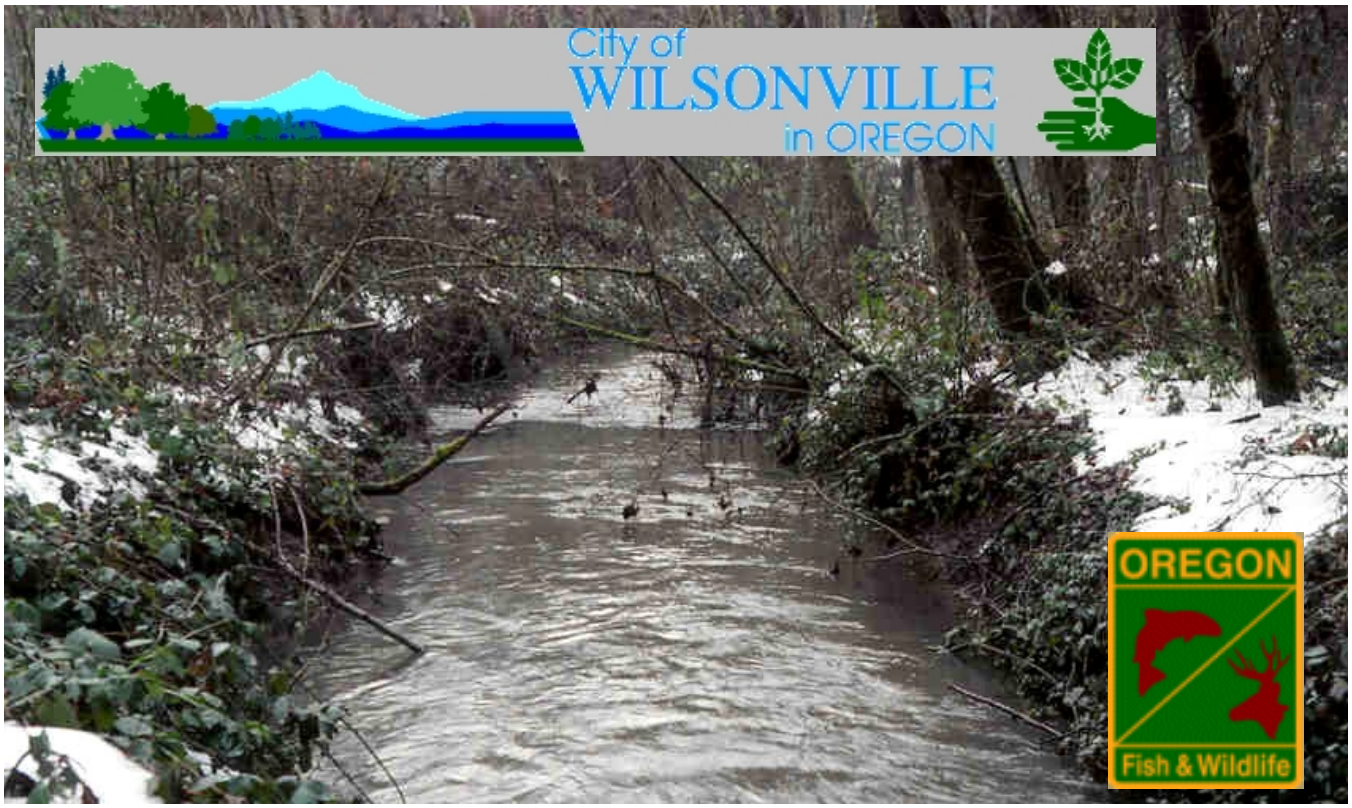
Surveys of Fish Species and Habitat in Wilsonville Streams



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EXECUTIVE SUMMARY

From summer 2003 through spring 2005, the Oregon Department of Fish and Wildlife (ODFW) investigated and inventoried fish communities and aquatic habitat in a number of streams within the city of Wilsonville: Boeckman, Coffee Lake, and Meridian creeks, which are all tributaries of the Willamette River, Arrowhead Creek and two unnamed tributaries to Coffee Lake Creek, and the north fork of Meridian Creek. None of these streams had been recently surveyed.

We sampled the streams in 91 reach/time surveys, collecting and examining 3,762 individuals. Among the fish collected, two-thirds (66.7%) were reticulate sculpin *Cottus perplexus*, or unidentified sculpin, 6.5% were western brook lamprey *Lampetra richardsoni*, or unidentified lamprey, and 2.9% were salmon or trout. We identified nine native species from five families. We identified six alien species from four families, which constituted about 19% of the total catch.

