UPPER DESCHUTES RIVER BASIN REMAP:

1997-98 VERTEBRATE SUMMARY

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INTRODUCTION

Water monitoring programs have historically focused on water chemistry as the way to interpret the integrity of a water body. Recently more water monitoring programs have begun incorporating biological data into the assessment process. The inclusion of biological data is important in several respects. Changes in water chemistry parameters can influence the composition of biological communities. Also, aquatic organisms may respond to changes in water quality below current detection capabilities. Another reason to include biological data--as well as physical, geological, and habitat data—is that water quality is not the only limiting factor in aquatic systems. A holistic approach to monitoring is more likely to accurately reflect the true conditions within a system.

Vertebrate assemblages make up an important component of most aquatic ecosystems, serving as grazers on algae and macrophytes, filter feeders, and predators of macroinvertebrates and other fish. Fish are a food source for terrestrial predators and play an important role in the nutrient and mineral cycles of aquatic ecosystems. For humans, fish provide food, recreation, and in some indigenous cultures they play a significant cultural role. Because vertebrates occupy such a vital position, it is important to include vertebrate assemblage data when assessing the integrity of aquatic systems.

What is REMAP?

In the summer months of 1997 and 1998 the Oregon Department of Environmental Quality performed stream surveys for the Regional Environmental Monitoring and Assessment Program (REMAP). The REMAP program is a spin-off of the national Environmental Monitoring and Assessment Program (EMAP), which focuses on determining ecological conditions at a large scale—national, western states, Mid-Atlantic states, etc. Both projects are funded by the United States Environmental Protection Agency (USEPA). The objective of EMAP is to provide decision-makers with objective data to make informed and effective environmental policies and regulations. Also, EMAP is designed to monitor changes in environmental quality over time through repeat sampling (EPA 1997).

REMAP uses similar methods as EMAP, but is focused at a smaller scale, such as a river basin or an ecoregion. The primary objective of the Deschutes REMAP project was to assess status and trends of the aquatic natural resources in the Upper Deschutes River basin (above Lake Billy Chinook). In order to assess conditions of the upper basin as a whole, survey sites were selected randomly throughout the study area.

The Upper Deschutes River basin—Background

The Upper Deschutes River basin is located in Central Oregon (Figureure 1). Major sub-basins include the Crooked, Metolius, Little Deschutes and Deschutes rivers. The Upper Deschutes basin is located within parts of Jefferson, Deschutes, Klamath, and Crook counties (with small portions of the basin in Lake, Harney, Wheeler, and Grant counties).

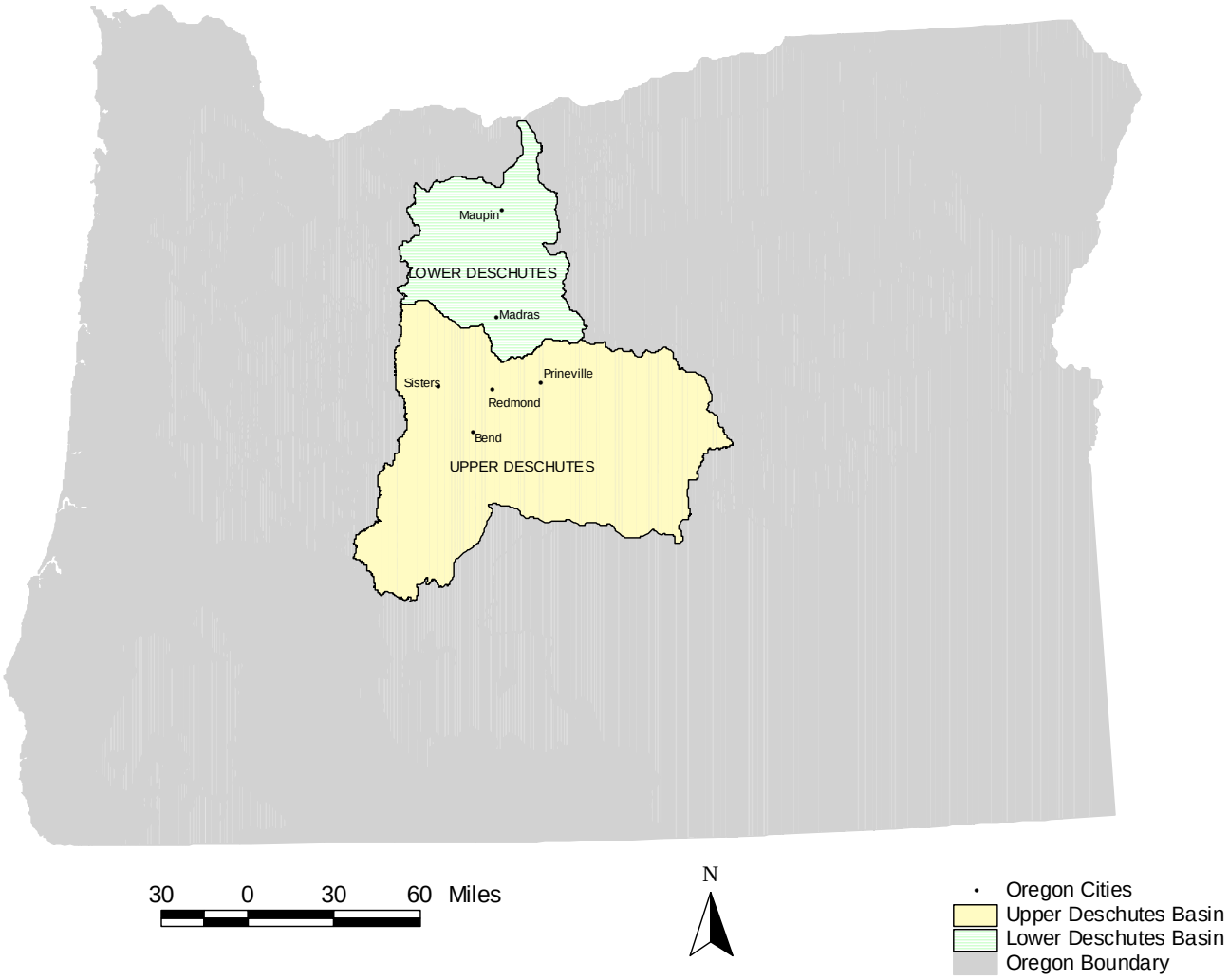


Figure 1 - Upper and Lower Deschutes Basins

Major urban centers include Bend, Prineville, and Redmond. Major land coverages include less than 8% agricultural/urban/industrial, nearly 50% coniferous forest, approximately 15% juniper and sage rangelands, and nearly 12% shrub and non-coniferous forests (Moore 1995). Land uses include urban development, agriculture/grazing, logging/forestry, recreational, and mining.

