lake Creek	27.96	7/11/02	26.45	7/9/02 to 7/15/02
Site 3 - Malheur River Site	23.98	7/11/02	20.36	7/9/02 to 7/15/02
Site 4 - Lower Big Creek	25.58	7/11/02	24.01	7/9/02 to 7/15/02
Site 5 - Upper Big Creek	na	na	na	na

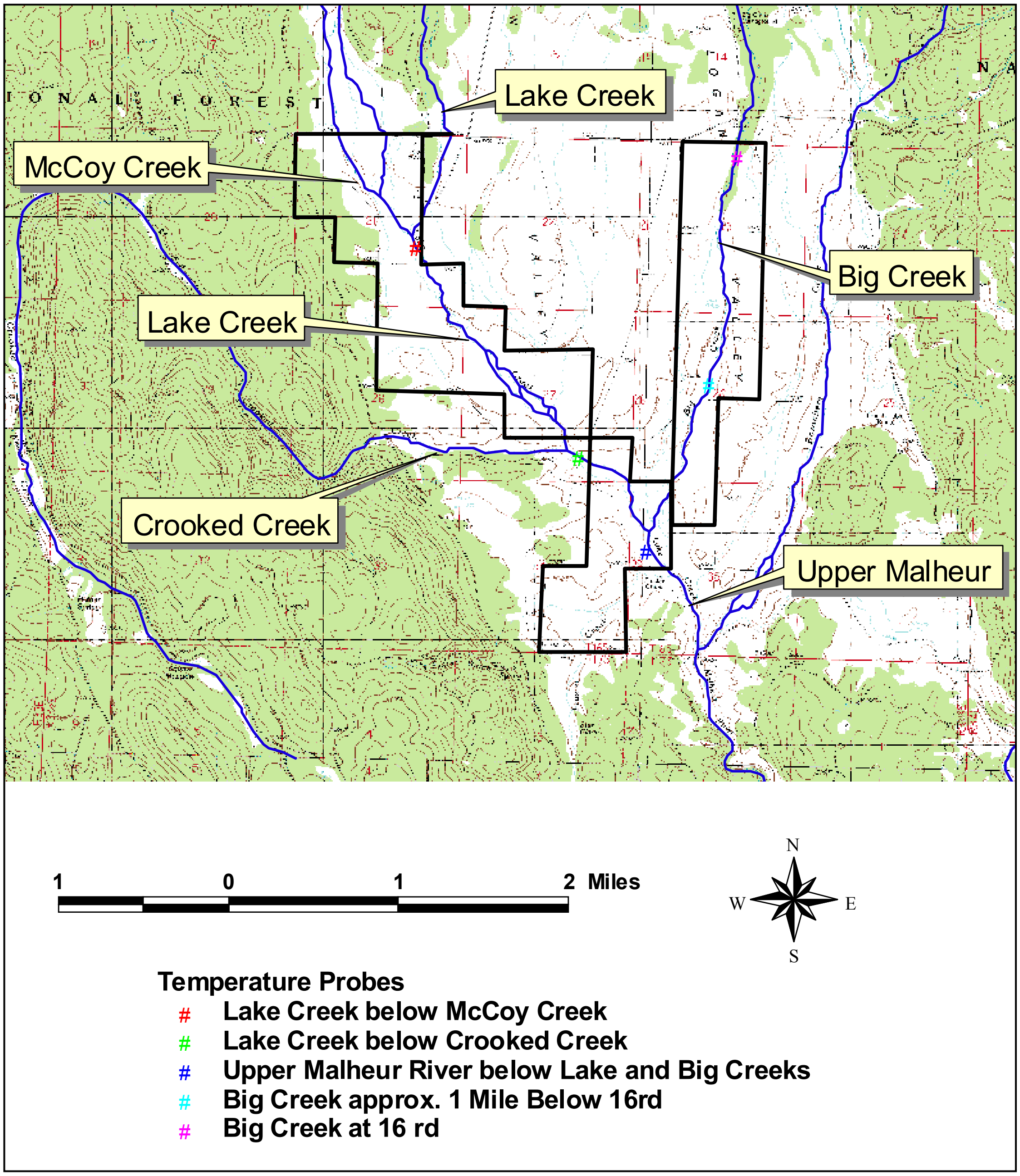

Figure 40. Locations of temperature probes in Logan Valley.

From the data collected from the stream temperature monitoring sites, maximum stream temperatures were recorded on July 11, 2002, at all sites. The MWAT include maximum temperatures from July 9 to July 15, 2002. The dates for MWAT are consistent at all sites. Appendix A contains all 2002 stream temperature data.

Discussion

With the data available, it is difficult to determine changes in temperature trends that can be attributed to changes in property management. As riparian and channel conditions improve, it is expected that aquatic habitat, stream temperatures, and flows will change. The established monitoring sites will provide BPT with stream temperature trend data. Recommended monitoring activities that need to be conducted concurrently with the stream temperature monitoring to adequately measure aquatic habitat trends on the Logan Valley mitigation property include:

- Establishing and maintaining stream channel cross section sites that will monitor channel condition over time.
- Establishing and maintaining stream discharge sites to monitor flow changes over time.
- Continued monitoring for stream temperature sites on Logan Valley.
- Collecting air temperature and precipitation data from Logan Valley.

References

Bowers, W., P. Dupee, M. Hanson, and R. Perkins. 1993. Bull trout population summary, Malheur River basin. Unpublished Data. Oregon Department of Fish and Wildlife. Hines, Oregon.

Buchanan, D.V., M.L. Hanson, and R. M. Hooton. 1997. Status of Oregon's bull trout. Oregon Department of Fish and Wildlife. Portland, Oregon.

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Rosgen, Dave. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado.

Wenick, J.J., D. Gonzalez, and A. First Raised. 2000. Logan Valley Management Plan. Burns Paiute Tribe. Burns, Oregon.

Appendix A. 2002 Logan Valley Stream Temperature Results

Table 35. 2002 Stream Temperature Data for Lake Creek below McCoy Creek.

Date	Low	High	Average	MWAT
5/30/02	7.38	16.42	11.90	
5/31/02	4.81	17.53	11.17	
6/1/02	7.54	11.88	9.71	
6/2/02	5.28	14.52	9.90	
6/3/02	4.73	16.89	10.81	
6/4/02	7.77	18.33	13.05	
6/5/02	6.76	19.14	12.95	16.39
6/6/02	6.61	17.85	12.23	16.59
6/7/02	5.21	13.43	9.32	16.01
6/8/02	3.80	10.64	7.22	15.83
6/9/02	3.72	8.16	5.94	14.92
6/10/02	5.05	15.63	10.34	14.74
6/11/02	4.73	15.79	10.26	14.38
6/12/02	5.75	19.06	12.41	14.37
6/13/02	7.07	20.52	13.80	14.75
6/14/02	9.01	20.52	14.77	15.76
6/15/02	8.93	20.52	14.73	17.17
6/16/02	9.08	19.71	14.40	18.82
6/17/02	9.39	14.59	11.99	18.67
6/18/02	9.39	16.89	13.14	18.83
6/19/02	5.52	18.17	11.85	18.70
6/20/02	6.14	19.47	12.81	18.55
6/21/02	9.55	15.86	12.71	17.89
6/22/02	9.86	21.01	15.44	17.96
6/23/02	10.80	19.88	15.34	17.98
6/24/02	9.94	21.51	15.73	18.97
6/25/02	10.95	23.44	17.20	19.91
6/26/02	12.03	24.64	18.34	20.83
6/27/02	13.28	22.85	18.07	21.31
6/28/02	13.58	21.43	17.51	22.11
6/29/02	13.12	22.93	18.03	22.38
6/30/02	10.18	22.43	16.31	22.75
7/1/02	9.55	22.01	15.78	22.82
7/2/02	8.77	23.35	16.06	22.81
7/3/02	11.57	23.69	17.63	22.67
7/4/02	10.64	22.68	16.66	22.65
7/5/02	9.01	23.35	16.18	22.92
7/6/02	10.49	24.47	17.48	23.14
7/7/02	12.11	24.73	18.42	23.47
7/8/02	12.65	23.86	18.26	23.73
7/9/02	9.24	25.60	17.42	24.05
7/10/02	10.80	27.00	18.90	24.53
7/11/02	12.42	28.72	20.57	25.39
7/12/02	13.12	27.09	20.11	25.92
7/13/02	16.42	26.65	21.54	26.24
7/14/02	15.71	26.74	21.23	26.52
7/15/02	13.97	26.57	20.27	26.91
7/16/02	13.89	25.34	19.62	26.87
7/17/02	12.03	25.34	18.69	26.64
7/18/02	12.81	23.35	18.08	25.87
7/19/02	15.47	19.63	17.55	24.80
7/20/02	10.26	24.20	17.23	24.45
7/21/02	10.33	25.17	17.75	24.23
7/22/02	12.34	21.18	16.76	23.46
7/23/02	12.58	25.17	18.88	23.43
7/24/02	12.03	25.17	18.60	23.41
7/25/02	12.97	19.88	16.43	22.91
7/26/02	10.02	24.47	17.25	23.61
7/27/02	11.49	23.78	17.64	23.55
7/28/02	10.18	23.95	17.07	23.37
7/29/02	12.50	25.78	19.14	24.03
7/30/02	11.80	24.56	18.18	23.94
7/31/02	11.57	22.01	16.79	23.49
8/1/02	8.47	23.27	15.87	23.97
8/2/02	9.70	23.35	16.53	23.81
8/3/02	8.47	19.88	14.18	23.26
8/4/02	10.64	18.17	14.41	22.43
8/5/02	8.16	18.09	13.13	21.33
8/6/02	8.47	19.14	13.81	20.56
8/7/02	5.67	20.36	13.02	20.32
8/8/02	5.83	21.26	13.55	20.04
8/9/02	7.38	22.85	15.12	19.96
8/10/02	8.70	23.61	16.16	20.50
8/11/02	10.49	22.68	16.59	21.14
8/12/02	9.24	23.69	16.47	21.94
8/13/02	9.24	24.13	16.69	22.65
8/14/02	8.93	22.76	15.85	23.00
8/15/02	10.26	23.18	16.72	23.27

Date	Low	High	Average	MWAT
8/16/02	9.08	22.35	15.72	23.20
8/17/02	8.31	21.68	15.00	22.92
8/18/02	8.24	22.43	15.34	22.89
8/19/02	8.16	21.51	14.84	22.58
8/20/02	8.62	19.23	13.93	21.88
8/21/02	8.01	15.39	11.70	20.82
8/22/02	5.52	19.06	12.29	20.24
8/23/02	8.47	15.39	11.93	19.24
8/24/02	7.07	17.77	12.42	18.68
8/25/02	7.46	19.06	13.26	18.20
8/26/02	10.64	21.18	15.91	18.15
8/27/02	9.70	21.35	15.53	18.46
8/28/02	9.70	21.09	15.40	19.27
8/29/02	8.93	21.85	15.39	19.67
8/30/02	10.80	20.28	15.54	20.37
8/31/02	8.93	21.68	15.31	20.93
9/1/02	8.31	20.52	14.42	21.14
9/2/02	9.39	22.35	15.87	21.30
9/3/02	10.02	19.55	14.79	21.05
9/4/02	8.93	19.14	14.04	20.77
9/5/02	9.63	16.89	13.26	20.06
9/6/02	7.70	15.47	11.59	19.37
9/7/02	4.58	14.44	9.51	18.34
9/8/02	3.01	14.83	8.92	17.52

Date	Low	High	Average	MWAT
9/9/02	3.64	17.85	10.75	16.88
9/10/02	5.21	18.82	12.02	16.78
9/11/02	5.52	19.55	12.54	16.84
9/12/02	6.45	19.79	13.12	17.25
9/13/02	7.07	20.36	13.72	17.95
9/14/02	7.07	17.85	12.46	18.44
9/15/02	8.01	16.26	12.14	18.64
9/16/02	9.39	18.33	13.86	18.71
9/17/02	10.49	12.97	11.73	17.87
9/18/02	6.45	16.42	11.44	17.43
9/19/02	5.44	17.53	11.49	17.10
9/20/02	6.30	16.89	11.60	16.61
9/21/02	3.01	15.31	9.16	16.24
9/22/02	2.69	15.94	9.32	16.20
9/23/02	3.80	16.58	10.19	15.95
9/24/02	4.42	16.10	10.26	16.40
9/25/02	4.27	15.55	9.91	16.27
9/26/02	2.37	12.81	7.59	15.60
9/27/02	5.28	10.64	7.96	14.70
9/28/02	2.06	14.05	8.06	14.52
9/29/02	3.48	9.24	6.36	13.57
9/30/02	2.93	11.26	7.10	12.81
10/1/02	1.10	10.25	5.68	11.97

Table 36. 2002 Stream Temperature Data for Lake Creek below Crooked Creek.

Date	Low	High	Average	MWAT	Date	Low	High	Average	MWAT
5/30/02	8.53	17.43	12.98		7/12/02	15.36	26.36	20.86	25.54
5/31/02	5.59	18.23	11.91		7/13/02	18.47	26.62	22.55	25.84
6/1/02	8.38	12.25	10.32		7/14/02	17.66	26.18	21.92	26.09
6/2/02	6.06	15.68	10.87		7/15/02	15.99	26.44	21.22	26.45
6/3/02	5.43	17.74	11.59		7/16/02	16.07	24.79	20.43	26.41
6/4/02	8.69	19.36	14.03		7/17/02	14.1	24.96	19.53	26.19
6/5/02	7.61	19.52	13.57	17.17	7/18/02	14.65	23.41	19.03	25.54
6/6/02	7.61	18.39	13.00	17.31	7/19/02	17.18	20.25	18.72	24.66
6/7/02	6.21	14.18	10.20	16.73	7/20/02	11.86	23.75	17.81	24.25
6/8/02	4.02	11.24	7.63	16.59	7/21/02	12.24	24.36	18.30	23.99
6/9/02	4.17	9.68	6.93	15.73	7/22/02	14.33	21.4	17.87	23.27
6/10/02	5.35	15.76	10.56	15.45	7/23/02	14.1	25.05	19.58	23.31
6/11/02	5.58	16.55	11.07	15.05	7/24/02	13.79	24.88	19.34	23.30
6/12/02	6.67	19.68	13.18	15.07	7/25/02	14.81	19.76	17.29	22.78
6/13/02	8.22	21.32	14.77	15.49	7/26/02	11.78	23.67	17.73	23.27
6/14/02	10.15	20.98	15.57	16.46	7/27/02	13.1	23.67	18.39	23.26
6/15/02	9.99	21.4	15.70	17.91	7/28/02	12.32	23.49	17.91	23.13
6/16/02	10.07	20.57	15.32	19.47	7/29/02	14.02	25.57	19.80	23.73
6/17/02	10.38	15.52	12.95	19.43	7/30/02	14.02	24.36	19.19	23.63
6/18/02	10.15	17.5	13.83	19.57	7/31/02	13.71	22.57	18.14	23.30
6/19/02	6.36	18.96	12.66	19.46	8/1/02	10.54	22.98	16.76	23.76
6/20/02	6.98	20.09	13.54	19.29	8/2/02	11.55	23.07	17.31	23.67
6/21/02	10.38	16.78	13.58	18.69	8/3/02	10.7	20.33	15.52	23.20
6/22/02	10.77	21.57	16.17	18.71	8/4/02	12.24	18.31	15.28	22.46
6/23/02	11.78	20.57	16.18	18.71	8/5/02	9.84	19.6	14.72	21.60
6/24/02	10.85	22.57	16.71	19.72	8/6/02	9.99	18.63	14.31	20.78
6/25/02	11.93	24.96	18.45	20.79	8/7/02	7.91	20.66	14.29	20.51
6/26/02	13.33	25.39	19.36	21.70	8/8/02	7.99	21.06	14.53	20.24
6/27/02	14.65	24.27	19.46	22.30	8/9/02	9.53	22.57	16.05	20.17
6/28/02	14.88	21.9	18.39	23.03	8/10/02	10.93	23.07	17.00	20.56
6/29/02	14.18	22.4	18.29	23.15	8/11/02	12.32	22.98	17.65	21.22
6/30/02	11.55	22.9	17.23	23.48	8/12/02	11	23.67	17.34	21.81
7/1/02	11.16	22.57	16.87	23.48	8/13/02	11.24	24.01	17.63	22.57
7/2/02	10.31	23.58	16.95	23.29	8/14/02	10.85	22.74	16.80	22.87
7/3/02	13.26	24.1	18.68	23.10	8/15/02	11.62	23.49	17.56	23.22
7/4/02	12.4	23.07	17.74	22.93	8/16/02	10.77	22.48	16.63	23.21
7/5/02	10.85	23.75	17.30	23.20	8/17/02	10.15	21.48	15.82	22.98
7/6/02	12.32	24.53	18.43	23.50	8/18/02	9.76	22.57	16.17	22.92
7/7/02	14.02	24.44	19.23	23.72	8/19/02	10.15	22.23	16.19	22.71
7/8/02	14.02	23.92	18.97	23.91	8/20/02	10.31	19.52	14.92	22.07
7/9/02	11.24	25.05	18.15	24.12	8/21/02	9.84	16.78	13.31	21.22
7/10/02	13.02	26.53	19.78	24.47	8/22/02	7.06	18.96	13.01	20.57
7/11/02	14.73	27.96	21.35	25.17	8/23/02	10.38	16.63	13.51	19.74

Date	Low	High	Average	MWAT
8/24/02	8.98	18.23	13.61	19.27
8/25/02	9.14	18.96	14.05	18.76
8/26/02	11.86	21.81	16.84	18.70
8/27/02	11.16	21.23	16.20	18.94
8/28/02	11.86	22.57	17.22	19.77
8/29/02	10.62	22.15	16.39	20.23
8/30/02	12.4	20.41	16.41	20.77
8/31/02	10.62	21.9	16.26	21.29
9/1/02	10.15	20.74	15.45	21.54
9/2/02	11.24	22.9	17.07	21.70
9/3/02	11.86	20.33	16.10	21.57
9/4/02	10.38	19.36	14.87	21.11
9/5/02	10.93	16.55	13.74	20.31
9/6/02	8.83	15.84	12.34	19.66
9/7/02	5.89	13.56	9.73	18.47
9/8/02	4.33	14.65	9.49	17.60
9/9/02	5.11	17.74	11.43	16.86
9/10/02	6.67	18.71	12.69	16.63
9/11/02	7.14	19.28	13.21	16.62
9/12/02	7.99	19.6	13.80	17.05

Date	Low	High	Average	MWAT
9/13/02	8.6	20.09	14.35	17.66
9/14/02	8.68	17.9	13.29	18.28
9/15/02	9.14	16.63	12.89	18.56
9/16/02	10.38	18.55	14.47	18.68
9/17/02	11.55	13.94	12.75	18.00
9/18/02	7.53	16.63	12.08	17.62
9/19/02	6.83	17.58	12.21	17.33
9/20/02	7.6	17.1	12.35	16.90
9/21/02	4.48	15.36	9.92	16.54
9/22/02	4.02	15.52	9.77	16.38
9/23/02	5.11	16.15	10.63	16.04
9/24/02	5.66	15.91	10.79	16.32
9/25/02	5.19	15.44	10.32	16.15
9/26/02	3.63	12.32	7.98	15.40
9/27/02	6.05	11.08	8.57	14.54
9/28/02	3.08	13.64	8.36	14.29
9/29/02	4.48	9.37	6.93	13.42
9/30/02	3.47	11.47	7.47	12.75
10/1/02	2.84	10.38	6.61	11.96

Table 37. 2002 Stream Temperature Data for Malheur River below Lake and Big Creeks.