Cutthroat trout *Oncorhynchus clarki* were the most common salmonid and were present throughout Boeckman Creek. We found indications of reproduction by cutthroat trout in Boeckman Creek. We found rainbow trout/steelhead *O. mykiss* during presence/absence surveys in the lower reach of Boeckman Creek, but not during other surveys. Chinook salmon *O. tshawytscha* were present in the lower reaches of both Boeckman and Coffee Lake Creeks during winter, and were present in Meridian Creek all seasons except fall. We found western brook lamprey in most streams sampled.

Index of Biotic Integrity (IBI) scores for all sampling efforts in fish-bearing streams ranged from 0 to 67. The mean IBI for all sampling efforts per stream reach indicated that all stream reaches were either marginally or severely impacted. No IBI scores were considered acceptable.

Most streams had a high number of pools and glides, predominately silt substrate, high amounts of erosion, and low amounts of large woody debris. Reach 1 of Coffee Lake Creek had the most gravel and cobble substrate, but reaches 2 and 3 of Boeckman Creek also contained gravel substrate. Most stream banks were moderately to highly eroded. Most streams had good shading and cover; however, limited riparian vegetation contributed to erosion. Woody debris levels were generally low other than in Meridian Creek.

Despite extensive urban development, Wilsonville streams still contain a relatively diverse assemblage of native fish species, including salmonids. Fish assemblages have obviously changed throughout the period of urban development, but persistence of native species, especially those most sensitive to habitat degradation, confirms the potential benefits of habitat protection and restoration. Final priorities for habitat protection and restoration in Wilsonville streams should be developed in conjunction with other stakeholders; however, a preliminary priority list of stream reaches offered here includes Reach 1 of Boeckman Creek (highest priority), reaches 2-7 of Boeckman Creek (high priority), Reach 1 of Coffee Lake Creek (medium priority), and reaches 1 and 2 of Meridian Creek (medium priority).

INTRODUCTION

As population and industrial use have increased, water quality and habitat in streams of the Portland metropolitan area, including Wilsonville, have been degraded. Prior to initiation of this project in 2003, little information existed about the presence, distribution, and abundance of fish species in Wilsonville streams. Information about the quality of available habitat was also scarce. Because initial surveys in Wilsonville (Pribyl et al. 2004) and in similar streams throughout Clackamas, Multnomah, and Washington counties have documented widespread distribution of anadromous and resident salmonids, including species listed under the Endangered Species Act (ESA), the Oregon Department of Fish and Wildlife (ODFW) and the City of Wilsonville identified a need to conduct further surveys in Wilsonville streams. Information from Wilsonville stream surveys will help complete information on fish presence in streams of the Portland metropolitan area, and may assist managers to set priorities on aquatic habitat protection and restoration work. The objectives of this study are to 1) evaluate the presence and distribution of fish species in Wilsonville streams, 2) evaluate seasonal habitat use of stream reaches by fish, 3) calculate an Index of Biotic Integrity for specific stream reaches, 4) summarize aquatic habitat information, and (5) develop recommendations for habitat protection and restoration.

Urban stream surveys conducted within the Portland metropolitan area (Ward 1995; Friesen and Ward 1996; Leader 2001a; Leader 2001b; Graham and Ward 2002; Tinus et al. 2003), and within Clackamas County specifically (Friesen and Zimmerman 1999; Tinus et al. 2003) documented numerous salmonid species including cutthroat trout *Oncorhynchus clarki*, rainbow trout/steelhead *O. mykiss*, coho salmon *O. kisutch*, and Chinook salmon *O. tshawytscha*. Currently, lower Columbia River and upper Willamette River Chinook salmon evolutionarily significant units (ESU), lower Columbia River and upper Willamette River steelhead ESUs, and the lower Columbia River coho salmon ESU are listed under the federal ESA as threatened (NOAA 1999).

Other species of interest include lamprey *Lampetra spp*. Lampreys require a diversity of habitat types depending on life history stage and are sensitive to habitat degradation and pollution. They have possibly declined throughout much of their historic range in western North America (Close et al. 1995; Vella et al. 1999). Western brook lamprey *L. richardsoni* and Pacific lamprey *L. tridentata* live within the study area. All Portland area lamprey species have been petitioned for listing under the federal ESA.