The Upper Deschutes River basin consists of three major sub-basins: the Crooked River, the Metolius River, and the Deschutes River. The Metolius sub-basin is located in the Eastern Cascades and Foothills ecoregion (Pater et al. 1998). The Deschutes sub-basin includes both the Eastern Cascades and Foothills ecoregion in the upper watersheds and the Snake River/High Desert ecoregion in the lower reaches of the sub-basin (Pater et al. 1998). The Crooked sub-basin has its origins in the Blue Mountains ecoregion, but it too makes a transition into the Snake River/High Desert ecoregion in the lower reaches (Pater et al. 1998).

The Metolius River sub-basin is located in the northwest corner of the Upper Deschutes River basin. It drains Blue and Suttle Lakes from the south and the eastern faces of Three Fingered Jack and Mount Jefferson. Major tributaries include Jefferson Creek and the Whitewater River. The Metolius sub-basin is highly spring fed, which helps to maintain steady flows and low temperatures year round. The Metolius is an important habitat base for bull trout, currently on the Endangered Species List. Primary land uses are logging and recreation, while residential land use is low. There is also some agriculture and grazing in the sub-basin. Road density, due to logging, can be somewhat high in areas. The northernmost tributaries are located on tribal lands in the Warms Springs Reservation.

The Deschutes sub-basin drains the east slope of the Cascades. Its major tributaries are Squaw Creek, the Little Deschutes River, and the Deschutes River. Much of the stream flow is regulated in the Deschutes sub-basin (mostly for irrigation), with impoundments at Crescent, Crane Prairie and Wickiup Reservoirs. Most of the Deschutes sub-basin is located in the Eastern Cascades and Foothills ecoregion. The lower section of the Deschutes sub-basin, including the lower reaches of Squaw Creek and the Deschutes River downstream of Bend, flows through the Snake River/High Desert ecoregion. The primary land uses in the Deschutes sub-basin include logging, recreation, agriculture, and urban development. Human disturbances progressively increase in the lower sections of the sub-basin.

The Crooked sub-basin, located in the Blue Mountains ecoregion, drains the Ochoco Mountains in the upper reaches. The lower section of the Crooked sub-basin flows through the Snake River/High Desert ecoregion, beginning at Prineville Dam. Due to the fact that the Crooked sub-basin originates in the Blue Mountains ecoregion, water chemistry conditions are more similar to the John Day River than the Deschutes River sub-basin. Land uses are dominated by agriculture/grazing and logging, but also includes urbanization and recreation. Streamflow is regulated at Ochoco and Prineville Reservoirs. Just as in the Deschutes sub-basin, water withdrawals for irrigation are high.

The Upper Deschutes River basin receives lower levels of precipitation than areas to the west. In the Deschutes sub-basin, average annual preciptation levels are 8.62 inches in Redmond and 11.70 inches in Bend (Oregon Climate Service 2000). In the Metolius sub-basin, the average annual precipitation level is 14.18 inches in Sisters and 9.96 inches in Metolius (Oregon Climate Service 2000). Average annual precipitation levels in the Crooked sub-basin range are 10.74 inches in Prineville, 12.49 inches in Paulina, and 17.10 inches at the Ochoco Ranch (Oregon Climate Service 2000). These lower precipitation levels are primarily a function of the rainshadow cast by the Cascades.

Historically, fish assemblages of the Deschutes River basin were dominated by steelhead, chinook, and bull trout (Marx 2000). The non-passable dams placed on the Deschutes River eliminated anadromous runs (steelhead and chinook) into the Upper Deschutes River basin. Also, sculpins were widely distributed throughout the basin (Marx 2000).

Past fish stocking patterns resulted in the introduction of non-native brown and brook trout to Deschutes sub-basin and Metolius sub-basin streams. Current stocking in streams in the Upper Deschutes River basin is limited to legal sized rainbow trout in sections of the South Fork Crooked River and Ochoco Creek (Crooked River sub-basin) and Fall River and the Deschutes River below Wickiup Reservoir (Deschutes sub-basin) (Marx 2000).

PURPOSE

To assess the status and trends of the aquatic natural resources in the Upper Deschutes River basin water chemistry, riparian habitat, macroinvertebrate, and vertebrate data were collected. This report provides a summary of the results of DEQ's REMAP vertebrate sampling in the Upper Deschutes River basin during the summer months of 1997-1998. Also, this report provides preliminary analyses of the fish assemblages in an attempt to determine spatial and temporal patterns throughout the basin.

METHODS

Fish and amphibians were captured using single-pass electrofishing along a 40-channel width stream segment (McCormick and Hughes 1997). Stunned fish were netted, placed in a bucket of cold water and allowed to recover. The fish were then identified, tallied, and measured for total length (cm) before being returned to the stream. The survey time was adjusted for the reach length to roughly normalize the effort between sites. The sampling effort was distributed proportionately among the different habitat types encountered to insure an unbiased sample. Abnormalities and incidental mortality were recorded. Voucher specimens were collected for species that were difficult to identify in the field for verification in the laboratory. Sculpins are among the most difficult freshwater fish to identify in North America (Page and Burr 1991). For this reason, specimens of sculpins from each site were identified in the laboratory.

Single-pass electrofishing methods bring inherent problems to the analysis of fish data. First, while the REMAP methods have shown that a reach length 40x the wetted channel width length typically captures all species within a given site, it is never certain. Second, single-pass electrofishing generates presence/absence and *relative* abundance , or proportional data. One major shortfall of this method is the inability to accurately assess population or productivity levels.

Riparian habitat, water chemistry, and biological information were collected at 55 second and third order wadeable streams (Figureure 2). Not all parameters were collected at every survey site. For example, chemistry, macroinvertebrates, and fish were not collected at dry sites (six sites). Also, fish were not collected at some streams (in the Metolius sub-basin) due to the presence of bull trout. Vertebrate surveys were completed at 47 sites (26 in 1997 and 21 in 1998), including repeat visits for quality assurance purposes. Some sites were removed from the data set used for "regional comparisons"

(repeat visits and the one site in the Metolius basin where vertebrates were collected). A total of 41 sites were used for the "vertebrate collection summary." Temperature data were collected using continuous monitoring devices, as described in Mochan (1998). Temperature