Date	Max	MWAT	Min	Average	Date	Max	MWAT	Min	Average
6/6/02	16.32		10.09	13.21	7/18/02	21	23.06	11.33	16.17
6/7/02	12.57		5.13	8.85	7/19/02	17.27	22.12	13.49	15.38
6/8/02	10.56		3.56	7.06	7/20/02	21.66	21.80	9.16	15.41
6/9/02	8.69		3.72	6.21	7/21/02	22.33	21.66	9.31	15.82
6/10/02	13.65		4.66	9.16	7/22/02	19.37	20.99	10.87	15.12
6/11/02	14.58		4.66	9.62	7/23/02	22.49	20.97	11.02	16.76
6/12/02	17.92	13.47	5.75	11.84	7/24/02	22.66	20.97	10.56	16.61
6/13/02	19.05	13.86	6.84	12.95	7/25/02	16.96	20.39	11.33	14.15
6/14/02	19.37	14.83	8.69	14.03	7/26/02	21.66	21.02	8.85	15.26
6/15/02	19.54	16.11	8.69	14.12	7/27/02	21.33	20.97	10.24	15.79
6/16/02	19.21	17.62	8.85	14.03	7/28/02	21.66	20.88	9.16	15.41
6/17/02	14.58	17.75	9.31	11.95	7/29/02	23	21.39	10.87	16.94
6/18/02	16.32	18.00	9.16	12.74	7/30/02	21.99	21.32	10.4	16.20
6/19/02	17.76	17.98	5.44	11.60	7/31/02	20.02	20.95	10.24	15.13
6/20/02	18.72	17.93	6.06	12.39	8/1/02	20.83	21.50	7.46	14.15
6/21/02	15.69	17.40	9.31	12.50	8/2/02	21	21.40	8.54	14.77
6/22/02	20.51	17.54	9.62	15.07	8/3/02	18.24	20.96	7.62	12.93
6/23/02	19.21	17.54	10.09	14.65	8/4/02	16.17	20.18	9.62	12.90
6/24/02	20.83	18.43	9.31	15.07	8/5/02	16.96	19.32	7.62	12.29
6/25/02	22.66	19.34	10.4	16.53	8/6/02	16.32	18.51	7.77	12.05
6/26/02	23.68	20.19	11.48	17.58	8/7/02	18.72	18.32	5.59	12.16
6/27/02	21.99	20.65	12.41	17.20	8/8/02	19.21	18.09	5.59	12.40
6/28/02	20.34	21.32	12.88	16.61	8/9/02	20.51	18.02	6.84	13.68
6/29/02	21.49	21.46	12.26	16.88	8/10/02	21.16	18.44	7.93	14.55
6/30/02	21.33	21.76	9.46	15.40	8/11/02	20.51	19.06	9.31	14.91
7/1/02	20.83	21.76	9	14.92	8/12/02	21.33	19.68	8.23	14.78
7/2/02	21.83	21.64	8.23	15.03	8/13/02	21.83	20.47	8.23	15.03
7/3/02	22.16	21.42	10.71	16.44	8/14/02	20.83	20.77	7.93	14.38
7/4/02	21.16	21.31	10.09	15.63	8/15/02	21	21.02	9	15.00
7/5/02	21.83	21.52	8.54	15.19	8/16/02	20.18	20.98	7.93	14.06
7/6/02	22.66	21.69	9.77	16.22	8/17/02	19.54	20.75	7.46	13.50
7/7/02	22.49	21.85	11.48	16.99	8/18/02	20.34	20.72	7.46	13.90
7/8/02	21.99	22.02	11.79	16.89	8/19/02	19.54	20.47	7.31	13.43
7/9/02	23	22.18	8.54	15.77	8/20/02	16.96	19.77	7.77	12.37
7/10/02	24.37	22.50	10.09	17.23	8/21/02	15.22	18.97	7.15	11.19
7/11/02	25.58	23.13	11.48	18.53	8/22/02	16.96	18.39	5.44	11.20
7/12/02	23.86	23.42	11.95	17.91	8/23/02	15.06	17.66	8.08	11.57
7/13/02	23.86	23.59	14.58	19.22	8/24/02	16.79	17.27	6.68	11.74
7/14/02	23.34	23.71	14.11	18.73	8/25/02	16.79	16.76	6.99	11.89
7/15/02	24.03	24.01	12.57	18.30	8/26/02	19.05	16.69	9.31	14.18
7/16/02	22.66	23.96	12.57	17.62	8/27/02	19.21	17.01	8.54	13.88
7/17/02	22.66	23.71	10.87	16.77	8/28/02	20.18	17.72	9.31	14.75

Date	Max	MWAT	Min	Average
8/29/02	19.86	18.13	8.08	13.97
8/30/02	17.27	18.45	9.62	13.45
8/31/02	19.54	18.84	8.08	13.81
9/1/02	18.89	19.14	7.46	13.18
9/2/02	20.34	19.33	8.54	14.44
9/3/02	18.24	19.19	9	13.62
9/4/02	16.48	18.66	7.93	12.21
9/5/02	14.27	17.86	8.54	11.41
9/6/02	13.49	17.32	6.99	10.24
9/7/02	12.88	16.37	4.34	8.61
9/8/02	13.49	15.60	2.93	8.21
9/9/02	16.32	15.02	3.72	10.02
9/10/02	17.11	14.86	4.97	11.04
9/11/02	17.76	15.05	5.28	11.52
9/12/02	18.08	15.59	5.91	12.00
9/13/02	18.4	16.29	6.53	12.47
9/14/02	16.01	16.74	6.53	11.27
9/15/02	14.89	16.94	7.31	11.10
9/16/02	16.48	16.96	8.39	12.44
9/17/02	12.1	16.25	9	10.55
9/18/02	15.22	15.88	6.06	10.64
9/19/02	16.17	15.61	5.13	10.65

Date	Max	MWAT	Min	Average
9/20/02	15.37	15.18	5.75	10.56
9/21/02	14.11	14.91	3.09	8.60
9/22/02	14.58	14.86	2.78	8.68
9/23/02	15.37	14.70	3.88	9.63
9/24/02	14.89	15.10	4.34	9.62
9/25/02	14.42	14.99	4.19	9.31
9/26/02	11.79	14.36	2.62	7.21
9/27/02	10.4	13.65	4.97	7.69
9/28/02	13.34	13.54	2.62	7.98
9/29/02	9.16	12.77	3.56	6.36
9/30/02	11.02	12.15	3.25	7.14
10/1/02	9.46	11.37	2.14	5.80
10/2/02	10.56	10.82	1.35	5.96
10/3/02	8.23	10.31	3.72	5.98
10/4/02	12.26	10.58	5.59	8.93
10/5/02	12.88	10.51	4.5	8.69
10/6/02	14.11	11.22	4.97	9.54
10/7/02	12.41	11.42	3.09	7.75
10/8/02	11.64	11.73	2.46	7.05
10/9/02	11.33	11.84	1.83	6.58
10/10/02	8.85	11.93	1.03	4.94
10/11/02	7.77	11.28	-0.09	3.84

Table 38. 2002 Stream Temperature Data for Big Creek One Mile below Road 16.

Date	Max	MWAT	Min	Average	Date	Max	MWAT	Min	Average
06/07/02	11.17				07/19/02	16.14	20.81	11.93	14.04
06/08/02	10.24		3.26	6.75	07/20/02	20.64	20.57	8.23	14.44
06/09/02	8.23		3.26	5.75	07/21/02	21.3	20.47	8.53	14.92
06/10/02	12.71		4.2	8.46	07/22/02	18.22	19.87	9.93	14.08
06/11/02	13.94		4.04	8.99	07/23/02	21.63	19.91	10.08	15.86
06/12/02	16.93		4.98	10.96	07/24/02	21.8	19.94	9.61	15.71
06/13/02	17.73	12.99	6.07	11.90	07/25/02	15.83	19.37	10.39	13.11
06/14/02	18.38	14.02	7.77	13.08	07/26/02	20.64	20.01	7.92	14.28
06/15/02	18.22	15.16	7.77	13.00	07/27/02	20.15	19.94	9.31	14.73
06/16/02	18.38	16.61	8.07	13.23	07/28/02	20.64	19.84	8.23	14.44
06/17/02	13.63	16.74	8.23	10.93	07/29/02	21.8	20.36	9.93	15.87
06/18/02	15.51	16.97	8.23	11.87	07/30/02	20.97	20.26	9.31	15.14
06/19/02	16.93	16.97	4.82	10.88	07/31/02	18.7	19.82	9.46	14.08
06/20/02	17.73	16.97	5.44	11.59	08/01/02	19.99	20.41	6.53	13.26
06/21/02	15.03	16.49	8.38	11.71	08/02/02	20.15	20.34	7.92	14.04
06/22/02	19.51	16.67	8.69	14.10	08/03/02	17.57	19.97	6.84	12.21
06/23/02	17.89	16.60	8.99	13.44	08/04/02	15.51	19.24	8.84	12.18
06/24/02	19.83	17.49	8.38	14.11	08/05/02	16.14	18.43	7	11.57
06/25/02	20.97	18.27	9.31	15.14	08/06/02	15.35	17.63	7	11.18
06/26/02	22.3	19.04	10.24	16.27	08/07/02	17.41	17.45	4.98	11.20
06/27/02	20.64	19.45	11.17	15.91	08/08/02	18.38	17.22	4.98	11.68
06/28/02	19.02	20.02	11.32	15.17	08/09/02	19.67	17.15	6.22	12.95
06/29/02	20.8	20.21	11.01	15.91	08/10/02	20.31	17.54	7.15	13.73
06/30/02	20.15	20.53	8.38	14.27	08/11/02	19.67	18.13	8.53	14.10
07/01/02	19.67	20.51	7.92	13.80	08/12/02	20.31	18.73	7.46	13.89
07/02/02	20.8	20.48	7.31	14.06	08/13/02	20.8	19.51	7.61	14.21
07/03/02	20.97	20.29	9.46	15.22	08/14/02	19.99	19.88	7.31	13.65
07/04/02	19.83	20.18	8.84	14.34	08/15/02	19.99	20.11	8.38	14.19
07/05/02	20.64	20.41	7.46	14.05	08/16/02	19.34	20.06	7.46	13.40
07/06/02	21.47	20.50	8.69	15.08	08/17/02	18.86	19.85	6.84	12.85
07/07/02	21.47	20.69	10.08	15.78	08/18/02	19.51	19.83	6.84	13.18
07/08/02	20.64	20.83	10.71	15.68	08/19/02	18.7	19.60	6.69	12.70
07/09/02	21.63	20.95	7.46	14.55	08/20/02	16.3	18.96	7.15	11.73
07/10/02	23.13	21.26	8.84	15.99	08/21/02	14.72	18.20	6.53	10.63
07/11/02	23.98	21.85	10.24	17.11	08/22/02	16.3	17.68	5.13	10.72
07/12/02	22.47	22.11	10.71	16.59	08/23/02	14.25	16.95	7.31	10.78
07/13/02	22.3	22.23	13.02	17.66	08/24/02	16.46	16.61	5.91	11.19
07/14/02	21.97	22.30	12.56	17.27	08/25/02	16.14	16.12	6.53	11.34
07/15/02	22.47	22.56	11.17	16.82	08/26/02	17.89	16.01	8.69	13.29
07/16/02	21.3	22.52	11.17	16.24	08/27/02	18.7	16.35	7.92	13.31
07/17/02	21.63	22.30	9.61	15.62	08/28/02	19.34	17.01	8.53	13.94
07/18/02	19.83	21.71	10.39	15.11	08/29/02	18.54	17.33	7.46	13.00

Date	Max	MWAT	Min	Average
08/30/02	16.46	17.65	8.84	12.65
08/31/02	18.7	17.97	7.31	13.01
09/01/02	18.22	18.26	6.84	12.53
09/02/02	19.51	18.50	7.92	13.72
09/03/02	17.25	18.29	8.23	12.74
09/04/02	15.98	17.81	7.46	11.72
09/05/02	13.94	17.15	7.92	10.93
09/06/02	13.17	16.68	6.53	9.85
09/07/02	12.24	15.76	4.04	8.14
09/08/02	13.17	15.04	2.79	7.98
09/09/02	15.83	14.51	3.58	9.71
09/10/02	16.62	14.42	4.67	10.65
09/11/02	17.09	14.58	4.98	11.04
09/12/02	17.41	15.08	5.76	11.59
09/13/02	17.73	15.73	6.22	11.98
09/14/02	15.67	16.22	6.22	10.95
09/15/02	14.56	16.42	6.84	10.70
09/16/02	15.83	16.42	8.07	11.95
09/17/02	11.47	15.68	8.38	9.93
09/18/02	14.72	15.34	5.6	10.16
09/19/02	15.67	15.09	4.82	10.25
09/20/02	14.88	14.69	5.44	10.16

Date	Max	MWAT	Min	Average
09/21/02	13.48	14.37	2.79	8.14
09/22/02	13.94	14.28	2.63	8.29
09/23/02	14.88	14.15	3.58	9.23
09/24/02	14.56	14.59	4.04	9.30
09/25/02	14.09	14.50	4.04	9.07
09/26/02	11.47	13.90	2.47	6.97
09/27/02	10.08	13.21	4.67	7.38
09/28/02	13.02	13.15	2.63	7.83
09/29/02	8.99	12.44	3.26	6.13
09/30/02	10.86	11.87	3.26	7.06
10/01/02	9.31	11.12	1.84	5.58
10/02/02	10.39	10.59	1.37	5.88
10/03/02	8.07	10.10	3.58	5.83
10/04/02	11.78	10.35	5.44	8.61
10/05/02	12.56	10.28	4.2	8.38
10/06/02	13.63	10.94	4.51	9.07
10/07/02	12.24	11.14	2.79	7.52
10/08/02	11.47	11.45	2.31	6.89
10/09/02	11.17	11.56	1.68	6.43
10/10/02	8.99	11.69	1.05	5.02
10/11/02	7.77	11.12	-0.07	3.85

CONDUCT DAY AND NIGHT SNORKEL SURVEYS TO DETERMINE SALMONID PRESENCE IN AREAS OF COOL WATER REFUGIA IDENTIFIED BY FORWARD LOOKING INFRARED RADIOMETRY (FLIR) IN THE UPPER MALHEUR RIVER, OREGON.

By Lawrence T. Schwabe, Burns Paiute Tribe

Bull trout *Salvelinus confluentus* require cold, clean water and are susceptible to anthropogenic alterations to the habitat (Howell and Buchanan 1992). Research conducted by the Burns Paiute Tribe (BPT) and cooperators have documented bull trout in streams and rivers that exceed 22 °C. The Oregon Department of Environmental Quality has adopted water temperature requirements to help bull trout that are stricter than any other for native fish species.

In 1998, Forward Looking Infrared Radiometry (FLIR) was used to determine areas of cool water refugia in the Upper Malheur River. FLIR has been used as an effective and efficient method for identifying cool drainages within watersheds, cool reaches in drainages, and cool habitats within reaches (McIntosh et al. 1995; Torgerson et al. 1995; Torgerson et al. 1999). The Upper Malheur River FLIR data helped identify cool water refugia; crews then surveyed the areas to identify whether salmonids or bull trout occupy reaches of the Upper Malheur River in FLIR-identified cool water refugia habitats.

Methods

Watershed Temperature Monitoring

Cold water inputs into a relatively warm body of water may provide the habitat or refugia salmonids need to survive. The BPT strategically placed eleven stream temperature probes in annual Upper Malheur River monitoring sites identified by the Oregon Department of Fish and Wildlife (ODFW) and the U.S. Forest Service (see Table 39 and Figure 41). Stream temperature data collected on the Upper Malheur River identify when maximum peak temperatures probably occurred throughout the basin in 2002. The BPT conducted snorkel surveys during these periods of elevated stream temperatures when salmonids would most likely use the cool water micro-habitats.