METHODS

Study Area

Fish and habitat surveys were conducted over a two-year period. From summer 2003 through spring 2004 we conducted surveys in Boeckman and Coffee Lake creeks, both of which are tributaries to the Willamette River (Figure 1). Surveys in Boeckman Creek were

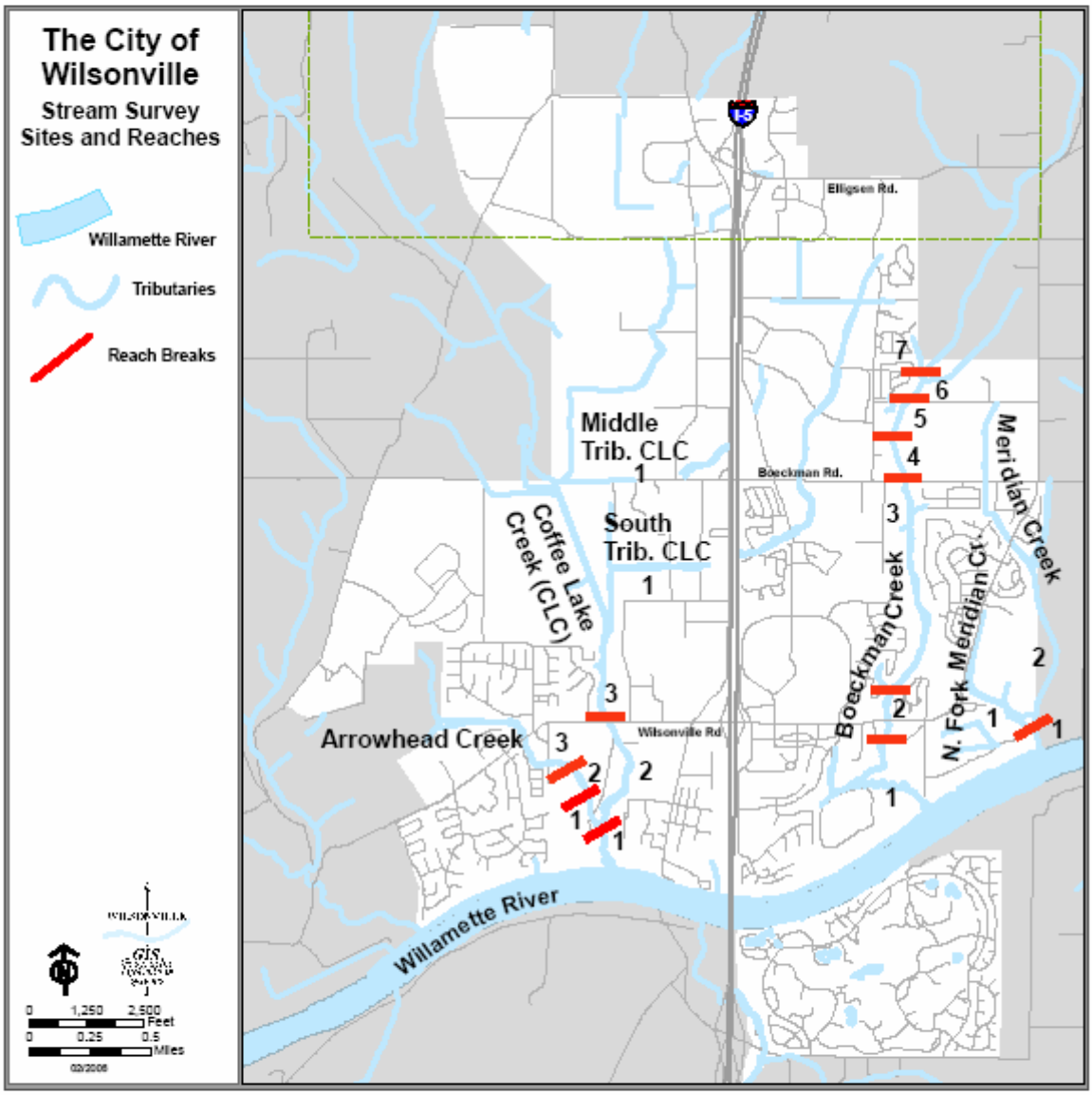

Figure 1. Location of streams and reaches surveyed in Wilsonville, summer 2003 – spring 2005.

limited to reaches 1 through 3, downstream from Boeckman Road. We surveyed Coffee Lake Creek from the mouth to the confluence with Arrowhead Creek (Reach 1). From summer 2004 through spring 2005 we sampled previously un-surveyed reaches of Boeckman and Coffee Lake creeks, as well as Meridian Creek, the north fork of Meridian Creek, Arrowhead Creek, and two unnamed tributaries to Coffee Lake Creek (Figure 1). Reach 2 of Coffee Lake Creek was dry during summer and early autumn; therefore, it was not sampled in other seasons. Reach 3 of Arrowhead Creek contained little water in any season and was therefore not sampled.