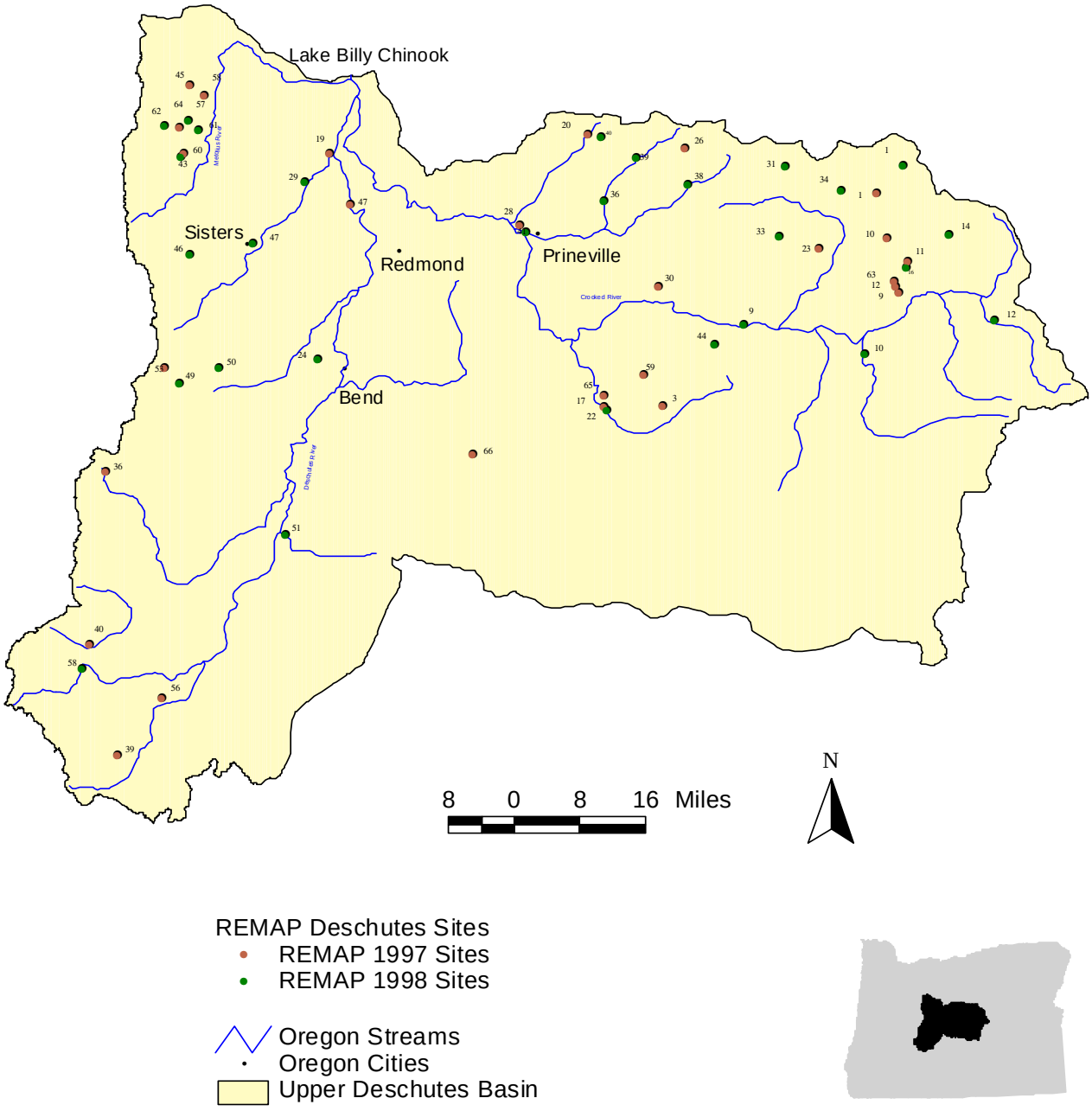


Figure 2 - REMAP Deschutes 1997 and 1998 sites

probes equipped with data loggers were placed instream beginning in early summer (June and early July) and removed after peak summer temperatures (mid to late September). Due to a variety of factors, temperature data were available for 35 out of the 41 sites.

Twenty-three fish assemblage metrics were calculated for each site. Comparisons among sites were performed with the metrics and various environmental variables to determine general patterns in the vertebrate data (Table 1). Adult amphibian data were removed from the metrics, as the electrofishing methods do not allow for a thorough sampling of adult amphibian assemblages.

Table 1. Fish assemblage metrics and environmental variables used in the assessment of sites in the Upper Deschutes River Basin

Fish Assemblage Metrics Assessed:		
total vertebrate taxa	% salmonids	% introduced taxa
total native vertebrate taxa	% introduced	% cold taxa
family richness	% filterers	% filterer taxa
native family richness	% hiders	% hider taxa
salmonid taxa	% invertivore/piscivore	% invertivore/piscivore taxa
cold water taxa	% sensitive	% sensitive taxa
sensitive taxa	% tolerant	
warm water taxa	% warm water	
	% cold water	
Environmental Variables Assessed:		
land use	elevation	ecoregion

RESULTS and DISCUSSION

VERTBRATE COLLECTION SUMMARY

A total of 6192 vertebrates were collected and identified throughout the Upper Deschutes River basin. We collected 20 unique vertebrate species in 1997 (16 fish, 4 amphibian) and 18 unique species in 1998 (15 fish, 3 amphibian), for a total of 24 unique species throughout the entire Upper Deschutes River basin (Table 1, Figureure 3). Including vertebrates that could not be identified to species, there were an additional 4 taxa, for a total of 28 unique taxa.

The most numerous species in both 1997 and 1998 were Umatilla dace and rainbow trout. These two species made up roughly 37% and 22%, respectively, of the total vertebrates collected. The least numerous species included amphibians, peamouth, Tui chubs, and threespine sticklebacks. The most common species included rainbow trout (collected at 28 of 47 sites; 60%), Umatilla dace (19 sites; 43%), and bridgelip suckers (15 sites; 32%). Four species were collected at only one site: bullfrogs, peamouth, Tui chubs, and smallmouth bass.

Salmonids (*Salmonidae*)

Overall, 1235 salmonids were collected in 1997, compared to 729 in 1998 (Table 2, Figureure 3). For brook and brown trout much of the inter-year difference lies in a large catch at one site for each species.

Rainbow trout (*Oncorhynchus mykiss*)—Resident rainbow trout populations in the Upper Deschutes River basin are likely derivations of either steelhead populations landlocked due to the erection of dams blocking ocean migration or from hatchery raised fish (Marx 2000). Rainbows were the second most numerous and the most ubiquitous species found throughout the Upper Deschutes River basin (Table 1, Figureure 3). Rainbow trout comprised 21.5% of all vertebrates collected throughout the study. The sites with the most rainbows collected in each year were Little McKay Creek (215) and Mill Creek--upper (65).

Brown trout (Salmo trutta)—Brown trout are a non-native species originally introduced to the U.S. in the late 1800s, with a natural range from Europe, North Africa, and West Asia (Page and Brooks 1991). Brown trout are more tolerant to warmer temperatures and higher turbidity, thus allowing displacement of natural trout species at disturbed locations (Wydoski and Whitney 1979). Brown trout were collected at five sites throughout the Upper Deschutes River basin for a total of 274 fish (Table 1, Figureure 3). The smallest catch (3) was at Tumalo Creek and the largest catch (121) was at Little Deschutes R. Sizes ranged from 5-50 cm. All of the sites where brown trout were collected were in the Deschutes sub-basin, typically in larger streams. Two of the sites (Tumalo Creek and Squaw Creek--lower) were cold-water streams, with maximum seven-day moving averages below 15.3 ^{o}C. Squaw Creek becomes much warmer upstream from this point, however, while Tumalo Creek remains cool. At the Little Deschutes R. (a repeat visit) 121 brown trout caught. Without this site, numbers of brown trout in 1997 and 1998 are virtually the same. Two possible explanations concerning the absence of brown trout in the Crooked River basin, where warm temperatures might supply a competitive advantage over native rainbow trout, are the following: first, they were not historically introduced to the Crooked sub-basin, and second, the poor water quality of the lower Crooked River may act as a migratory barrier to salmonids from Lake Billy Chinook (where the Deschutes and Crooked Rivers converge).