Continuous data recorders are commonly used to gather water temperature data. StowAway XT data loggers, manufactured by Onset Computer, were used at stream temperature monitoring sites. Loggers were calibrated for accuracy using Oregon's Water Quality Monitoring Guide Book methods (Oregon Plan for Salmon and Watersheds 1999).

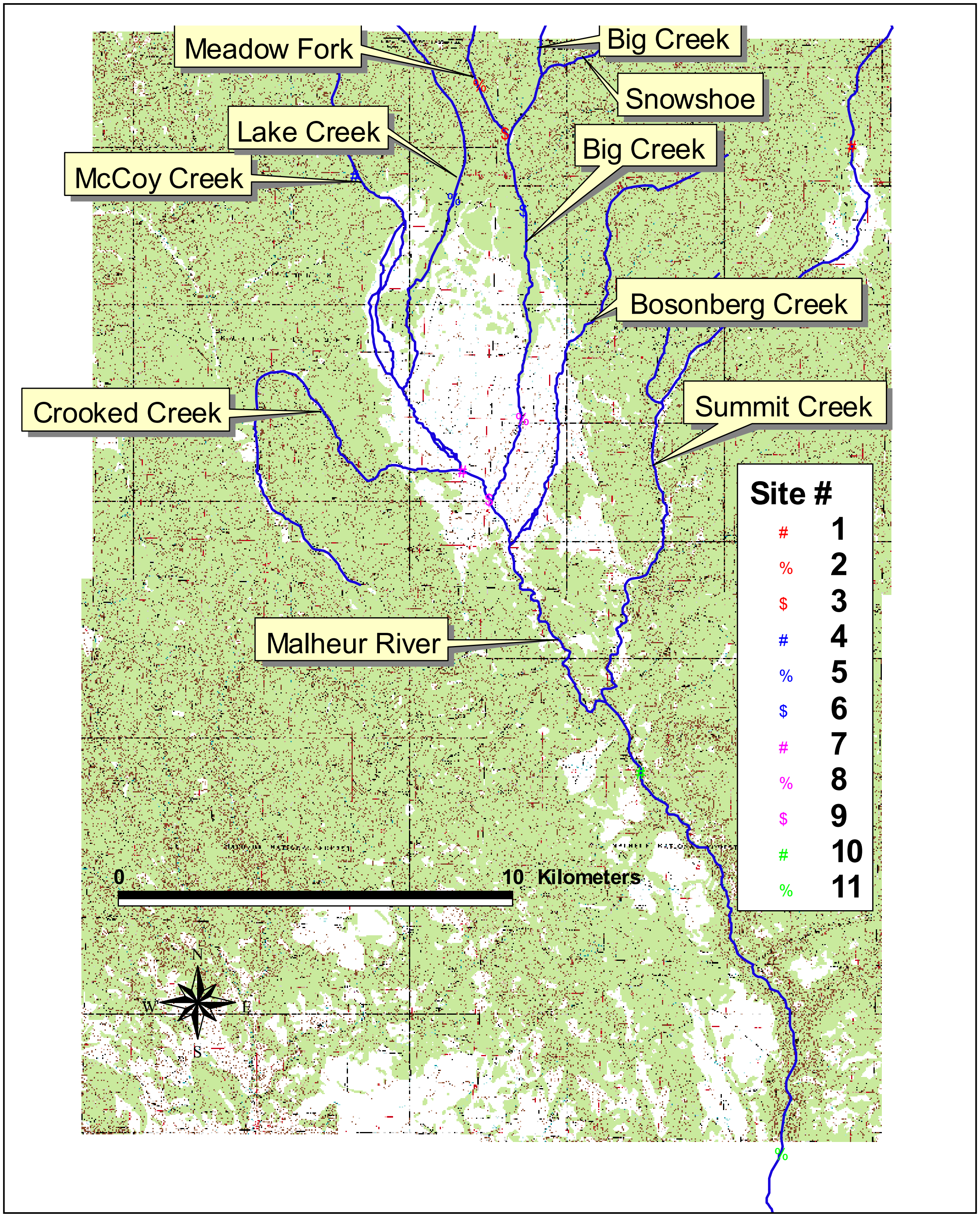

Figure 41. Locations for eleven stream temperature probing sites in the Upper Malheur River.

Temperature data were analyzed using rolling daily maximum temperatures averaged over a seven day period (called Maximum Weekly Average Temperature, or MWAT). The maximum MWAT for the season was compared to the MWAT for the week of snorkel surveys, July 23 through July 29, 2002, to determine the variation between the time of seasonal peak temperatures in the basin in 2002 relative to basin stream temperatures at the time of surveys.

Table 39. List of Upper Malheur River Stream Temperature Sites.

Probe Site Number	Location
1	Summit Creek above road 1660 culvert
2	Meadow Fork near the wilderness trailhead
3	Meadow Fork at mouth
4	McCoy Creek above 1648 road culvert
5	Lake Creek above 1648 road culvert
6	Big Creek above 1648 road culvert
7	Lake Creek below the confluence of Crooked Creek
8	Big Creek below 16 road
9	Malheur River below the confluence of Lake and Big Creek
10	Malheur River below Ford
11	Malheur River near hog flat

Site Selection

Thermal infrared images collected during the Upper Malheur River survey helped develop broad scale temperature patterns in the basin. The images were collected using a helicopter-mounted Thermal Infrared Radiometer (TIR, also know as FLIR). The radiometer was adjacent to a video-camera in a gyro-stabilized gimbal mount. The radiometer and camera captured images while flying longitudinally over the center of the stream channel. The TIR images were tagged with GPS information and recorded directly to an on-board computer. The video-camera imagery was also tagged with GPS positions and recorded to a videocassette recorder on the helicopter. The survey was conducted in mid-afternoon on August 7 and August 8, 1998.

The radiometer measured the thermal infrared energy emitted objects in the view, including the water's surface. This measured energy, the ambient conditions, and the emissivity of the water were used to determine water temperature. As a result, each pixel in the image represented the radiant temperature at that location.

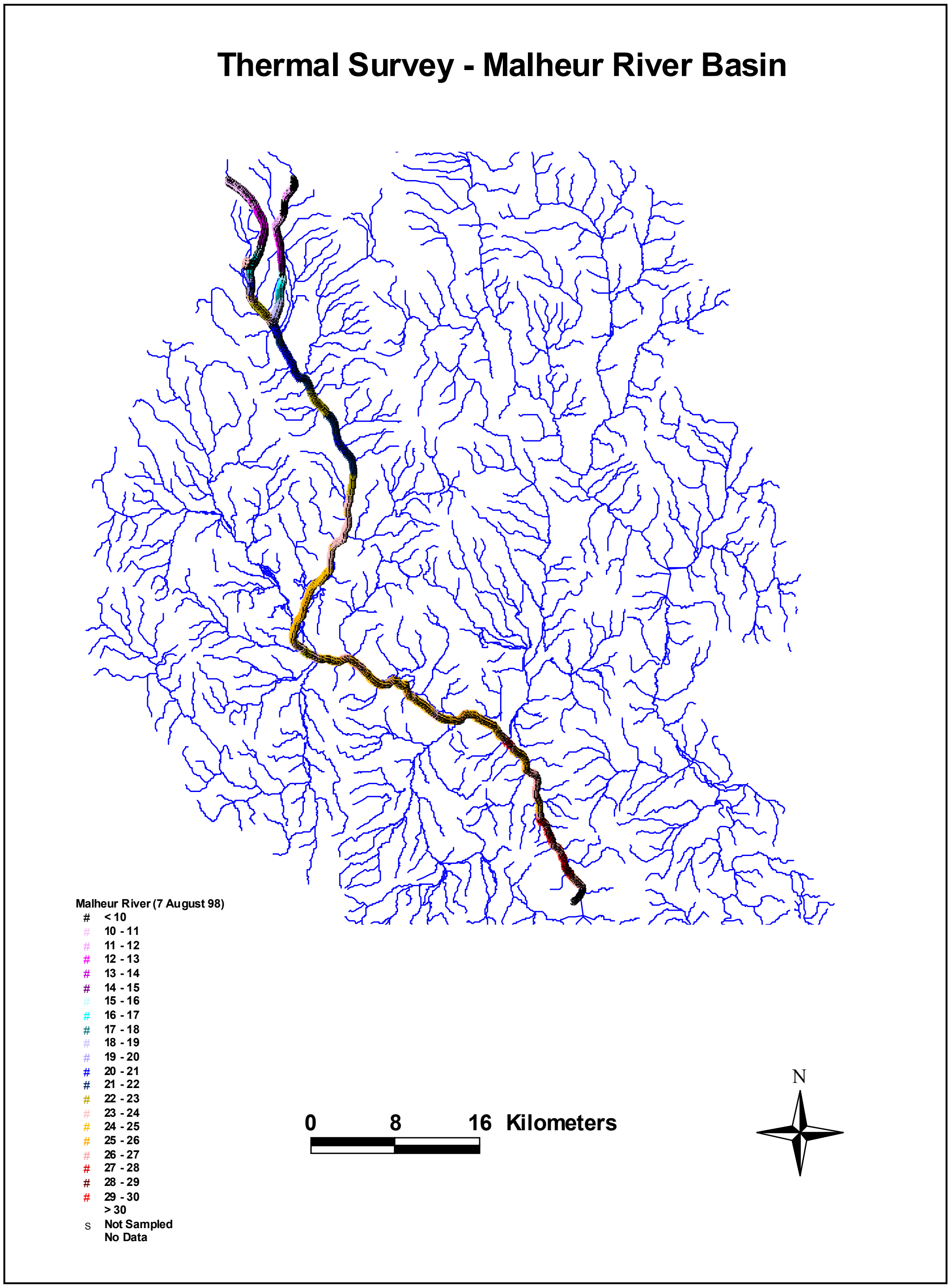

Figure 42. Mapped FLIR results of the Upper Malheur River, Lake Creek, and Big Creek, 1998.

Data collected during the flight were incorporated into a Geographic Information System (GIS) map. Detailed maps of the survey area and FLIR data were used to define areas of cool water refugia within a relatively warm stream. Figure 42 displays the mapped results of the flight.

The survey identified three areas of cool water refugia. Two surveyors snorkeled eight to ten slow-water habitat units at each site. In general, riffle habitat was too shallow to be sampled. Surveyors recorded tributaries, springs, and habitat length, depth, and width for each unit; they also recorded water temperature for tributaries, springs, and selected units.

Each unit was surveyed from the downstream end to the upstream end twice, once during the day and once at night. Daytime snorkeling was conducted because salmonids may use the cool water refugia during peak daytime temperatures. Cool stream temperatures at night may result in a dispersal of fish species away from these areas of cool water refugia. However, because bull trout are primarily nocturnal, night snorkeling has been more successful.

Results

Stream Temperature Monitoring

Eleven stream temperature probes were deployed in the Upper Malheur River in 2002. These sites have been long-term monitoring sites for local land managers. Seven of the eleven sites provided useable data (see Table 40).

Habitat

Site 1 was the lowest survey site on the Malheur River (approximately 1341 meters above sea level). Site 1 included portions of river kilometers (RK) 289 and 290. Snorkelers traveled over 200 meters upstream through eight habitat units on July 23, 2002. Table 41 shows the habitat types for each unit, according to its hydraulic characteristics.

Table 40. Maximum Daily and Maximum Weekly Average Temperature compared to MWAT During Upper Malheur River Snorkel Surveys.

Probe Site Number	Elevation (meters)	Date of Maximum Temperature	Maximum MWAT (°C)	Date of Maximum MWAT	Snorkel Survey MWAT (°C)	Comment
1	1341.12	NA	NA	NA	NA	Probe stolen
2	1432.56	NA	NA	NA	NA	Probe stolen
3	1507.236	7/11/02	25.6	7/10/02 to 7/16/02	21.39	
4	1508.76	7/11/02	24.0	7/9/02 to 7/15/02	20.36	
5	1508.76	NA	NA	NA	NA	Probe stolen
6	1600.2	7/11/02	15.6	7/10/02 to 7/16/02	13.94	
7	1600.2	7/11/02	14.8	7/10/02 to 7/16/02	12.55	
8	1615.44	7/11/02	15.5	7/10/02 to 7/16/02	14.22	
9	1661.16	7/11/02	14.9	7/10/02 to 7/16/02	12.93	
10	1722	7/11/02	13.7	7/10/02 to 7/16/02	11.67	
11	1748	NA	NA	NA	NA	Only 14 days of data

Table 41. Habitat Attributes for Snorkel Site 1 on the Upper Malheur River.

	Habitat Type	Habitat Length (meters)	Habitat Width (meters)	Habitat Depth (meters)	Boulder Count	Temperature (Day pass only; °C)
1	LP	12.1	12.1	.85	19	24
2	RP	21.2	10.6	.58	80	24
3	RP	9.1	9.1	.64	20+	23
4	RP	18.2	9.1	.64	20+	23
5	GL	18.2	10.6	.64	20+	23
6	RP	18.2	17.6	.46	8	22
7	RP	16.7	10.6	.3	8	22
8	RP	16.7	7.6	.58	3	22

LP = Lateral Scour Pool; RP = Riffle with Pockets; GL = Glide

Skookum Creek drainage flows into the Upper Malheur River near RK 290 between habitat units 7 and 8. Flow at time of survey was estimated to be less than 0.5 cubic feet per second (cfs). The temperature of the water entering the Malheur River was 12 °C, while the temperature of the mainstem was 22 °C.

Site 1's dominant habitat type was riffle with pockets. One lateral scour pool and one glide comprised only 20.6 percent of the total cubic feet of surveyed habitat. Eight units were sampled. Site 1 had the least habitat type diversity.

Site 2 included portions of RK 293 and 295 and was at an elevation of approximately 1432 meters above sea level. Snorkelers traveled 126 meters upstream through ten habitat units on July 29, 2002. Table 42 shows the habitat types for each unit, according to its hydraulic characteristics.

Table 42. Habitat Attributes for Snorkel Site 2 on the Upper Malheur River.

	Habitat Type	Habitat Length (m)	Habitat Width (m)	Habitat Depth (m)	Boulder Count	Temperature (Day pass only; °C)
1	DP	15.2	15.2	.8	20+	22
2	RP	15.2	12.1	.61	15	23
3	RP	12.1	13.7	.61	20+	23
4	RP	12.1	7.6	.61	20+	23
5	RP	18.2	12.1	.61	20+	23
6	RP	9.1	9.1	.49	20+	23
7	RP	12.1	7.6	.49	20+	23
8	RP	6.1	10.6	.55	20+	23
9	RP	7.6	10.6	.61	20+	23
10	RP	18.2	7.6	.91	20+	23

LP = Lateral Scour Pool; RP = Riffle with Pockets; GL = Glide

Cliff Creek drainage flows into the Upper Malheur River near RK 293 above habitat unit 10. The only identified cool water inflow source to the Malheur River was a spring that entered from the east between units 9 and 10. Flow at time of survey was estimated to be approximately 1 cfs. The temperature of the water entering the Malheur River was recorded at 5 °C; the temperature of the mainstem was 23 °C.

Site 2's dominant habitat type was riffle with pockets. One dam pool comprised 20.0 percent of the total cubic feet of surveyed habitat.

Site 3 was the uppermost site surveyed that included portions of RK 301 and 303 (approximately 1480 meters above sea level). Snorkelers traveled 170 meters upstream through ten habitat units on July 24, 2002. Table 43 shows the habitat types for each unit, according to its hydraulic characteristics.

Table 43. Habitat Attributes for Snorkel Site 3 on the Upper Malheur River.

	Habitat Type	Habitat Length (m)	Habitat Width (m)	Habitat Depth (m)	Boulder Count	Temperature (Day pass only; °C)
1	GL	18.2	10.6	.46	0	22
2	RP	61.9	12.1	.42	20+	22
3	RP	13.7	9.1	.46	0	21
4	RP	13.7	13.7	.46	20+	22
5	RP	10.9	6.1	.55	20+	22
6	GL	12.1	9.1	.61	20+	22
7	RP	10.6	6.1	.46	0	22
8	RP	9.1	6.1	.3	0	22
9	RP	13.7	7.6	.8	0	23
10	RP	6.1	9.1	.3	0	22

LP = Lateral Scour Pool; RP = Riffle with Pockets; GL = Glide

The surveyors identified a cool spring entering the mainstem Malheur River from the west at unit 5. Spring flow was estimated less than 1 cfs. The temperature of the spring water entering the Malheur River was 16 °C; the temperature of the mainstem was 23 °C.

Site 3's dominant habitat type was riffle with pockets. Two habitat units were typed as glides that comprised 19.5 percent of the total cubic feet of habitat surveyed.

Fish Observations

For Site 1, four genus groups of fish species were observed: redband trout *Oncorhynchus mykiss*, mountain whitefish *Prosopium williamsoni*, suckers *Catostomus spp.* and redside shiners *Richardsonius balteatus*. Night snorkeling observations of salmonid species yielded 42 more redband and 30 more whitefish than day snorkeling observations (see Figure 43 and Figure 44). This site had the least genus diversity (see Figure 45).

For Site 2, five genus groups of fish species were observed: redband trout, mountain whitefish, suckers (species unidentified), sculpin *Cottus spp.*, and redside shiners. Night snorkel survey observations of salmonid species had 4 less redband and 11 less whitefish than day snorkeling observations (see Figure 46 and Figure 47). Mountain whitefish and redband trout were the dominant species at 79 percent of the identified fish (see Figure 48).

For Site 3, six genus groups of fish species were observed: redband trout, mountain whitefish, suckers, dace *Rhinichthys spp.*, sculpin, and redside shiners. Night snorkel survey observations of salmonid species yielded 12 more redband and 1 more whitefish than day snorkel observations (see Figure 49 and Figure 50). This site had the greatest genus diversity (see Figure 51).