Brook trout (Salvelinus fontinalis)—Brook trout are another non-native salmonid introduced to the west. Their native range covers much of eastern North America (Page and Brooks 1991). While browns can out-compete native rainbows at higher temperatures, brooks tend to do best in cold streams, below 18^{o}C (Wydoski and Whitney 1979). Brook trout were collected at 7 sites and totaled 282 fish (Table 1, Figureure 3). The smallest catch was recorded at Squaw Creek--upper (1 brook trout) and the highest

catch occurred at Cultus Creek (215 brook trout). It was somewhat surprising to find a brook trout at Upper Squaw Creek because this was a warm stream (19.2°C, seven-day maximum moving average), due to heavy irrigation withdrawals. However, the upstream reaches of Squaw Creek drain North Sister mountain and are quite cold. After Cultus Creek with 215 brook trout collected, Soda Creek was the next highest with 10 brook trout. Cultus Creek likely had so many brook trout because the habitat was good (lots of large wood, pools, cover providing structure, etc.), human pressures were low (it was in designated wilderness), and the stream fed into and out of Muskrat Lake.

Mountain whitefish (Prosopium williamsoni)—Mountain whitefish are naturally found throughout most of the Columbia basin (Page and Brooks 1991). Typically they are found in larger streams with average annual temperatures of 9-11°C (Wydoski and Whitney 1979). Mountain whitefish were collected at two sites, both of which were on the Crooked River. The seasonal maximum 7-day moving averages for these sites were 23 and 25 °C, respectively. These values cannot be directly compared to the average annual temperature range listed above because they include only part of the yearly temperature regime.

Table 2. A summary of vertebrate collections made in the Upper Deschutes River basin in 1997 and 1998.

Common name	Scientific name	1997 # sites	1997 # collected	1998 # sites	1998 # collected	Totals	Percent
Amphibians						**49**	**0.79**
unidentified frogs--adult	Anura	--	--	2	3	3	0.05
unidentified tree frog--adult	Hylidae	1	1	--	--	1	0.02
bull frog--larvae	Rana catesbeiana	1	18	--	--	18	0.29
Cascade frog--adult	Rana cascadae	1	2	1	2	4	0.06
Pacific tree frog--adult	Pseudacris regilla	3	6	1	6	12	0.19
Pacific tree frog--larvae	Pseudacris regilla	2	3	--	--	3	0.05
spotted frog--adult	Rana pretiosa	2	3	--	--	3	0.05
western toad--adult	Bufo boreas	--	--	2	5	5	0.08
Sculpins						**299**	**4.83**
Paiute sculpin	Cottus beldingi	1	95	4	110	205	3.31
shorthead sculpin	Cottus confusus	1	4	3	90	94	1.52
Suckers						**513**	**8.28**
unidentified suckers	Catostomus spp.	1	7	--	--	7	0.11
bridgelip sucker	Catostomus columbianus	5	182	10	80	262	4.23
largescale sucker	Catostomus macrocheilus	3	236	1	8	244	3.94
unidentified suckers/minnows	Cypriniformes	1	531	--	--	531	**8.58**
Minnows						**2534**	**40.92**
chiselmouth	Acrocheilus alutaceus	1	76	1	5	81	1.31
northern pikeminnow	Ptychocheilus oregonensis	2	16	2	38	54	0.87
longnose dace	Rhinichthys cataractae	1	13	2	58	71	1.15
peamouth	Mylocheilus caurinus	--	--	1	3	3	0.05
Umatilla dace	Rhinichthys osculus umatilla	9	1057	11	1253	2310	37.31
Tui chub	Gila bicolor	1	15	--	--	15	0.24
Salmonids						**1964**	**31.72**
brook trout	Salvelinus fontinalis	3	232	4	50	282	4.55
brown trout	Salmo trutta	3	199	3	75	274	4.43
mountain whitefish	Prosopium williamsoni	1	52	1	24	76	1.23
rainbow trout	Oncorhynchus mykiss	11	752	17	580	1332	21.51
Miscellaneous						**302**	**4.88**
three-spine stickleback	Gasterosteus aculeatus	2	15	1	2	17	0.27
brown bullhead	Ameiurus nebulosus	2	248	--	--	248	4.01
small-mouth bass	Micropterus dolomieui	--	--	1	37	37	0.60
Totals			**3763**		**2429**	**6192**	**100%**