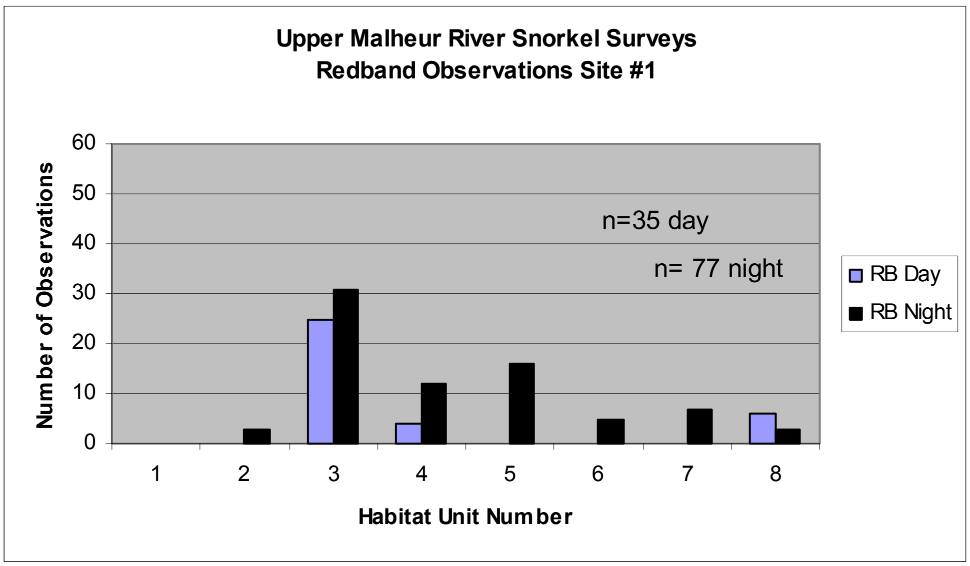

Figure 43. Site 1 Redband trout observations from snorkel surveys.

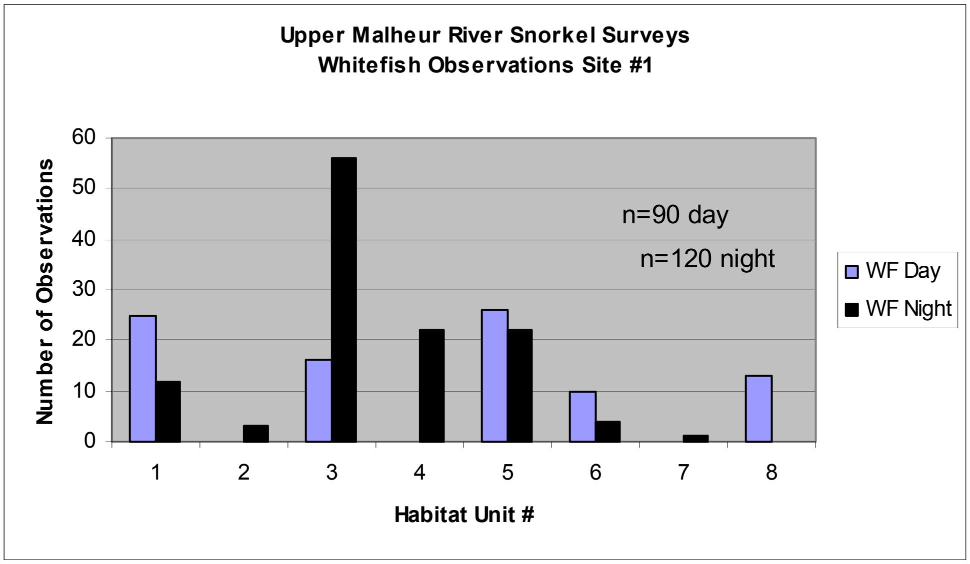

Figure 44. Site 1 Mountain whitefish observations from snorkel surveys.

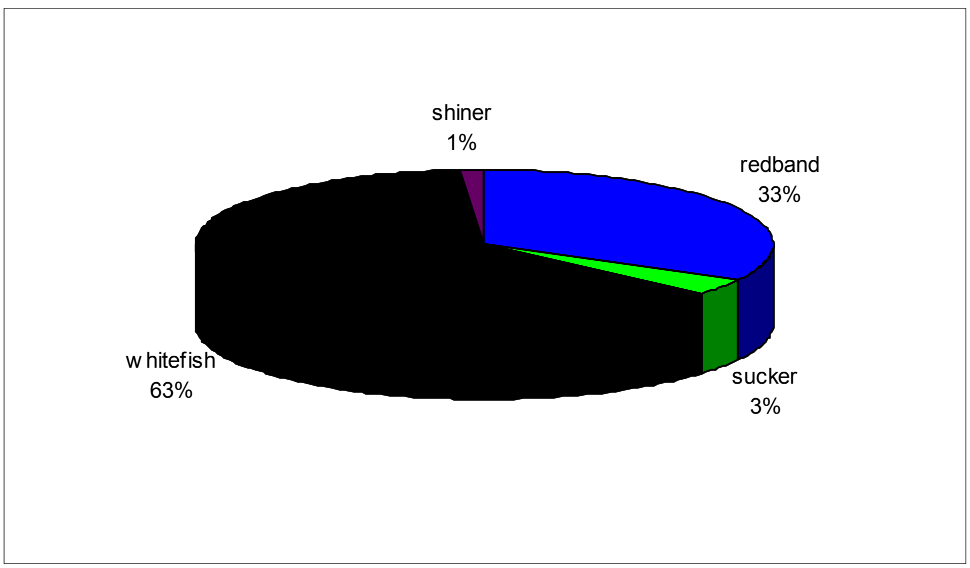

Figure 45. Site 1 genus composition.

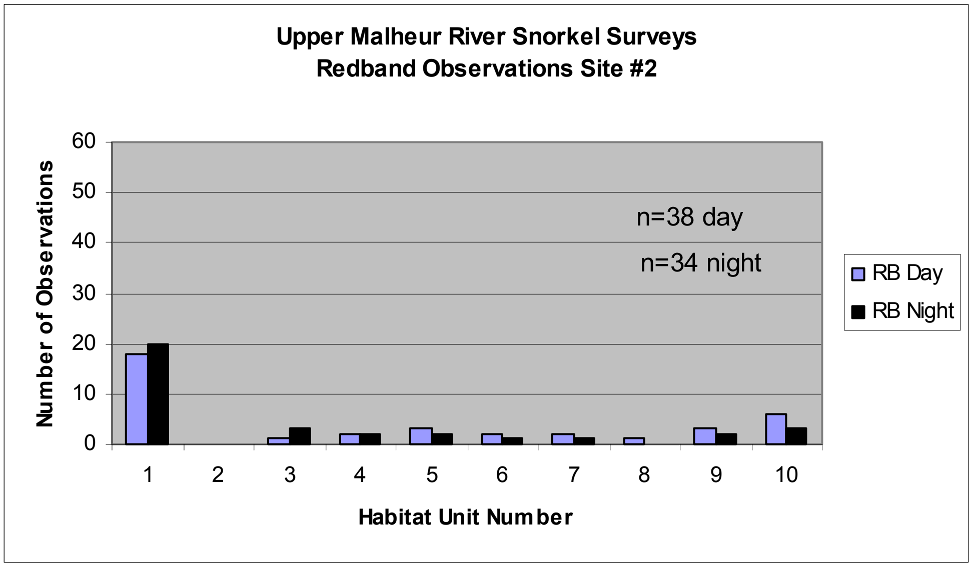

Figure 46. Site 2 Redband trout observations from snorkel surveys.

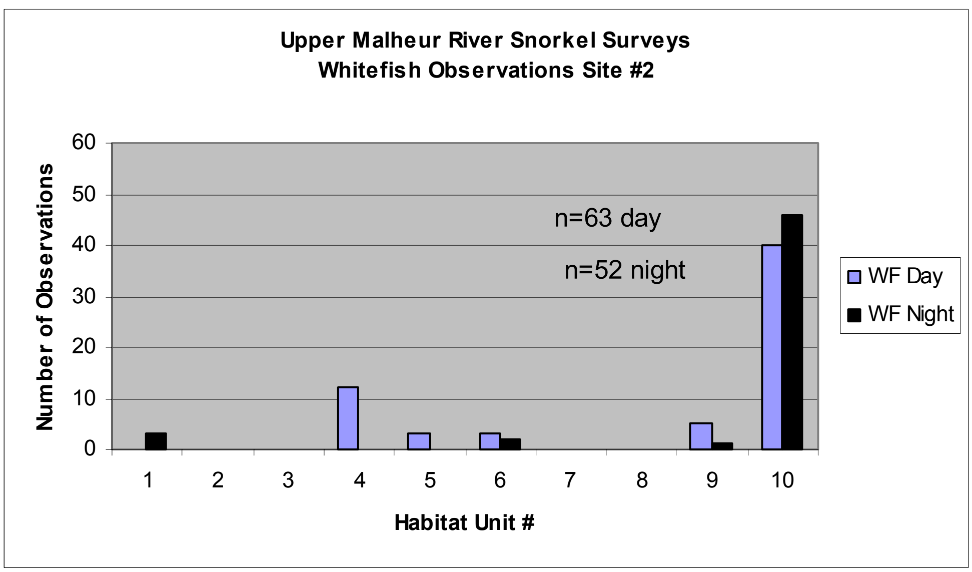

Figure 47. Site 2 Mountain whitefish observations from snorkel surveys.

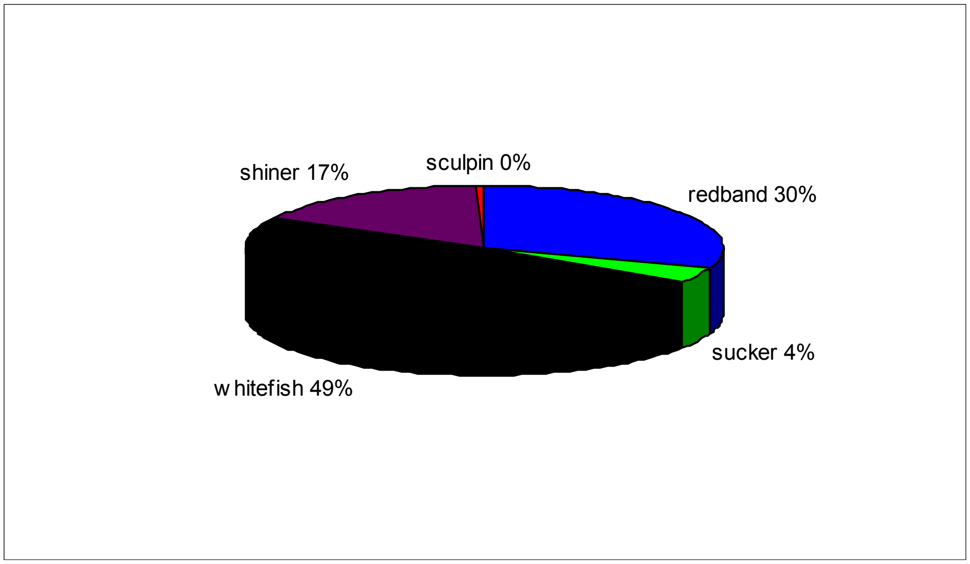

Figure 48. Site 2 genus composition.

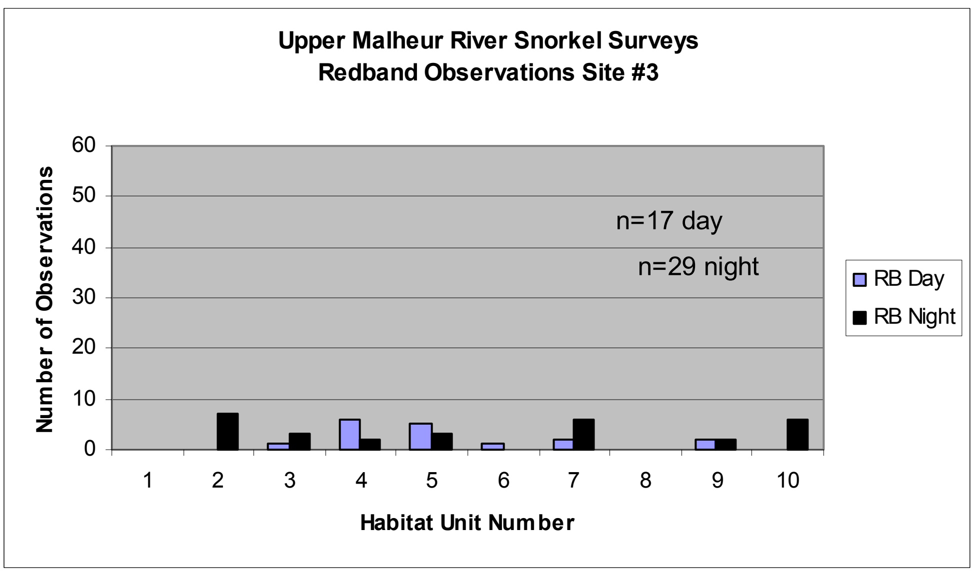

Figure 49. Site 3 Redband trout observations from snorkel surveys.

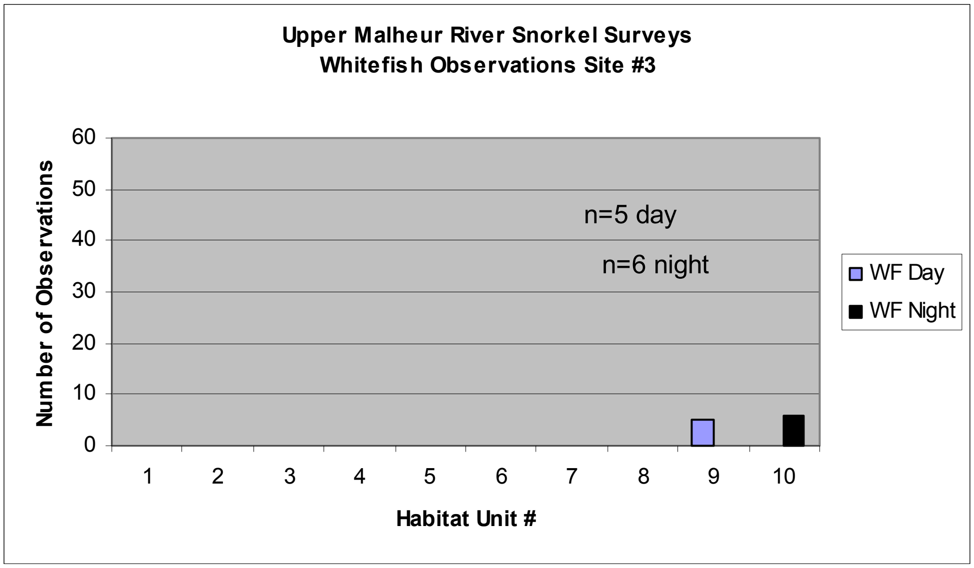

Figure 50. Site 3 Mountain whitefish observations from snorkel surveys.

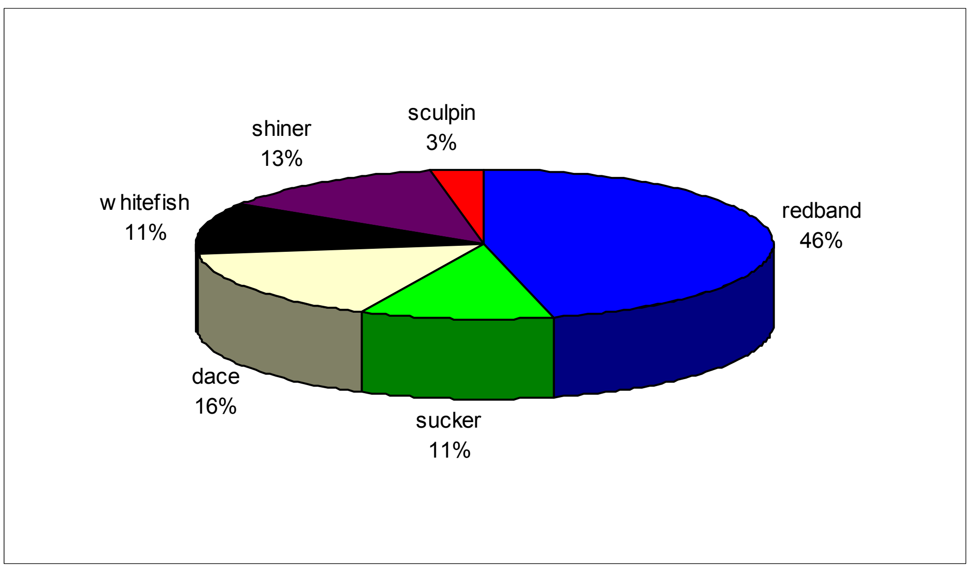

Figure 51. Site 3 genus composition.

Discussion

Data from stream temperature probes in the Upper Malheur River indicated peak temperatures on July 11, 2002. The snorkel surveys occurred approximately two weeks after peak temperatures. Stream temperatures remained relatively warm with day temperatures exceeding 22 °C at all snorkel sites.

The main purpose of the snorkel surveys was to groundtruth the areas of cool water influences into the Malheur River from the FLIR data and determine the presence of salmonid use, particularly bull trout. Since bull trout require relatively cooler water temperatures than other salmonids, it is assumed that the highest success of detection of the presence of bull trout using the mainstem Malheur River during peak summer temperatures would occur near these areas of cool water refugia. The only salmonids present were redband trout and mountain whitefish. Snorkel methods were unable to detect bull trout at these sites.

Several conclusions are possible to explain why no bull trout were detected: they could have been absent from this area, they may have been present in low numbers and left undetected, or they could have been present in large numbers and, using high avoidance behavior, been left undetected.

Many researchers have great success using snorkel methods to detect the presence of bull trout, particularly at night (Goetz 1991). Night snorkeling was conducted at these sites because it allows greater possibility for bull trout detection. Therefore, it is very unlikely that bull trout were present in large numbers but were left undetected. The first two conclusions are more likely. It is undetermined if all age classes of bull trout migrate upstream during peak stream temperatures to more suitable areas or if the bull trout present occupy areas of the mainstem not sampled in this survey. In reference to the FLIR data, the sites snorkeled represent relatively cool refugia areas of the Upper Malheur River. The data collected suggests that these cool refugia areas may not be strategically utilized by bull trout during peak summer temperatures.

Past telemetry research in the Upper Malheur River document adult bull trout (>266 grams) migrating out of the Upper Malheur River by August and into tributaries that have temperature profiles more suitable for bull trout. This upstream migratory behavior may be influenced by the need for adult bull trout to access the spawning areas located in the headwaters of the subbasin. Sub-adult bull trout may exhibit a unique behavior and possibly oversummer in different reaches of the subbasin. Using radio telemetry to identify sub-adult migration behavior would benefit land and fisheries managers throughout the basin.

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Oregon Plan for Salmon and Watersheds. 1999. Water Quality Monitoring. Technical Guide Book. (www.oweb.state.or.us/publications/mon_guide99.shtml)

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Torgerson, C.E., D.M. Price, H.W. Li, and B.A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associates of chinook salmon in Northeastern Oregon. Ecological Applications. 9(1), pp 301 – 319.

Appendix A. Snorkel Sites on the Malheur River

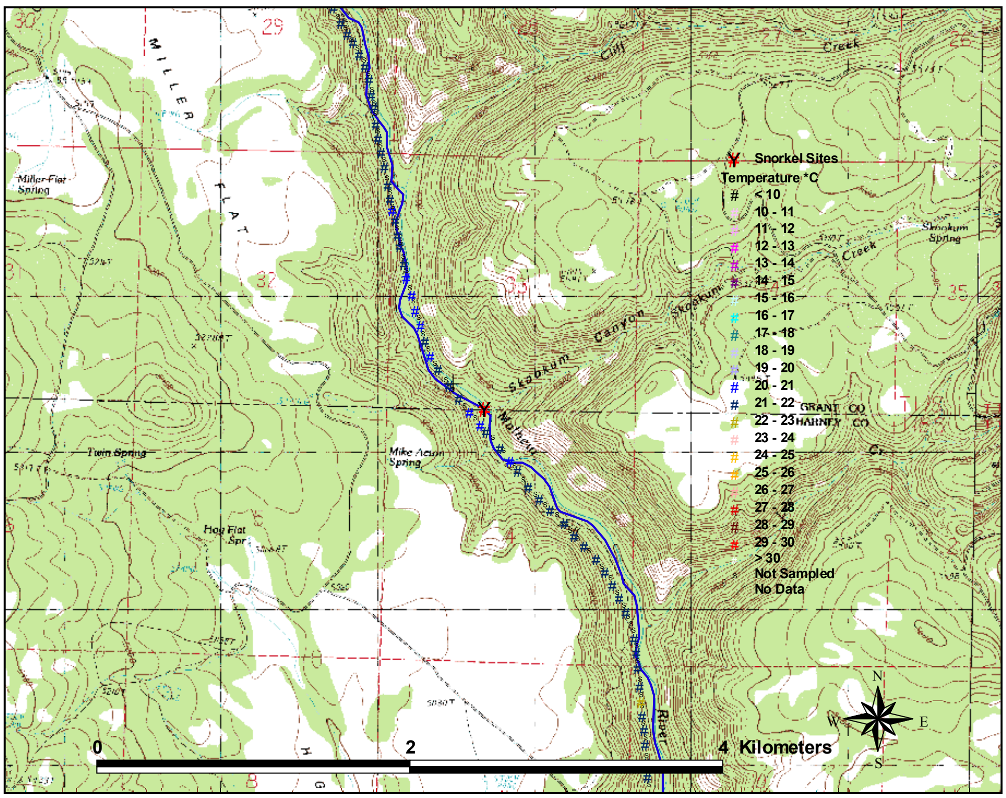

Figure 52. Site 1 snorkel site, identified as potential cool water refugia for bull trout during times of peak maximum stream temperatures.

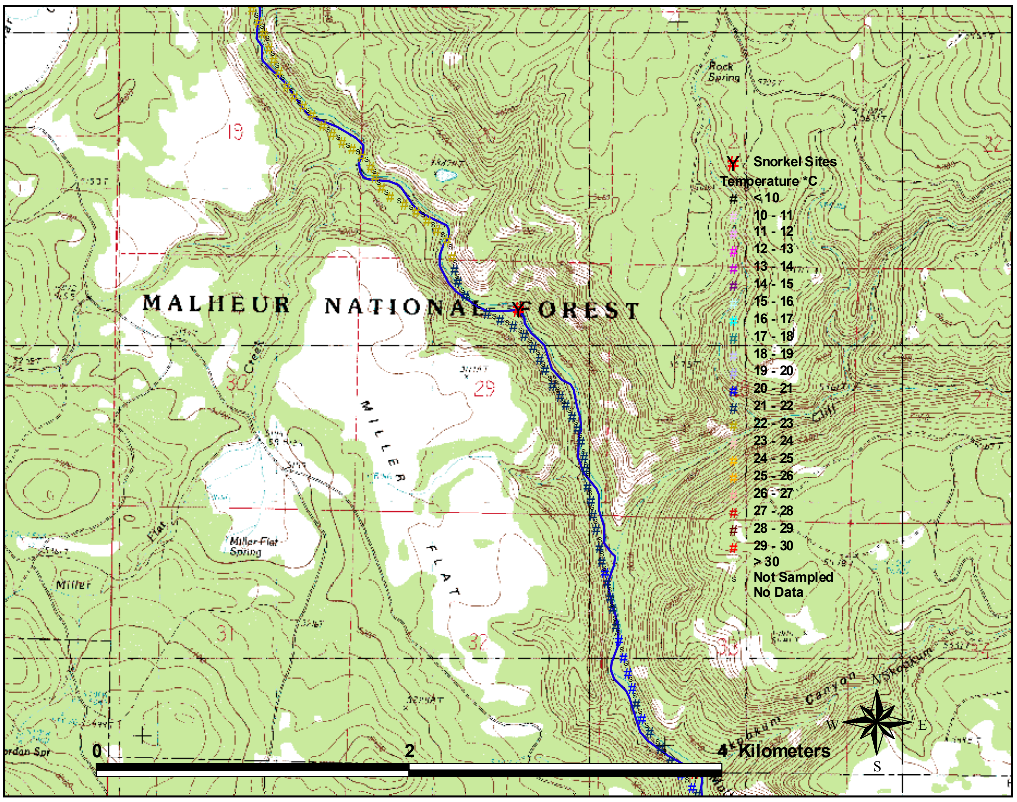

Figure 53. Site 2 snorkel site, identified as potential cool water refugia for bull trout during times of peak maximum stream temperatures.

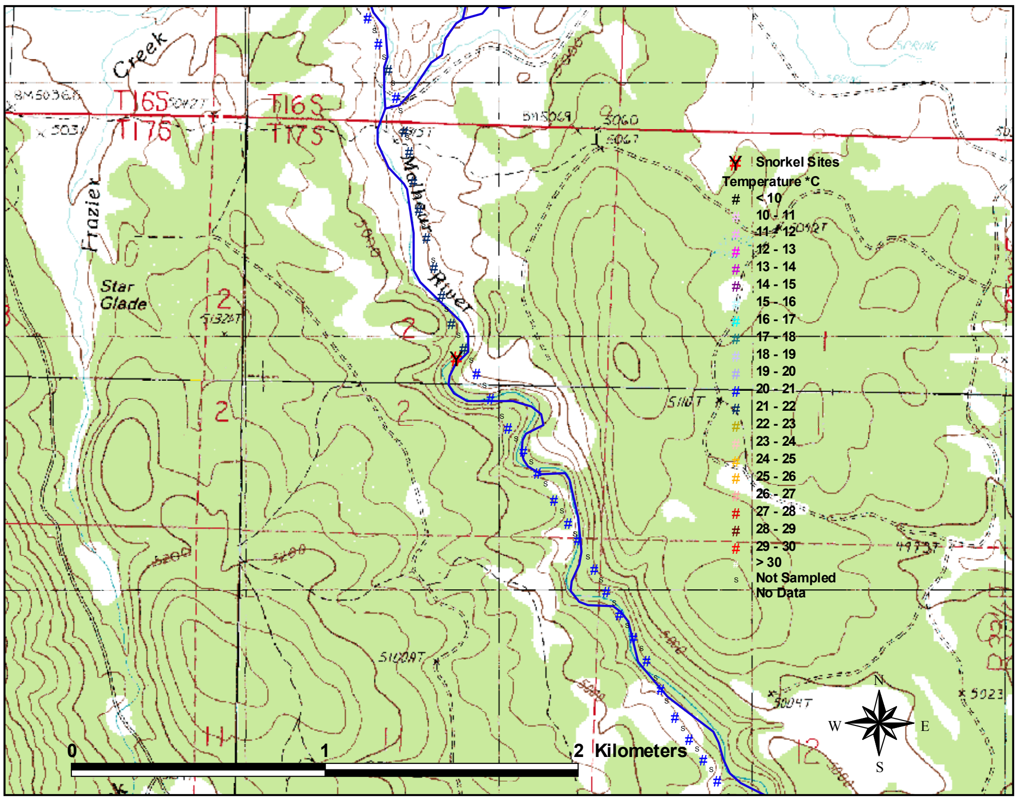

Figure 54. Site 3 snorkel site, identified as potential cool water refugia for bull trout during times of peak maximum stream temperatures.

PRESENCE/ABSENCE OF BULL TROUT AT JONESBORO, OREGON, 2002

By Jason Fenton, Burns Paiute Tribe

Introduction

The Burns Paiute Tribe (BPT) and the Oregon Department of Fish and Wildlife (ODFW) conducted this study to document whether bull trout *Salvelinus confluentus* reside in the Malheur River on the Malheur River Ranch (formerly known as the Jonesboro property), located 11 kilometers east of Juntura, Oregon (see Figure 55). The BPT acquired this property in November 2000 with BPA funding. Bull trout, highly dependant on temperatures, are considered a cold-water species. The Malheur River at Jonesboro, Oregon, flows through an area heavily impacted by irrigation and cattle grazing. Water temperatures during August can exceed 23 °C. Two dams upriver of the study site have no upstream passage for fish that are entrained through the dams. Bull trout entrainment at Agency Valley Dam has been documented (Schwabe 2000); bull trout may be present at this downstream location.

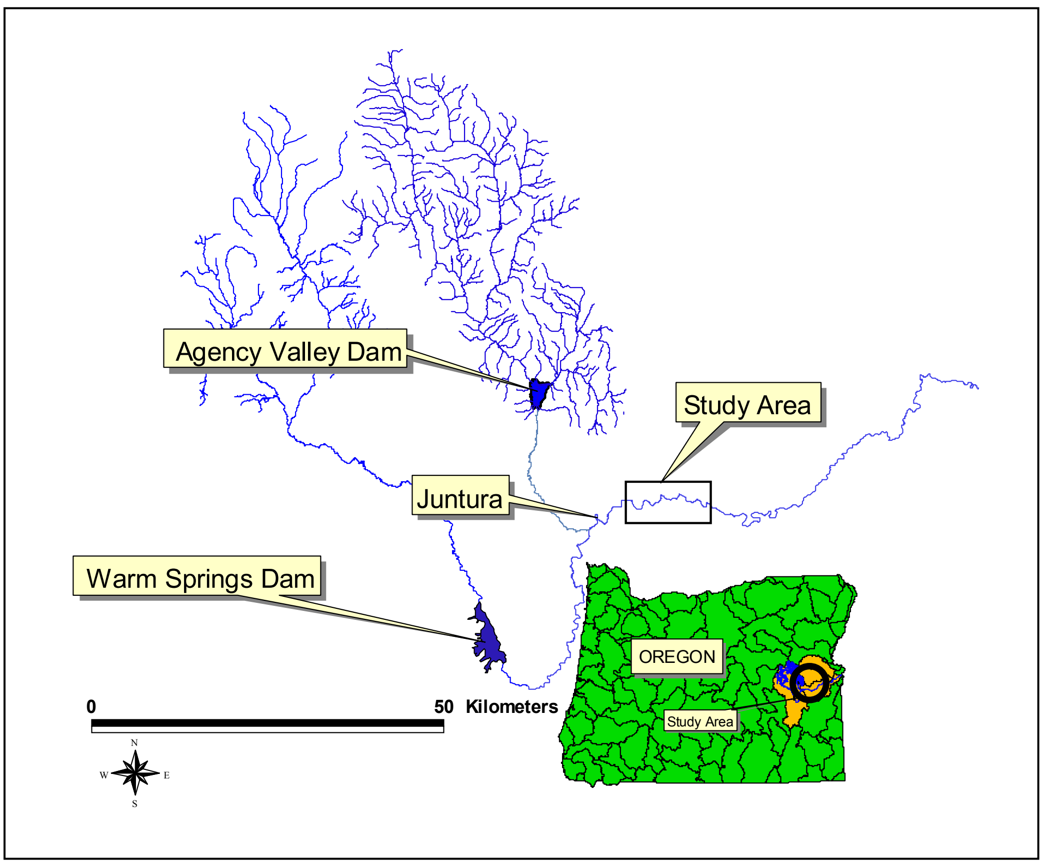

Figure 55. Location of Malheur River Study Area at Jonesboro, Oregon, 2002.

The objectives of this study are:

- Document the presence/absence of bull trout.
- Determine what fish species reside in the Malheur River at Jonesboro.

This study was conducted August 20 to August 23, 2002.

Methods

Nine units along an 11-kilometer reach of the Malheur River at Jonesboro were selected as representative habitat sites (see Figure 56). Each unit had at least two riffles and two pools. If an area was over one meter deep, it was not considered for the study. The shocking team started at the bottom of the unit and worked upstream to the end, which was usually a pool at the bottom of a riffle.

The study used a small drift boat with a generator and two handheld probes. One person walked behind the boat to steer and to control the safety shutoff switch. One person on either side of the boat held a shocker probe. A person with a dip net accompanied each shocker probe.

All captured fish were placed in a holding bucket with an aerator to supply oxygen. All fish tallied; all salmonids were measured. After processing, the fish were released into the nearest pool.

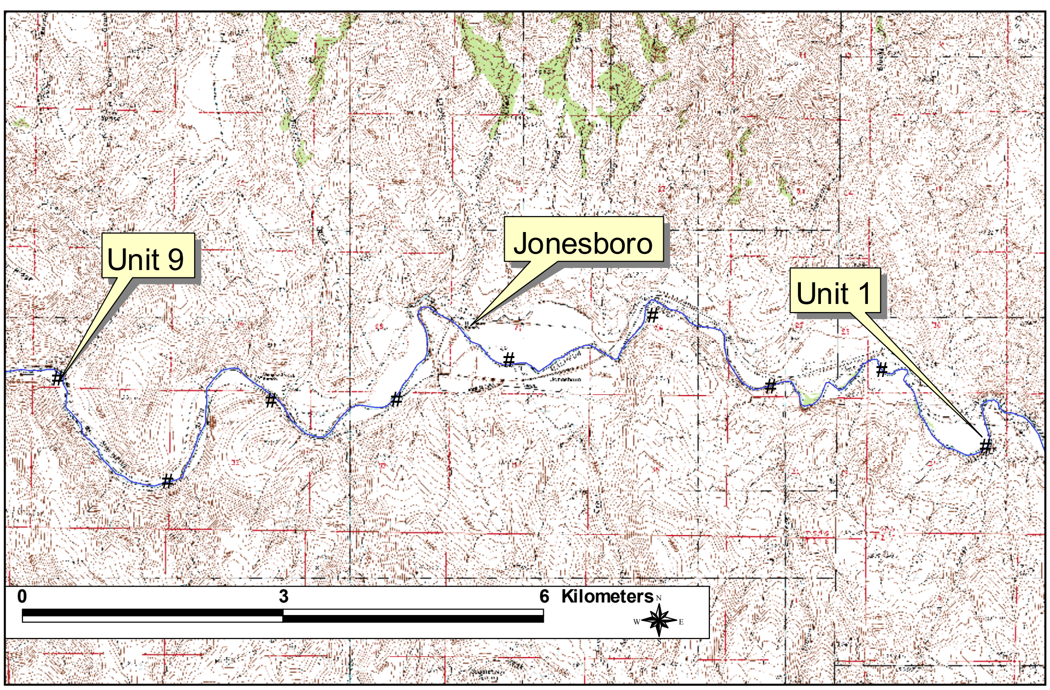

Figure 56. Malheur River Study Area at Jonesboro, Oregon, 2002.

Results

The temperature for the shocked units ranged from 17 °C to 23 °C. Nine fish species were identified:

- Bridge Lip Sucker *Catostomus columbianus*
- Coarse Scale Sucker *Catostomus occidentalis*
- Northern Pike Minnow *Ptychocheilus oregonensis*
- Red Side Shiner *Richardsonius balteatus*
- Speckled Dace *Rhinichthys osculus*
- Long Nose Dace *Rhinichthys cataractae*
- White Crappie *Pomoxis annularis*
- Chisel Mouth Chub *Acrocheilus alutaceus*
- Rainbow Trout *Oncorhynchus mykiss*

Table 44 shows the sizes and locations for captured rainbow trout. Table 45 shows the number and distribution of captured fish. With the exception of white crappie and rainbow trout, all species of fish were distributed fairly evenly. No bull trout were observed during the study.

Table 44. Rainbow Trout Captured in Malheur River at Jonesboro, Oregon, August 2002.