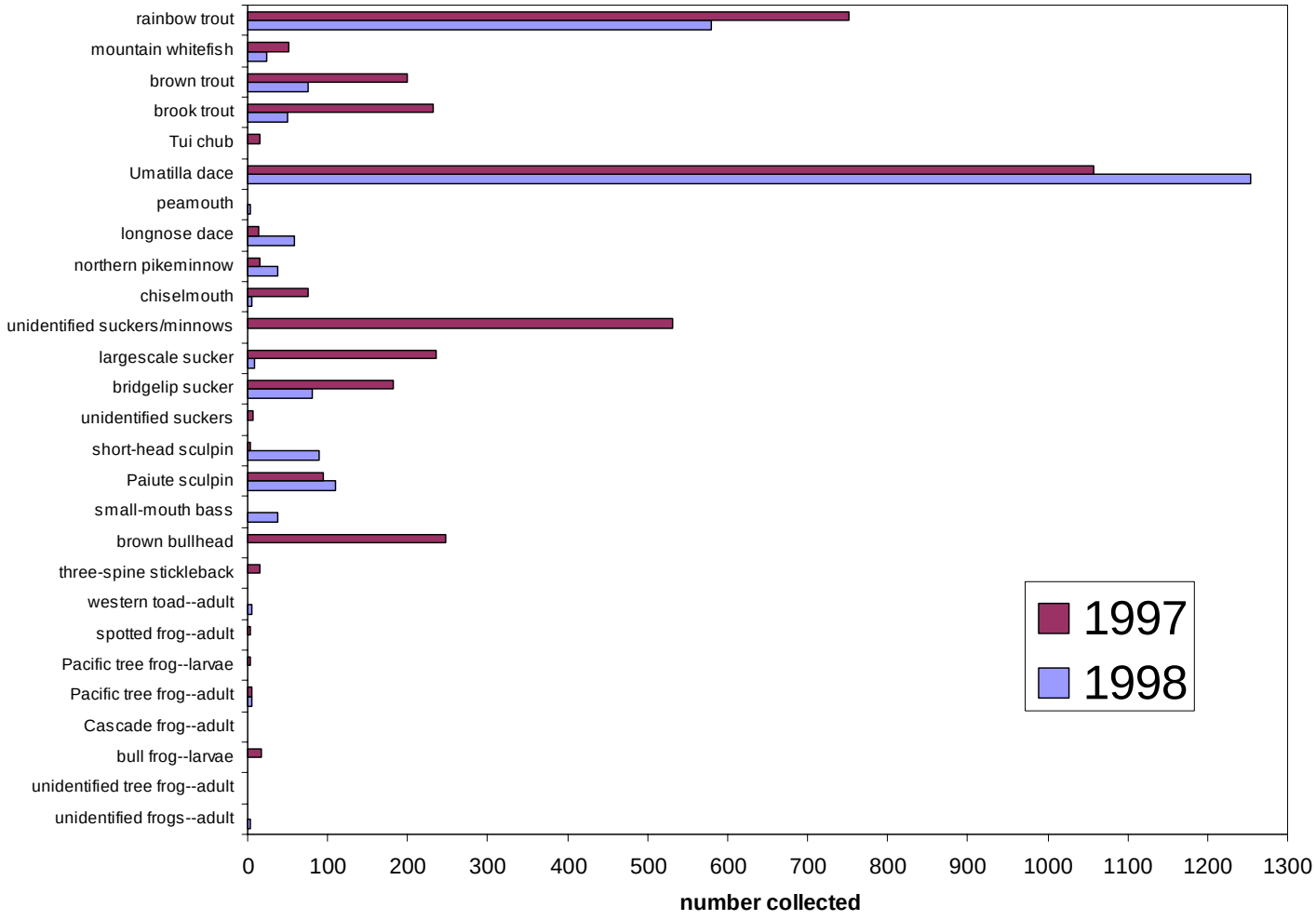


Figure 3. The total number of each taxa collected throughout the entire Upper Deschutes River Basin

Sculpins (*Cottidae*)

Two species of sculpins were collected in the Upper Deschutes River basin; Paiute (*Cottus beldingi*) and shorthead (*Cottus confusus*), totaling 299 individuals (Table 1, Figureure 3). Paiute sculpins were collected at five sites and shorthead sculpins were collected at four sites; one site had both species present. Two of eight sites where sculpins were collected were located in the Deschutes sub-basin. These two sites were both in Squaw Creek, located in the Deschutes sub-basin and the Snake River/High Desert ecoregion. Only shorthead sculpins were collected at the Squaw Creek sites.

The site with the lowest number of sculpins collected was South Fork Crooked River, with only one Paiute sculpin. The site with the greatest number of sculpins collected was Marks Creek, with 95 Paiute sculpins. Only at South Fork Beaver Creek were both Paiute and shorthead sculpins observed together. All of the sites where Paiute sculpins were collected were in the Crooked sub-basin between 3680-4200 ft in elevation.

Shorthead sculpins were collected at elevations ranging from 2160-4110 ft. Markle et al. (1996) state that shorthead sculpins have a similar range as Paiute sculpins, but typically occupy higher elevations, a statement that was not supported by this study.

Suckers *(Catostomidae)*
As a family, suckers made up approximately 8% of the total catch (Table 1). Only two species were collected, bridgelip and largescale suckers. The number of suckers collected in 1998 was approximately 21% of the number collected in 1997. However, the number of sites where suckers were collected was greater in 1998 (11 sites) than in 1997 (8 sites). Although bridgelip suckers were collected at more locations than largescale suckers, both species composed approximately 4% of the total fish catch for the basin. All suckers were collected from the Crooked sub-basin, except for collections of bridgelip suckers at Squaw Creek—middle and Squaw Creek--upper, in the Deschutes sub-basin.

Minnows *(Cyprinidae)*
Minnows are the largest family of fishes in the world, with approximately 2100 species (Page and Brooks 1991), however, there are relatively few native cyprinids represented in the Pacific Northwest. With six species collected, minnows were the most diverse family of fish collected throughout the Upper Deschutes River basin and represent nearly 41% of all fish collected (Table 1). The minnow species collected include chiselmouth, northern pikeminnow, longnose dace, peamouth, Umatilla dace, and Tui chub. Chiselmouth, northern pikeminnow, and longnose dace each composed approximately 1% of the total fish catch throughout the entire basin. Both peamouth and Tui chub made up much less than 1% of the total fish catch. Of all six minnow species collected in the Upper Deschutes basin, only Umatilla dace were collected at more than two sites in a single year or more than four sites in both years. All minnows were collected from the Crooked sub-basin, except for Tui chub, which were collected only at the Deschutes River site.

Umatilla dace (Rhinichthys osculus umatilla)—Umatilla dace were collected at 19 sites, all of which were located in the Crooked sub-basin. Umatilla dace were by far the most numerous species. A total of 2312 Umatilla dace were collected, comprising about 37% of the total catch (Table 1, Figureure 3). Only rainbow trout were collected at more sites than Umatilla dace.

Miscellaneous fish taxa
Three fish families were represented by only one species each. The family Gasterosteidae was represented by the three-spine stickleback (*Gasterosteus aculeatus*). This species was collected at three sites. The family Centrarchidae was represented by the smallmouth bass (*Micropterus dolomieu*). Smallmouth bass were collected at only one site, South Fork Crooked River. Brown-bullheads (*Ameiurus nebulosus*) represented the family Ictaluridae. This species was collected at only two sites, Dry Paulina Creek 97-12 and Paulina Creek. Smallmouth bass and brown bullheads are both introduced warm-water species, and were collected only in the Crooked River sub-basin.

Unidentified fish species

The third most numerous category of vertebrates collected was unidentified suckers/minnows. These were fish that were collected at one of the first site visits in 1997 (Bear Creek 97-17). When the voucher specimens were reviewed in the laboratory, it was determined that what was identified in the field as a bridgelip sucker, was in fact a Umatilla dace. Because there were many fish spanning many size classes identified as bridgelip suckers, we were unable determine how many of each species were collected, making it necessary to raise the identification to order level. However, in reviewing data from two other repeat visits to this site (once later in 1997 and once in 1998), the bridgelip suckers and Umatilla dace fall into mostly two separate size classes. Bridgelip suckers ranged from 7-16 cm in length (with very few below 8 cm) and Umatilla dace ranged from 3-8 cm. Going back to the first site visit, estimates of bridgelip sucker and Umatilla dace numbers are 80 and 450, respectively. Adding these estimated values into the totals for these species increases the percentage of the total vertebrate catch for Umatilla dace from 37% to an estimated 45%, and increases the percentage of bridgelip suckers from 4.2% to an estimated 5.5%.

Another case of misidentification in the field was at Squaw Creek--lower, where the field crew misidentified collected suckers as mountain suckers. It was later brought to our attention by fish biologists with the United States Forest Service that there is no record of mountain suckers occurring in this basin. We therefore moved the identification up one taxonomic level to genus (*Catostomus sp.*). These seven individuals are either bridgelip or largescale suckers.

Amphibians

There were five frog species collected throughout the Upper Deschutes River basin: bullfrogs, Cascade frogs, Pacific tree frogs, spotted frogs, and western toads (Table 1). As a group, the amphibians accounted for only 0.8% of the total vertebrate catch. Frogs were collected at eight different sites in 1997 and six sites in 1998. Pacific tree frog adults were the most common species of frog, occurring at three sites. A total of 49 frogs were collected, with bullfrog larvae (18) and Pacific tree frog adults (12) being the most numerous**.**

REGIONAL COMPARISONS

Fish assemblage metrics and environmental variables were assessed to see if there were any patterns that might explain the differences in fish assemblages among sites. When analyzed with these metrics and environmental variables, vertebrate assemblages in the Upper Deschutes River basin fit a regional pattern. Four regions were observed in the fish assemblages of the Upper Deschutes River basin: the Lower Deschutes, the Upper Deschutes, the Crooked River Lowlands, and the Ochoco Mountains (Table 3). (Again, we were unable to interpret vertebrate data from the Metolius River sub-basin due to the presence of bull trout.) Metrics that were found useful in discerning patterns among the sites were the number of taxa collected (Figure 4), percent salmonids (Figure 5), and percent introduced species (Figure 6). Environmental characteristics that were useful in discerning fish assemblage patterns included ecoregion, elevation (Figure 7), and land use.

Sub-basin differences
The first difference in fish assemblages is due to sub-basin differences, with sites in the Deschutes River sub-basin separated from sites in the Crooked River sub-basin. Fish assemblages in the Deschutes sub-basin were dominated by rainbow trout and/or introduced trout (brown and brook). Fish assemblages in the Crooked sub-basin were dominated by rainbow trout or Umatilla dace. No Umatilla dace were found within the Deschutes sub-basin, whereas they were the most abundant fish in the Crooked sub-basin.

This difference is close to being entirely explained by ecoregions. Most of the Deschutes sub-basin sites fall into either the East Cascades Slopes and Foothills (9d and 9e) or Cascades ecoregions (4c), while most of the Crooked sub-basin sites fall in the John Day/Clarno Uplands (11a) and Highlands (11b). Four sites in the Deschutes sub-basin (the three Squaw Creek and the Deschutes R. sites) and two sites in the Crooked sub-basin (the two mainstem Crooked R. sites) were located in the Snake River Basin/High Desert ecoregion (12a). However, the Snake River Basin/High Desert ecoregion sites in the Deschutes sub-basin had higher salmonid compositions (35-71%) than the two mainstem Crooked R. sites in the same ecoregion. Both of these sites had low salmonid composition (6-14%), high numbers of Umatilla dace, and no introduced salmonids. One possible explanation for the differences in the sub-basins, despite shared ecoregions, could be the presence of Lake Billy Chinook, which lies at the bottom of both sub-basins. Perhaps conditions in this large reservoir act as a barrier, limiting migration between the two sub-basins.

Deschutes sub-basin differences
Sites in the Deschutes sub-basin were further divided into the *Upper Deschutes region* and the *Lower Deschutes region* (Table 3).

The *Upper Deschutes region* fish assemblages were characterized by 1-2 taxa (Figureure 4), 100% salmonid composition (Figureure 5), and a higher proportion of introduced trout composition (Figureure 6). Generally shared environmental characteristics included ecoregion, higher elevations (Figureure 7), and forestry land use. The eight sites in this region (Table 3) were located in either the East Cascades Slopes and Foothills or the Cascades ecoregions. There were two sites in the Upper Deschutes region (Odell Creek and Trout Creek) that stood apart from the others. These sites differ from other sites because they were made up entirely of rainbow trout, whereas the other sites in the region had introduced brook or brown trout present. Although brook trout were not collected at Odell Creek, they are present in the Odell Lake/Creek system (Marx 2000). Trout Creek is an isolated stream with no connection to the adjacent Squaw Creek drainage. With no connection to surrounding drainages where introduced trout are present (Squaw Creek contained both brook and brown trout), the absence of these species is logical.

Table 3. Regional fish assemblage, environmental characteristics, and sampling sites located in each region.

REGION:	Lower Deschutes	Upper Deschutes	Crooked R. Dace	Crooked River Rainbow
Assemblage characteristics:	35-70% trout	100% trout	0-40% trout	85-100% rainbow
	lower introduced trout composition	higher introduced trout composition	high Umatilla dace composition	low Umatilla dace composition
	4-5 taxa	1-2 taxa	0, or 2-7 taxa	1-2 taxa
Environmental Characteristics:	ecoregion 12a	ecoregions 9d, 9e, 4c	ecoregion 11a	ecoregion 11b
	lower elevation (2160-3150	higher elevation (1080-6200)	lower elevation (2840-5410)	higher elevation (3480-4840)
	grazing/urban	forestry	grazing/urban	forestry/grazing
Sites:	Deschutes R.	Cultus	Bear--lower	Fox
	Squaw--lower	Hemlock	Bear--middle	Fox Canyon
	Squaw--middle	Little Deschutes R.	Cow	Little McKay
	Squaw--upper	North Fork Tumalo	Crooked--lower	Little Summit
		Odell	Crooked--upper	McKay
		Soda	Dry Paulina--lower	Pine
		Trout	Dry Paulina--middle	Porter
		Tumalo	Gray	Roba
			Jackson	Wildcat
			Little Bear--lower	
			Little Bear--upper	
			Marks	
			Mill--lower	
			Mill--upper	
			Ochoco	
			Paulina	
			Sout Fork Crooked	
			South Fork Beaver	
			Wickiup	
			Wolf	

Figure 4. The number of taxa collected at sites within each region.