Date	Site	Fork Length (mm)
8/20/02	1	103
8/20/02	2	215
8/21/02	3	99
8/21/02	3	109
8/21/02	3	124
8/21/02	4	125
8/21/02	4	128
8/21/02	4	136
8/21/02	4	128
8/21/02	4	120
8/21/02	4	132
8/21/02	4	128
8/21/02	5	268
8/22/02	9	122
8/22/02	9	191

Table 45. Number of Fish Captured in Malheur River at Jonesboro, Oregon, August 2002.

Unit	Bridge Lip Sucker	Coarse Scale Sucker	Northern Pike Minnow	Red Side Shiner	Speckled Dace	Long Nose Dace	White Crappie	Chisel Mouth Chub	Rainbow Trout
1	18	29	3	12	18	2	0	5	1
2	34	7	1	6	4	0	0	5	1
3	27	15	1	22	1	2	0	0	3
4	78	16	10	43	12	0	1	27	7
5	79	21	2	2	6	3	0	8	1
6	7	27	12	8	19	0	0	7	0
7	4	20	8	5	31	8	1	2	0
8	55	2	1	5	36	7	0	1	0
9	18	30	3	33	19	7	0	4	2
Total	**320**	**167**	**41**	**136**	**146**	**29**	**2**	**59**	**15**

Discussion

Some pools in this stretch of river were too deep to sample. Bull trout could reside in these pools if the bottom water temperature was sufficiently cool. Since some bull trout have passed through Agency Valley Dam, some may have survived. However, with bull trout spawning grounds above the dams and no fish passage facilities around the dam, bull trout in this area would likely become non-existent.

More work needs to be done to determine if bull trout reside below the dams. Some of the deeper pools should be snorkeled to determine if the bull trout could survive until winter. However, it is unlikely that any adult bull trout are over wintering in this area.

The BPT has documented that in the spring, adult bull trout are migrating upstream towards the headwaters (Schwabe 2000). Adult bull trout below the reservoir tended to remain in the tailrace. If these bull trout are not trapped and hauled above the dam, summer water temperatures may be too high for survival. Bull trout that return in the fall are not in danger of entrainment because water releases are not occurring.

References

Schwabe, L.T. 2000. Evaluate the life history of native salmonids within the Malheur subbasin. Bonneville Power Administration project # 9701900 / 9701901.

BULL TROUT SPAWNING SURVEY REPORT, 2002

By Ray Perkins, Malheur Fish District

Introduction

Bull trout *(Salvelinus confluentus*) were known to exist in the North Fork and in the Upper Malheur River watersheds prior to 1992. The Oregon Department of Fish and Wildlife (ODFW) initiated bull trout spawning surveys in the North Fork Malheur River watershed in 1992 as a result of increasing interest in the status of bull trout. These surveys were to provide trends in spawning bull trout abundance. The North Fork watershed was selected for initial surveys because it would be simpler to understand bull trout spawning without the presence of brook trout (*Salvelinus fontinalis*).

ODFW district staff and volunteers conducted surveys in 1992. Since then, additional cooperators have assisted with the surveys. Present survey participants include ODFW, Malheur National Forest, U.S. Fish and Wildlife Service, Burns Paiute Tribe (BPT), Bureau of Land Management, and a number of volunteers. This report summarizes data collected through 2002.

From 1992 to 1996, surveyors investigated numerous stream reaches to locate bull trout redds. Survey reaches were selected using stream habitat data and a population estimate completed in 1992 for upper North Fork tributaries. Stream reaches were surveyed in mid-September and mid-October. In 1997 stream reaches were surveyed in late August. Since 1997, stream reaches have been surveyed in late August, mid-September, and late September. Since 1997, Horseshoe Creek is the only new stream surveyed where redds were observed. Personnel changes prevented the 2002 surveys for the lower portion of Little Crane, Swamp, Cow, Little Cow, Flat, and Spring Creeks. These stream reaches were dropped to facilitate survey completion.

Spawning surveys began in the Upper Malheur River watershed in 1998. A 1994 stream habitat survey and population estimate for Meadow Fork, Snowshoe, Big, and Lake Creeks were used to select the initial stream reaches for survey. Since then, stream reaches in lower Summit and Bosonberg Creeks have been added and dropped, and stream reaches in Big and Summit Creeks have been added. In 2002, forest fires that burnt from Lake Creek to Big Creek prevented access to much of the watershed. One survey was completed on Meadow Fork and Snowshoe Creeks. Because Summit Creek was outside the fire boundaries, it had three completed surveys. No other watershed stream surveys were completed in 2002.

The areas being surveyed most likely constitute the core bull trout spawning areas in the North Fork Malheur River basin. All streams sections with known bull trout populations are currently being surveyed. The surveys also include many streams that have good habitat. Several other stream sections that historically contained bull trout have not yet been surveyed. Stream sections may be extended or dropped in the future to incorporate new information.

The main objectives for this study are:

- Determine where bull trout spawn.
- Determine when bull trout spawn.
- Determine the number of spawning bull trout.
- Determine the location and timing of brook trout spawning in relation to bull trout spawning in the Upper Malheur River watershed.
- Estimate time spent on redd construction.
- Estimate the number of adults per redd.

The first three objectives apply to both watersheds. The fourth objective applies specifically to the Upper Malheur River watershed and is an effort to separate bull trout spawning from brook trout spawning. The fifth and sixth objectives were added in 1999 to determine how many adults are associated with a single redd and how much time an adult spends on the spawning grounds. This information would allow better estimates for spawning adults. Currently, objectives 5 and 6 are being investigated only in upper Little Crane Creek.

Methods

Spawning surveys were completed on streams in the North Fork Malheur and Upper Malheur watershed streams known or suspected to support bull trout spawning. Stream reaches were surveyed on August 27 to August 29, September 10 to September 12, and September 24 to September 26. Two or more people surveyed each stream reach in an upstream direction with at least one experienced surveyor per team. The surveyors typically walked on opposite sides of the stream. Crews counted redds, recorded numbers of bull trout seen, and estimated total length of identified bull trout. All redds, except for the last survey, were flagged to avoid double counting on subsequent surveys.

Each crew used a GPS unit to record beginning and ending locations for each stream section; locations for redds; and locations for positively-identified bull trout. GPS readings were manually transferred to data sheets during surveys. Each GPS unit was set to record coordinates in decimal degrees or decimal minutes and used NAD 1983. All GPS coordinates were entered into ArcView 3.1 and mapped. Attempts were made to correct for GPS unit or recording errors when points were mapped.

In the Upper Malheur watershed, distinguishing the difference between bull trout and brook trout redds is impossible without identifying the fish creating each redd. Very few fish species were identified and directly associated with redds. Redds enumerated and mapped in the Upper Malheur watershed are an aggregate of both species. The mid-October survey in the Upper Malheur watershed is an attempt to differentiate peak bull trout and brook trout spawning times.

Little Crane Creek was surveyed three consecutive days during the first survey period in late August to estimate how many redds a bull trout pair might build and the amount of time a pair would spend on a redd. Each day, redd and bull trout locations were noted. The locations of bull trout with similar descriptions and length were then compared between days.

Results

North Fork Malheur River Watershed

North Fork Malheur River

The upper North Fork Malheur was surveyed three times. The survey began at the mouth of Deadhorse Creek and ended 2.9 miles upstream (see Appendix A, Figure 57). As in 2001, the water temperature in the upper half-mile of stream was too warm to necessitate surveying. No redds or bull trout were observed on August 27, five redds and no bull trout were observed on September 11, and three redds and no bull trout were observed on September 24 (see Table 46).

Table 46. Bull Trout Redds Observed in the North Fork Malheur River Mainstem.

Year	Redds	Miles	Redds per Mile
1992[1]	1	5.9	0.2
1993	1	15.5	0.1
1994	0	7.3	0.0
1995	0	6.0	0.0
1996	6	3.9	1.5
1997	10	2.3	4.4
1998	3	3.8	0.8
1999	9	3.5	2.6
2000	16	3.5	4.3
2001	5	3.0	1.7
2002	8	2.3	3.5

[1] Does not include 14 questionable redds observed by volunteers included in earlier reports.

Horseshoe Creek

Horseshoe Creek was surveyed three times. The survey began at the confluence with North Fork Malheur River and ended about 1.2 miles upstream (see Appendix A, Figure 57). No redds and one bull trout were observed on August 27, one redd and no bull trout were observed on September 11, and two redds and no bull trout were observed on September 24 (see Table 47).

Table 47. Bull Trout Redds Observed in Horseshoe Creek, Tributary to the North Fork Malheur River.

Year	Redds	Miles	Redds per Mile
1998	4	0.4	10.0
1999	4	0.8	5.0
2000	7	0.8	6.3
2001	6	0.6	10.3
2002	3	1.2	2.5

Deadhorse Creek

Deadhorse Creek was surveyed once in late August. The survey began at the confluence with North Fork Malheur River and ended about 0.8 miles upstream at Forest Road 13 (see Appendix A, Figure 57). No redds or bull trout were observed (see Table 48).

Table 48. Bull Trout Redds Observed in Deadhorse Creek, Tributary to the North Fork Malheur River.

Year	Redds	Miles	Redds per Mile
1999	0	0.8	0.0
2000	0	0.8	0.0
2001	0	0.8	0.0
2002	0	0.8	0.0

Flat Creek

Flat Creek was not surveyed in 2002.

Spring Creek

Spring Creek was not surveyed in 2002.

Swamp Creek

Upper Swamp Creek was surveyed three times. The survey began at RM 2 and continued upstream to RM 4 (see Appendix A, Figure 58). Reduced personnel prevented lower Swamp Creek from being included in the survey in 2002. One redd and no bull trout were observed on

August 27, 13 redds and 12 bull trout were observed on September 10, and five redds and five bull trout were observed on September 25 (see Table 49).

Table 49. Bull Trout Redds Observed in Deadhorse Creek, Tributary to the North Fork Malheur River.

Year	Redds	Miles	Redds per Mile
1992	0	1.2	0.0
1993	3	2.2	1.4
1994	9	3.9	2.3
1995	0	3.9	0.0
1996	8	3.8	2.1
1997	21	4.1	5.1
1998	24	4.2	5.7
1999	35	4.1	8.5
2000	40	4.1	9.8
2001	22	4.2	5.3
2002	19	2.0	9.5

Sheep Creek

Sheep Creek was surveyed three times. The survey began at the mouth and ended approximately 3.5 miles upstream (see Appendix A, Figure 58). One redd and 10 bull trout were observed on August 28, seven redds and two bull trout were observed on September 11, and nine redds and six bull trout were observed on September 24 (see Table 50).

Table 50. Bull Trout Redds Observed in Sheep Creek, Tributary to the North Fork Malheur River.

Year	Redds	Miles	Redds per Mile
1992	0	1.1	0.0
1993	0	2.2	0.0
1994	0	2.2	0.0
1995	2	2.9	0.7
1996	13	3.4	3.8
1997	8	2.9	2.8
1998	17	3.5	4.9
1999	22	3.0	7.3
2000	25	4.0	6.3
2001	15	3.5	4.3
2002	17	3.5	4.9

Cow Creek

Cow Creek was not surveyed in 2002.

Little Cow Creek

Little Cow Creek was not surveyed in 2002.

Elk Creek

Elk Creek was surveyed three times. The survey began at the confluence with North Fork Malheur River and covered 1.5 miles up the North Fork and 0.7 miles up the South Fork (see Appendix A, Figure 59). One redd and 13 bull trout were observed on August 28, four redds and two bull trout were observed on September 10, two redds and no bull trout were observed on September 24 (see Table 51).

Table 51. Bull Trout Redds Observed in Elk Creek and its Two Tributaries, the North and South Forks.

Year	Redds	Miles	Redds per Mile
1992	1	1.0	1.0
1993	1	2.3	0.4
1994	0	2.0	0.0
1995	1	4.0	0.3
1996	3	4.1	0.7
1997	9	4.1	2.2
1998	6	3.5	1.7
1999	12	3.0	4.0
2000	5	3.0	1.7
2001	3	3.2	0.9
2002	7	2.8	2.5

Crane Creek

Crane Creek was not surveyed in 2002.

Little Crane Creek

Little Crane Creek was surveyed four times. The survey began at the fence downstream from the campground enclosure and ended about 2.8 miles upstream at Road 1665-0498 (see Appendix A, Figure 60). The stream section was surveyed twice during the first week of surveys and once during each of the two following weeks of surveys. No redds or bull trout were observed on August 25, eleven redds and no bull trout were observed on August 26, 16 redds and seven bull trout were observed on September 11, and 18 redds and three bull trout were observed on September 25 (see Table 52).

Table 52. Bull Trout Redds Observed in Little Crane Creek, tributary to North Fork Malheur.

Year	Redds	Miles	Redds per Mile
1992			
1993	3	5.6	0.5
1994	4	7.5	0.5
1995	6	6.0	1.0
1996	8	6.0	1.3
1997	16	4.2	3.8
1998	20	6.0	3.3
1999	33	6.1	5.4
2000	60	6.1	9.8
2001	74	6.2	12.0
2002	45	2.8	16.1

Bull Trout Observations

Beginning in 1999, surveyors recorded the number and location of bull trout observed during spawning ground surveys. The number of bull trout observed during the North Fork surveys continued to decline from a peak of 272 fish in 2000 (see Table 53). In 2002, fish were difficult to see under blue skies and bright sun conditions. The number of larger (>13 inches) bull trout seen was almost even for each of the three survey periods, with two on the first pass, two on the second pass, and three on the third pass.

Table 53. Bull Trout Observed During Spawning Surveys on the North Fork Malheur River.

Stream	1999	2000	2001	2002	Total
Little Crane Creek	95	125	65	10	295
Swamp Creek	48	66	16	17	147
Sheep Creek	43	41	42	18	144
Horseshoe Creek	2	0	1	2	5
Upper North Fork	12	11	0	0	23
Elk Creek	18	24	9	15	66
Deadhorse Creek	0	0	0	0	0
Flat Creek	0		0	0	0
Spring Creek			0	0	0
Cow Creek		5	0	0	5
Little Cow Creek		0	0	0	0
Total	**218**	**272**	**133**	**62**	**685**

Bull Trout Observed On Redds

In the North Fork Malheur River watershed, a total of 9 redds (9 percent) had bull trout present. Bull trout were present on redds during all three surveys. Three redds had two bull trout in proximity, and no redds had more than two bull trout present. The average number of bull trout per redd was 2.0, which is the lowest observed to date. The low density of bull trout on redds may be the result of poor viewing conditions and low water.

Upper Malheur River Watershed

Summit Creek

Upper Summit Creek was surveyed three times. The survey began at a fence downstream from Road 1600-0598 and ended upstream about 1.4 miles (see Appendix B, Figure 61). No redds or bull trout were observed on August 27, 16 redds and no bull trout were observed on September 12, and 20 redds and no bull trout were observed on September 24 (see Table 54).

Table 54. Redds Observed in Summit Creek, Tributary to the Upper Malheur River, from Late August to Late September.

Year	Redds	Miles	Redds per Mile
1999	18	2.3	7.8
2000	43	4.8	9.0
2001	87	1.9	45.8
2002	19	1.4	13.6

Snowshoe Creek

Snowshoe Creek was surveyed once on September 11. The survey began at the confluence with Big Creek and ended about 1.4 miles upstream near the wilderness boundary sign. No redds or bull trout were observed (see Table 55).

Table 55. Redds Observed in Snowshoe Creek, Tributary to Big Creek, from Late August to Late September.

Year	Redds	Miles	Redds per Mile
1998	10	1.7	5.9
1999	25	1.7	14.7
2000	3	1.7	1.8
2001	16	1.7	9.4
2002	0	1.4	0.0

Big Creek

Big Creek was not surveyed in 2002.

Meadow Fork Big Creek

Meadow Fork was surveyed once on September 11. The survey began at the confluence with Big Creek and ended 3.2 miles upstream at a waterfall (see Appendix B, Figure 62). Sixteen redds and no bull trout were observed (see Table 56).

Table 56. Redds Observed in Meadow Fork Big Creek, Tributary to Big Creek, from Late August to Late September.

Year	Redds	Miles	Redds per Mile
1998	39	3.3	11.8
1999	25	3.3	7.6
2000	51	3.3	14.8
2001	92	3.2	28.9
2002	16	3.2	5.0

Lake Creek

Lake Creek was not surveyed in 2002.

Bosonberg Creek

Bosonberg Creek was not surveyed in 2002.

Discussion

Survey techniques and timing varied from 1992 to 1995. During these years, project personnel struggled with spawning timing and location uncertainties. Consequently, there was variation in timing of surveys and areas surveyed. In addition, livestock were abundant in some spawning areas, making identification of redds difficult. However, survey data can be compared effectively from 1996 to the present. Survey areas and timing have been standardized. Surveyor expertise and area familiarity have increased. Livestock management changes have also reduced stream disturbance and made redds more easily identifiable.

A total of 99 redds were observed in the North Fork Malheur River watershed in 2002. This was a 21 percent decline from the 125 redds in 2001 (see Appendix C, Figure 63). Little Crane Creek, Swamp Creek, and Sheep Creek continue to be prime spawning areas for bull trout. In 2002, these streams contained 89 percent of all redds counted. Good spawning habitat seems to be concentrated in small areas of these three streams (see Appendix A, Figure 58 and Figure 60). Spawning activity is known to occur in three other streams but at comparably low levels.

Little Crane Creek's 23 percent decline in redds counted was the largest. The other streams varied little from 2001 counts. Swamp Creek decreased by two percent, Sheep Creek increased by two percent, Horseshoe Creek decreased by two percent, the upper North Fork Malheur River increased by two percent, and Elk Creek increased by three percent.

Redds were concentrated in areas with the best habitat conditions, particularly those with strong groundwater influence. In Little Crane Creek, few redds were observed downstream of the enclosure fence. In Swamp Creek, most redds were concentrated in the upper mile of the upper stream section surveyed. In Sheep Creek, most redds were concentrated in an area about a mile from the mouth. In the upper North Fork Malheur River reach, redds were observed in a short section of stream between a large boggy meadow near River Mile 58 and Forest Road 1370 near RM 55 (see Appendix A, Figure 57). All of these areas have strong ground water influence.