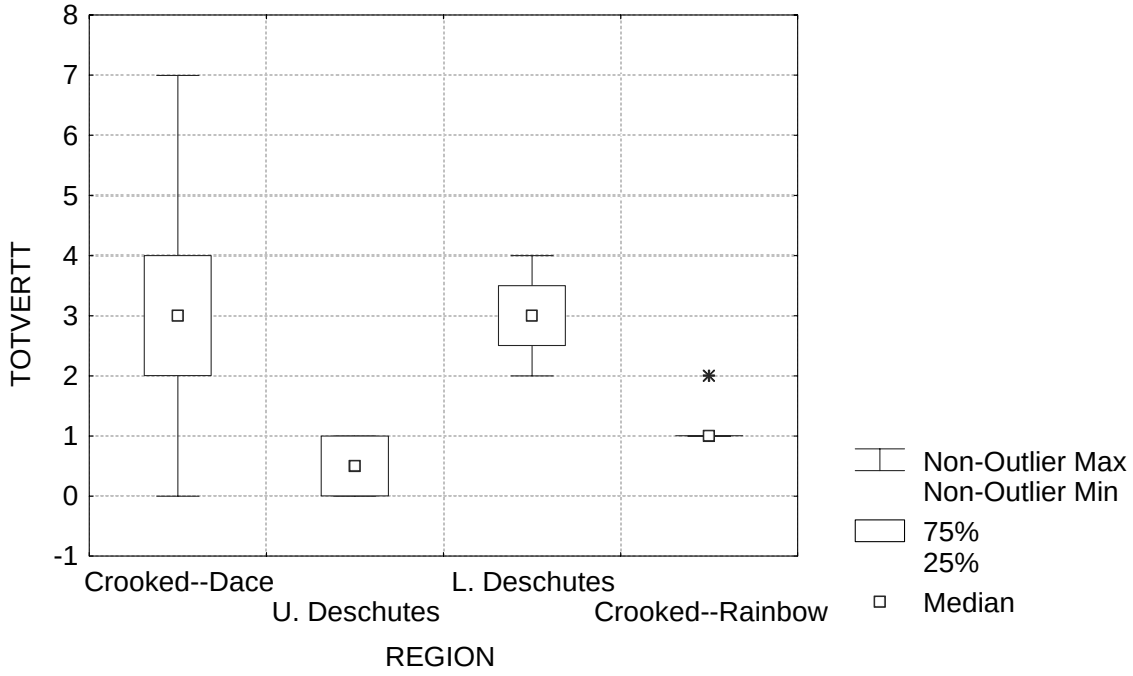


Figure 5. The percentge of salmonids collected within each region.

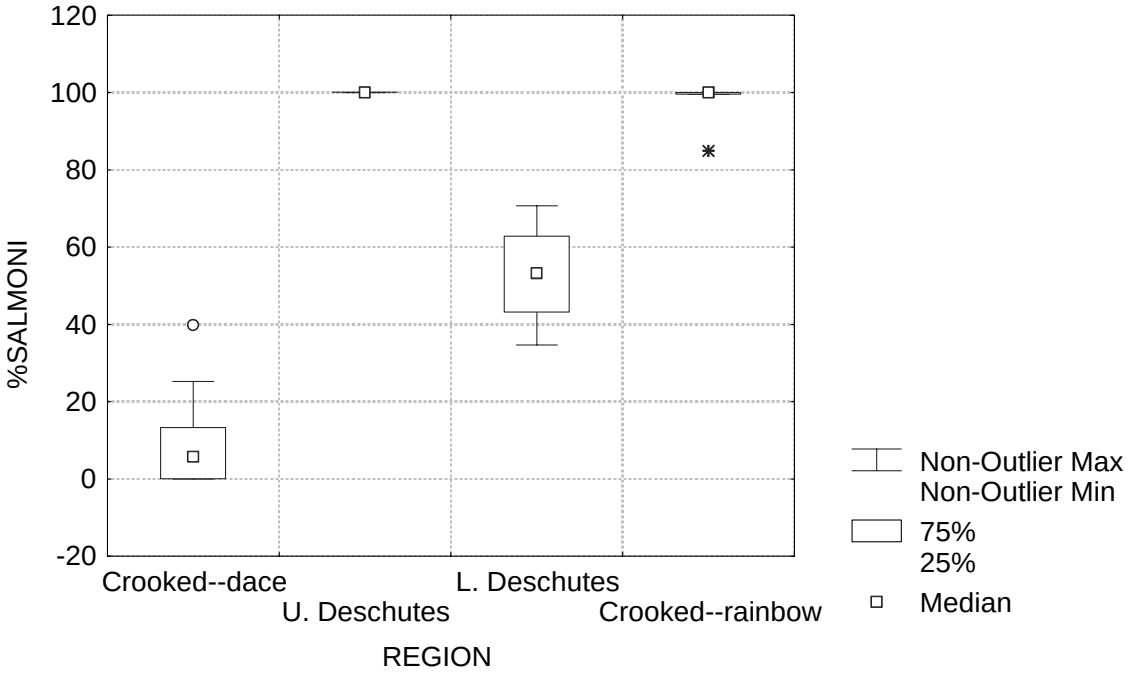


Figure 6. The percentage of introduced fish collected within regions.

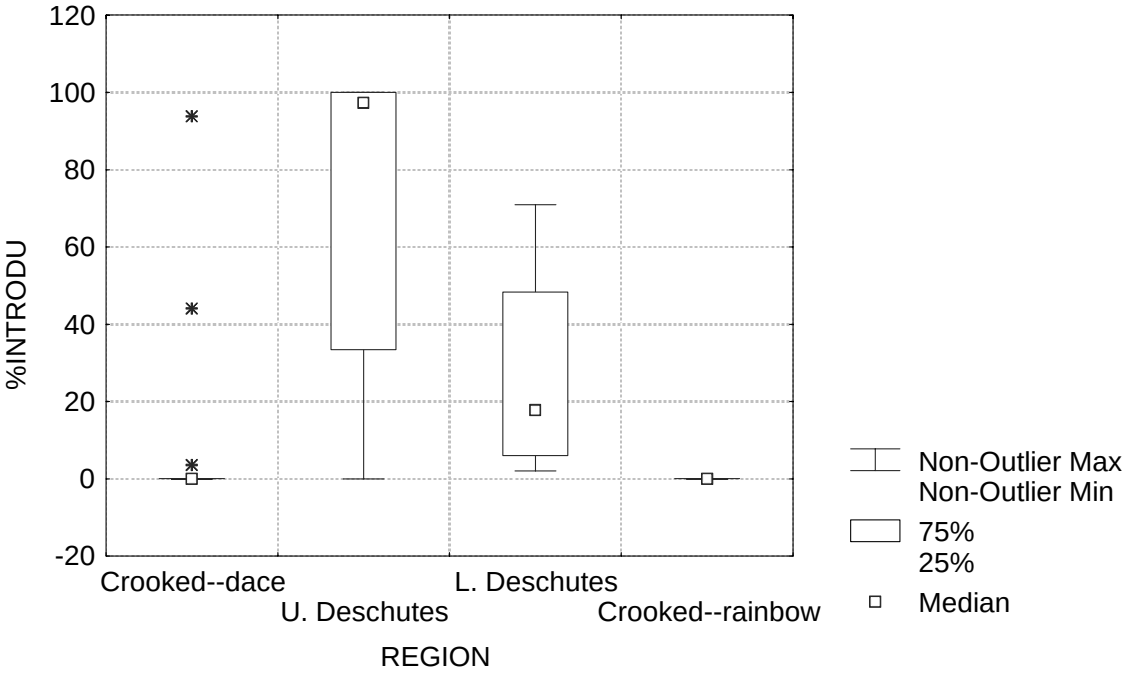
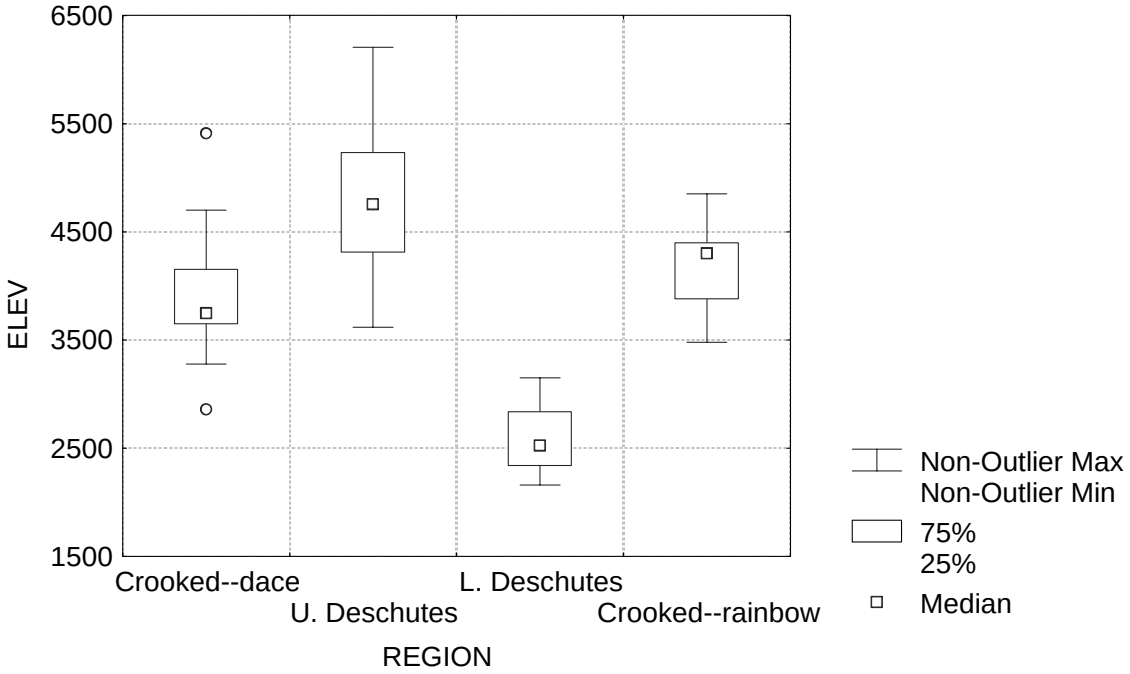