Most of the Upper Malheur River watershed stream sections surveyed were located in the High Lakes – Roberts Forest Fire boundary, which limited access. During the first survey, the actively-burning fire prevented access. During the second survey, only forest service personnel were able to access streams in the fire boundary. Summit Creek was the only stream section surveyed three times in 2002; Meadow Fork and Snowshoe Creeks were only surveyed once.

Drought conditions in 2001 and 2002 have been associated with a 34 percent decline in the number of redds counted in the North Fork Malheur River bull trout population. Changes in redd counts varied by stream within the North Fork Malheur River watershed. In 2001, all streams except Little Crane Creek had significant declines in redds counted. In 2002, Little Crane Creek was the only stream with a large decline.

Operations at Beulah Reservoir may or may not be impacting adult bull trout in the North Fork Malheur River watershed. During the winter of 2000-2001, the Beulah Reservoir water level ranged from 11,000 acre-feet on October 1, 2000, to 36,000 acre-feet on March 31, 2001. The number redds counted dropped 17 percent from 150 in 2000 to 125 in 2001. However, during the winter of 2001-2002, a small pool was maintained. The Beulah Reservoir water level ranged from 2,000 acre-feet on October 1, 2001, to 31,000 acre-feet on March 31, 2002. The number of redds counted dropped 21 percent from 125 in 2001 to 99 in 2002.

The presence of brook trout complicates the documentation of drought impacts in the Upper Malheur River watershed. Between 2000 and 2001, the number of redds counted in the North Fork Malheur River watershed decreased while the number of redds counted in the Upper Malheur River watershed increased. Limited access from forest fires further complicated the comparison of redd counts. Redd counts in 2002 in Meadow Fork appear to be similar to counts over same time in 2001, but redd counts in Summit Creek were slightly down.

Continued drought may impact bull trout populations in 2003. Winter snowpacks are well below normal and reservoir levels are not expected to be significantly better than those in 2002.

Appendix A. Locations of Bull Trout Redds Observed during Spawning Surveys in the North Fork Malheur Watershed in 2001

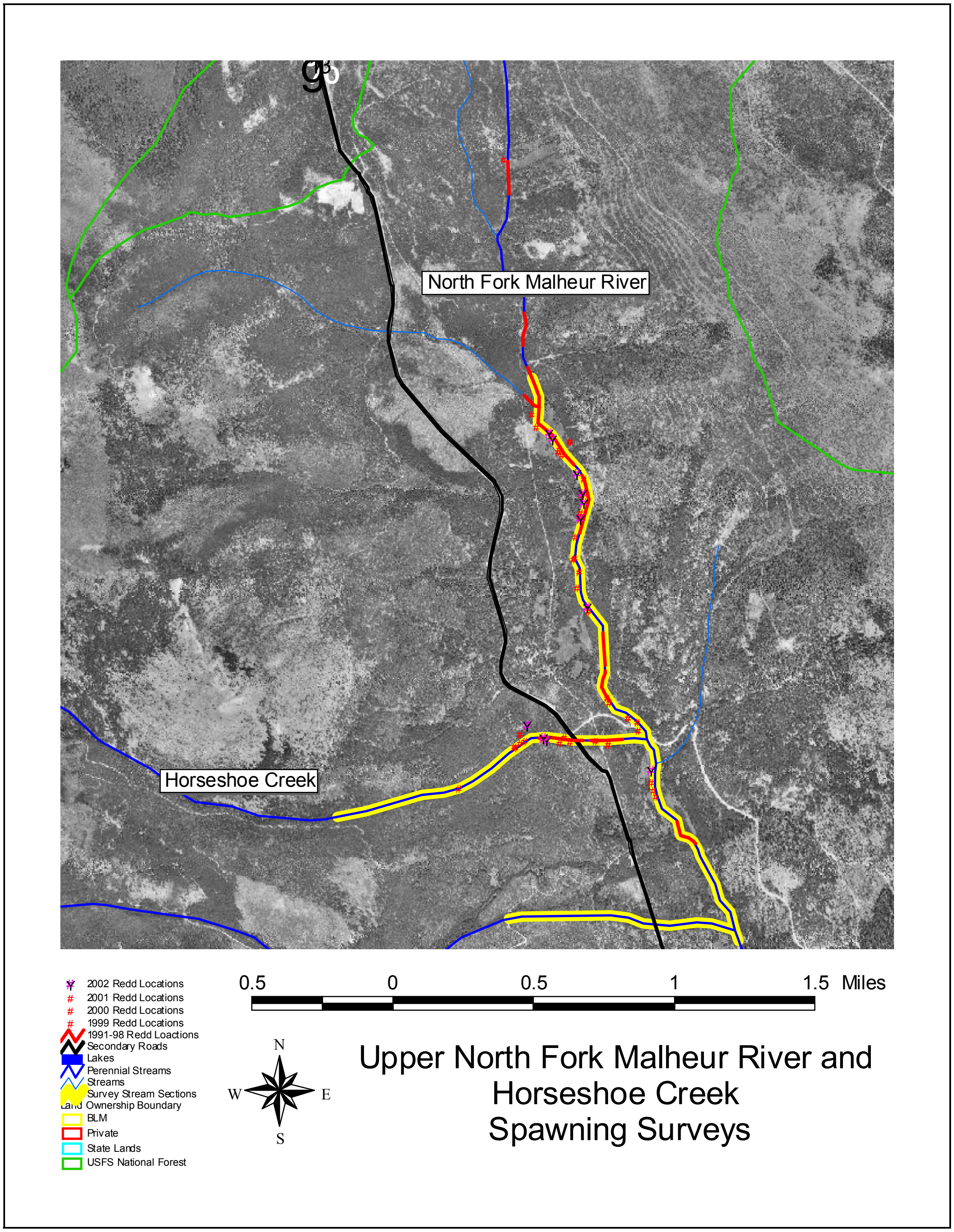

Figure 57. Bull trout redds observed in Horseshoe, Deadhorse, and upper North Fork Malheur River stream sections in 2002.

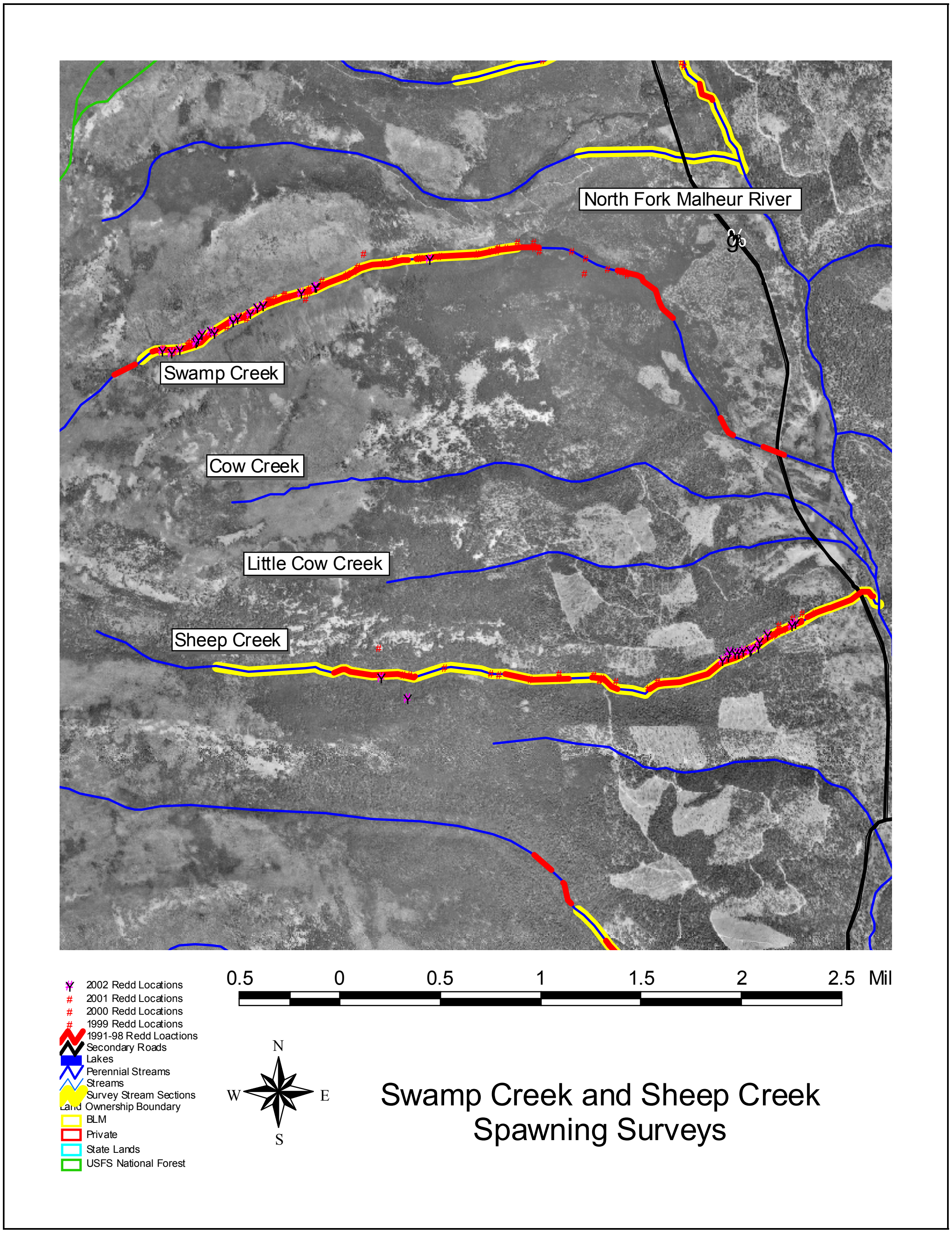

Figure 58. Bull trout redds observed in Swamp, Cow, Little Cow, and Sheep Creeks in 2002.

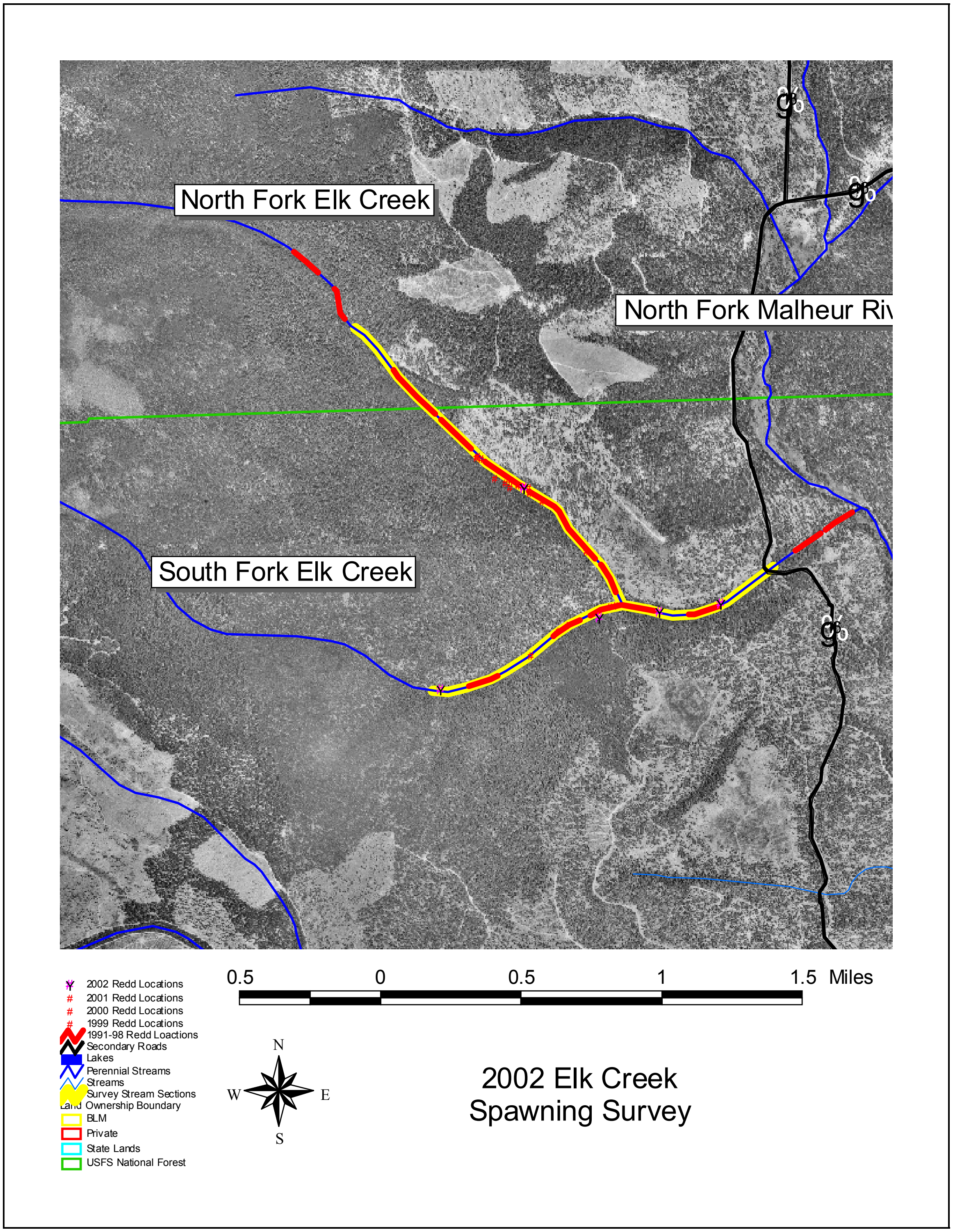

Figure 59. Bull trout redds observed in Elk Creek stream sections in 2002.

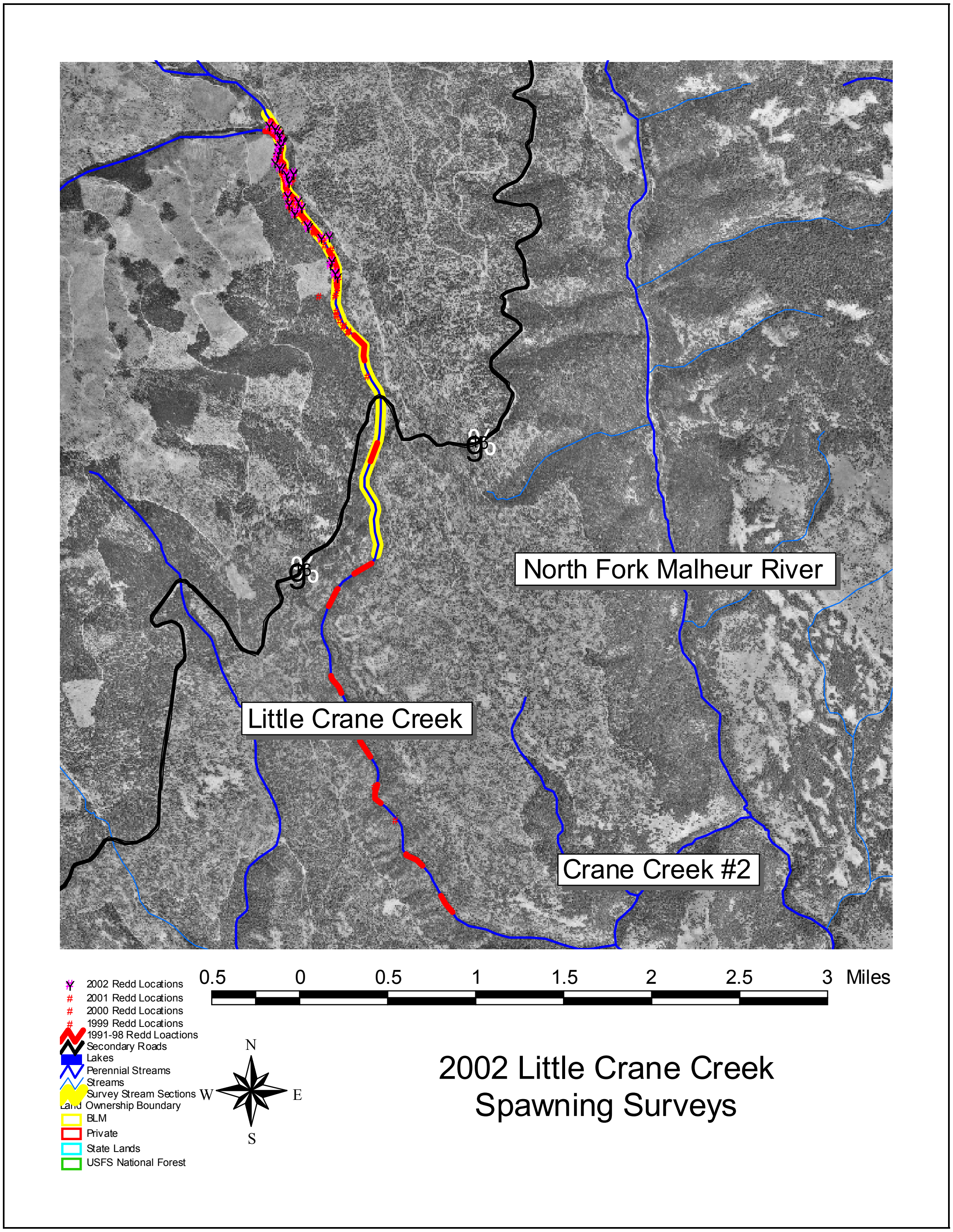

Figure 60. Bull trout redds observed in Little Crane Creek stream sections in 2002.