Figure 7. The elevation range for each fish assemblage region.



The *Lower Deschutes region* fish assemblages were characterized by 4-5 taxa (Figureure 4), 30-70% salmonid composition (Figureure 5), and lower introduced trout composition (Figureure 6). Common environmental characteristics were ecoregion, lower elevations (Figureure 7), and grazing/urban land use. The four sites in this region (Table 3) were located in the Snake River Basin/High Desert ecoregion.

Crooked sub-basin differences

Unlike the Deschutes sub-basin, where fish assemblages differed geographically, there was not a clear explanation for differences in the Crooked sub-basin. Differences in fish assemblages were expressed as the ratio of rainbow trout to Umatilla dace (or the absence of any fish species). Sites in the Crooked River sub-basin were further divided into *Crooked River—Rainbow* sites and *Crooked River—Dace* sites (Table 3).

The *Crooked River—Rainbow* fish assemblages were characterized by a low taxonomic diversity (Figureure 4), high rainbow trout composition (Figureure 5), and low Umatilla dace composition (15% or less, and 0% for most). Environmental characteristics that were common within this group of sites included a mixture of forestry and grazing land use, public ownership (national forest land), and inclusion in the John Day/Clarno Highlands ecoregion. There are two exceptions to this grouping of sites. First, two sites, Roba Creek and Wildcat Creek, were located in the John Day/Clarno Uplands ecoregion (Uplands being lower than Highlands). Second, the site on Wildcat Creek was privately owned and dominated by grazing land. A total of nine sites were classified as a part of the Crooked River—Rainbow fish assemblage grouping (Table 3).

The *Crooked River--Dace* fish assemblages were characterized by higher taxonomic diversity (Figureure 4), low salmonid composition (Figureure 5), high Umatilla dace composition, or the absence of fish species. Twenty sites were classified into this fish assemblage grouping (Table 3). Environmental characteristics were not as successful at defining fish assemblages in the Crooked River sub-basin. In general, the sites of this fish assemblage were located in the John Day/Clarno Uplands or Snake River/High Desert ecoregions, dominated by grazing or urban land use, and located on private property. Six sites did not fit these characteristics completely. Ochoco, Mill 98-36, Gray, Marks, Jackson, and Wolf creeks all were located in the John Day/Clarno Highlands ecoregion. Ochoco, Mill, and Gray creeks were similar to other sites in the *Crooked River—Dace* fish assemblages in that grazing was the predominant land use and they were located on private property. Ochoco and Mill creeks were both located at the edge of the John Day/Clarno Highlands ecoregion and were not far from national forest boundaries. Gray Creek, however, was located well up into the John Day/Clarno Highlands and the site was located on a small piece of private property surrounded by public lands. Marks, Jackson, and Wolf creeks were further different from other sites in the fish assemblage by a mixture of forestry and grazing land use and being located on public lands (national forest). Both Marks and Wolf were lower in the John Day/Clarno Highlands ecoregion and not far into national forest lands. Interestingly, both Jackson and Gray creeks were two of the highest elevation sites in the Crooked River sub-basin and both were open meadow systems.

Neither introduced species (Figureure 6) or elevation (Figureure 7) were particularly useful for explaining differences in Crooked River sub-basin fish assemblages.

CONCLUSIONS

The overall goal of this project was to provide data describing the status and trends of aquatic natural resources throughout the Upper Deschutes River basin. This report provides an overview of the vertebrate collection portion of our stream surveys throughout the Upper Deschutes River basin. Unfortunately, we were unable to collect information on vertebrates in the Metolius River sub-basin, due to the presence of bull trout (a federally protected species).

Overall, 24 unique vertebrate species (28 unique taxa) were collected. Two species dominated our vertebrate collections. The most numerous species collected were Umatilla dace and rainbow trout. The most ubiquitous species was rainbow trout, followed by Umatilla dace. Despite the fact that the Umatilla dace was the most numerous species collected, this species was only collected in the Crooked River sub-basin and was not found at any site in the Deschutes sub-basin.

There appear to be four regions based on fish assemblages within the Upper Deschutes River basin (excluding the Metolius River sub-basin): the *Lower Deschutes region*, the *Upper Deschutes region*, the *Crooked River--Rainbow*, and the *Crooked River--Dace*. Classification of sites into these regions was based on fish assemblage composition and limited environmental characteristics (elevation, ecoregion, landuse). The classification of the sites into regions was not perfect, however. Within the two Crooked River sub-basin assemblages there were several sites with fish assemblages that were different from other sites sharing similar environmental characteristics. The fish assemblage metrics and environmental characteristics used in these regional analyses were insufficient at explaining this overlap of sites and fish communities in the Crooked River sub-basin.

Future Work

We plan to further analyze the vertebrate data presented in this report in conjunction with aquatic macroinvertebrate, water chemistry, and habitat data. Analyzing the data using multivariate analyses and GIS will further refine our groupings of the fish assemblages. These analyses will also allow us to determine which environmental variables are most important in determining the characteristics of fish assemblages within the Upper Deschutes River basin.

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