Appendix B. Locations of Redds in the Upper Malheur River Watershed in 2002

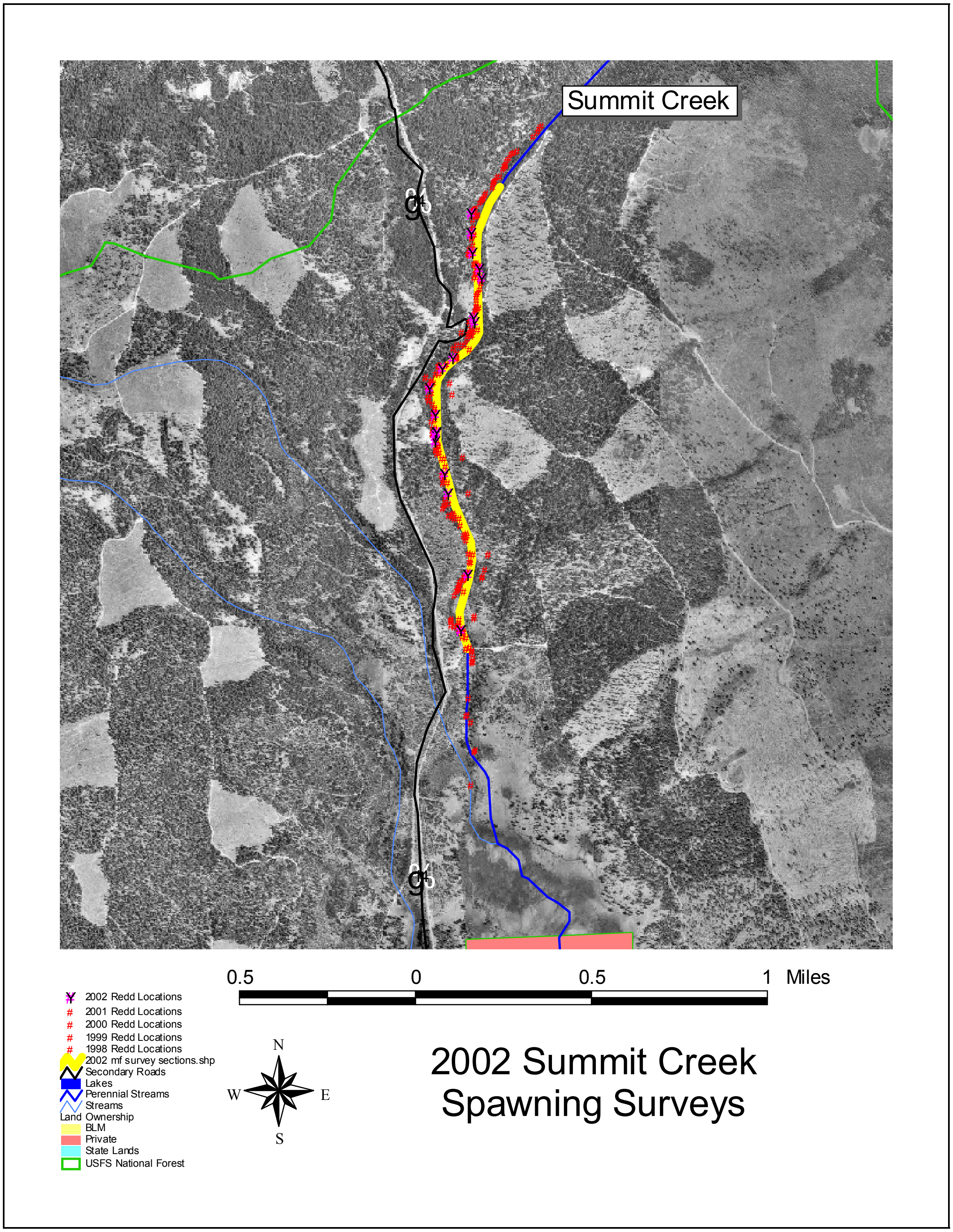

Figure 61. Bull trout redds observed in Summit Creek stream sections in 2002.

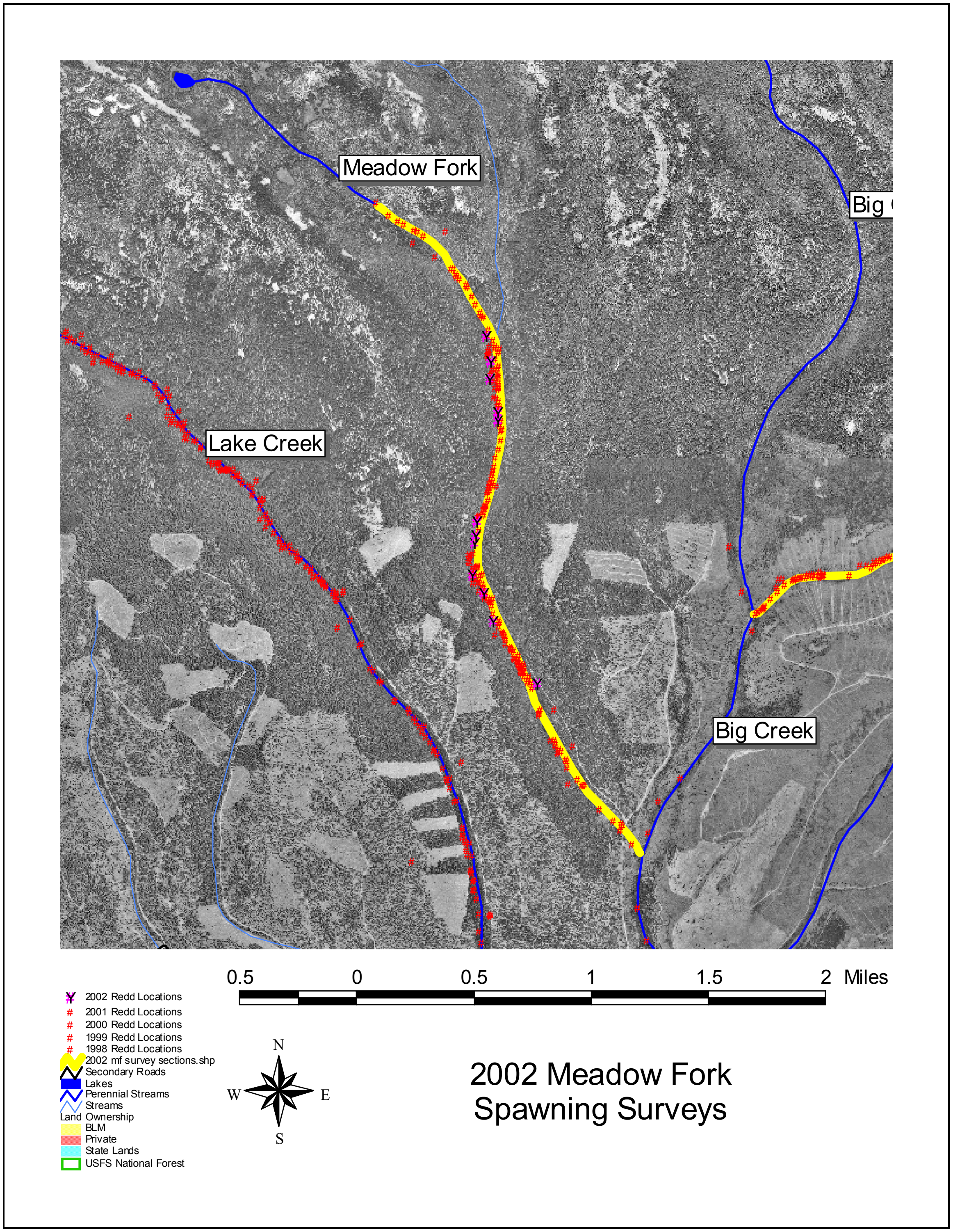

Figure 62. Bull trout redds observed in Meadow Fork stream sections in 2002.

Appendix C. Total Redds Observed in the Upper Malheur River and North Fork Malheur Watersheds from 1992 to 20

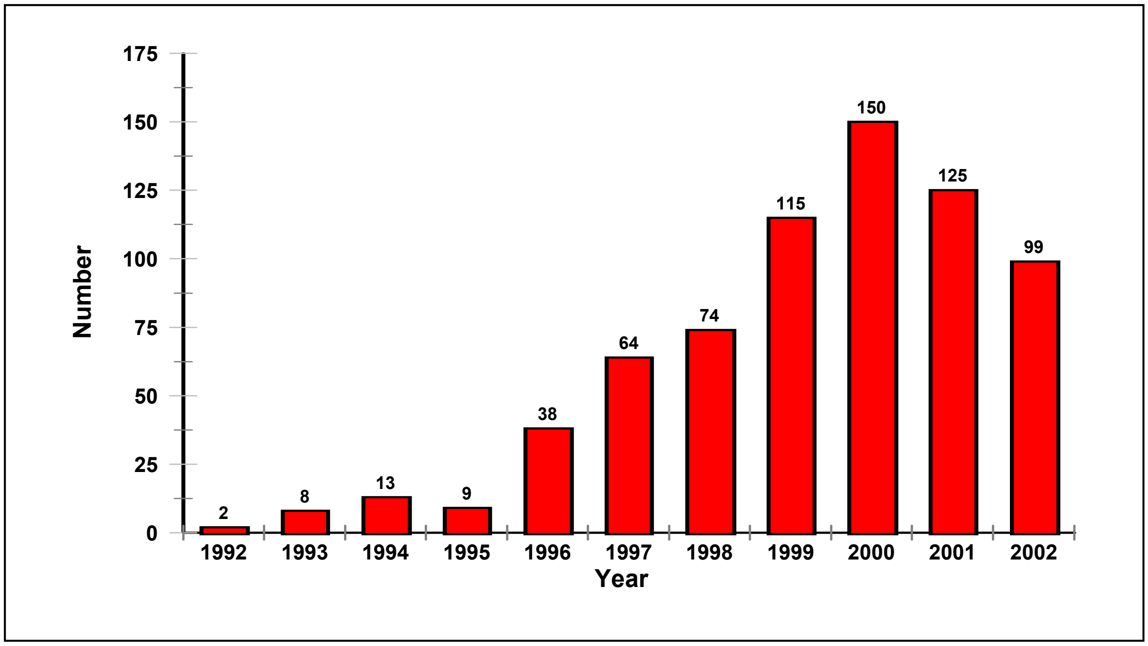

Figure 63. Bull trout redds observed in the North Fork Malheur River watershed from 1992 to 2002.

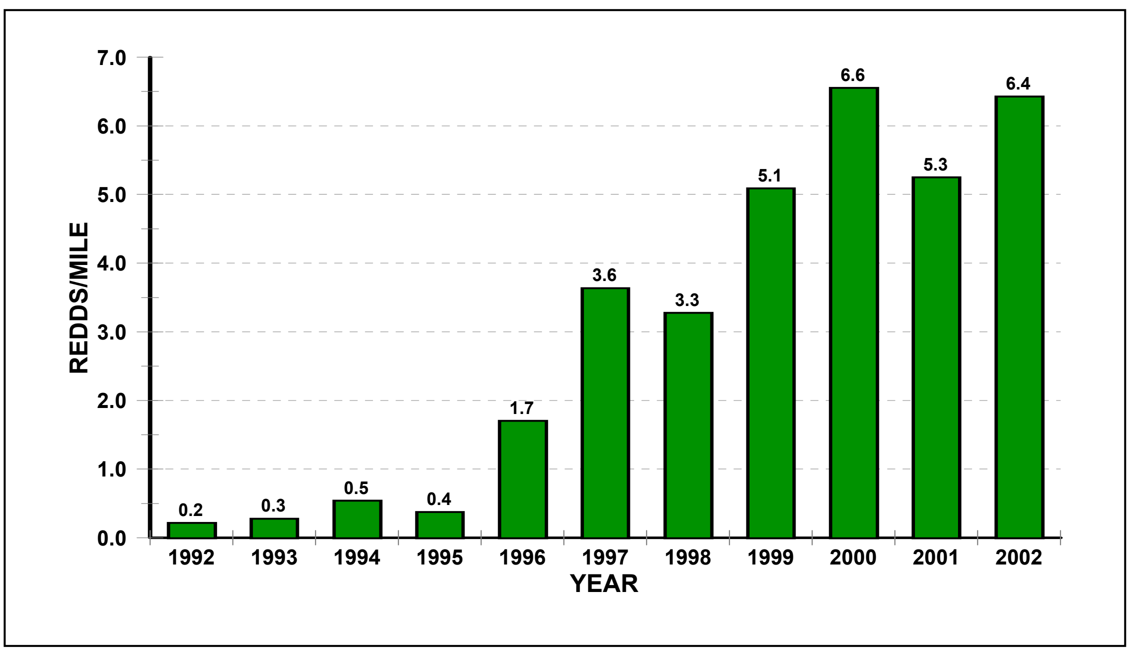

Figure 64. Bull trout redds per mile of stream observed in the North Fork Malheur River watershed from 1992 to 2002.

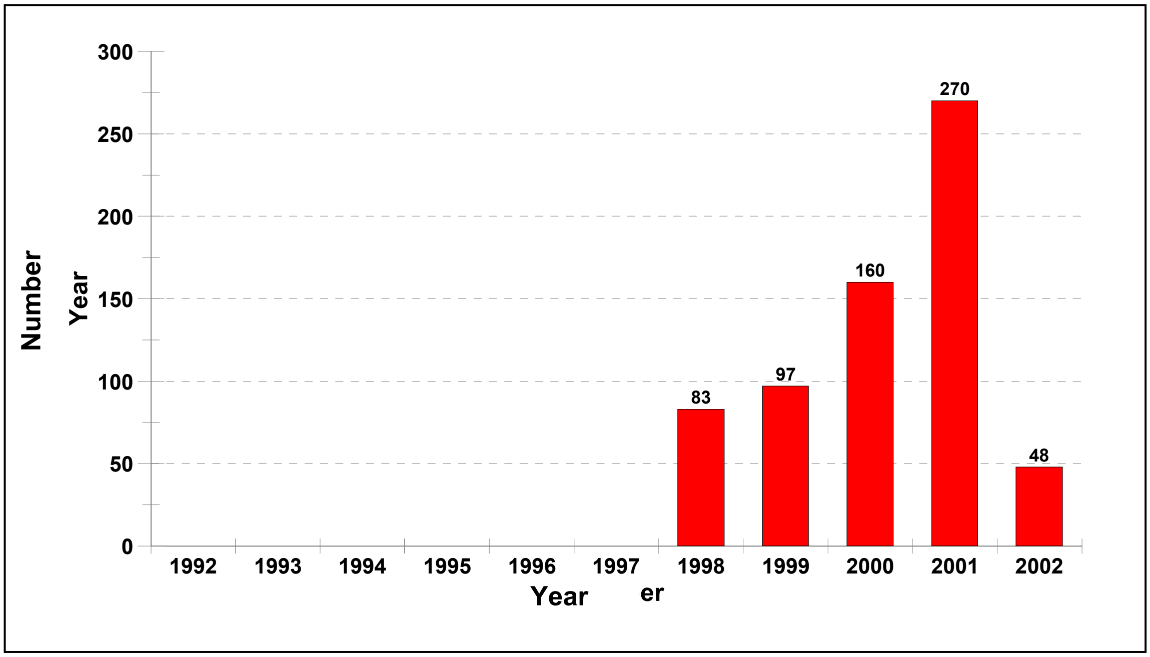

Figure 65. Redds observed in the Upper Malheur River watershed during August and September from 1998 to 2002. The counts for 2002 only include counts from Meadow Fork, Snowshoe, and Summit Creeks.

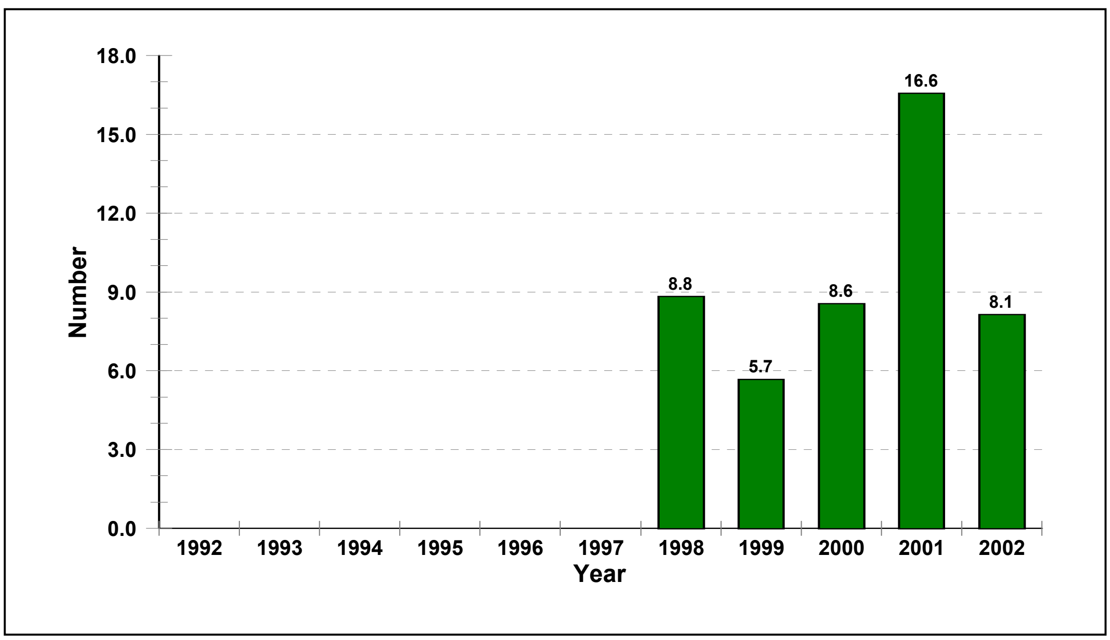

Figure 66. Redds per mile in the Upper Malheur River watershed during August and September from 1998 to 2002. The counts for 2002 only include counts from Meadow Fork, Snowshoe, and Summit Creeks.