Field Sampling

Presence/Absence Sampling

We conducted fish presence/absence surveys during low flows in summer 2003 and 2004 to evaluate the presence and distribution of fish species in Wilsonville streams. Within each stream reach, we used backpack electrofishing to sample approximately 20% of the pools, riffles and glides (Hankin and Reeves 1988). We used significant landscape changes, major tributaries, or fish passage barriers to delineate stream reaches (Moore et al. 2001). We randomly selected one of the first five units of each habitat type as a starting point for sampling each reach, and then sampled every fifth unit of each habitat type. The backpack electrofisher was set at 30 Hz DC, and output ranged from 200 – 400 volts depending on water conductivity. Electrofishing was conducted in a downstream to upstream direction and limited to one pass through each designated habitat unit. Length and width of each unit were measured to calculate the total surface area electrofished. Fish collected from each habitat unit were identified, measured, and examined for anomalies. Fish were then released back into the habitat unit where they were collected.

Seasonal Sampling

We conducted multiple pass electrofishing surveys each season from summer 2003 through spring 2005 to evaluate seasonal habitat use by fish species, and to determine salmonid population abundance. We selected 100-m of representative stream habitat that was easily accessible within each stream reach surveyed during presence/absence surveys for multiple pass surveys. Prior to sampling, we placed block nets at both ends of the 100-m sampling reach to prevent fish from entering or leaving the sampling area. Electrofishing began at the downstream net and ended at the upstream net. During the first electrofishing pass, all fish were collected in the 100-m reach, and if salmonids were captured, additional electrofishing passes were conducted until salmonids were no longer present (up to three passes). Only salmonids were collected during additional electrofishing passes. At the end of each pass, fish were identified, measured, and examined for anomalies. Fish were then released back into the stream, below the downstream net.

Habitat

We conducted habitat surveys in summer 2003 and summer 2004 using standardized ODFW sampling protocol (Moore et al. 2001). Habitat surveys began at the downstream end of a reach

and proceeded upstream. We identified habitat units (pool, riffle, glide, etc.) and estimated or measured length, width, and depth of each unit. Within each unit we counted the number of boulders, visually estimated the substrate composition, percent each bank was eroded, and percent each bank was undercut, and measured woody debris volume and distribution. We also used a clinometer to estimate stream shading by measuring the angle, in degrees, from the middle of the stream channel to the apex of the riparian canopy or landform on each side of the stream.

Data Analyses

Seasonal Distribution and Abundance of Sensitive Species

We calculated the abundance of salmonids for each 100-m stream reach sampled during multiple pass electrofishing surveys with a population estimate model designed specifically for multiple pass electrofishing surveys (Armour et al. 1983). We were unable to use the model to calculate salmonid abundance in surveys where salmonid catch did not decline with additional electrofishing passes.

We also examined the seasonal distribution of all salmonid and lamprey species for each stream reach. This information was used to determine which part of the year sensitive species utilized individual stream reaches.

Index of Biotic Integrity

We calculated an Index of Biotic Integrity (IBI) for each stream reach sampled during presence/absence surveys and for each stream reach sampled during multiple pass surveys. An IBI is a complex measure of the ability of a habitat to support a species composition comparable with that of natural habitats in the region. This makes the IBI a useful tool for assessing the impacts of anthropogenic disturbances on fish assemblages. We generated IBIs for Wilsonville streams by applying our fish collection data to a set of 12 metrics (Table 1; Hughes et al. 1998). All fish collected during presence/absence surveys and the first pass of electrofishing during multiple pass surveys were used to calculate IBI scores. IBI scores range from 0 to 100, where streams with an IBI $\leq$50 are considered severely impaired, streams scoring 51-74 are marginally impaired, and streams with a score $\geq$75 are considered acceptable. IBI scores could not be calculated for streams without fish. In several stream reaches, we captured sculpins and lamprey too small to be identified; these fish were considered reticulate sculpin *Cottus perplexus* and western brook lamprey *Lampetra richardsoni* in the calculation of IBIs because all adult sculpin captured were reticulate sculpin, and all lamprey identified were western brook lamprey.

Habitat

To evaluate general stream morphology we determined the proportion of different habitat units (pool, fast water, glide) and different substrates (silt, sand, gravel, etc.) within each stream reach. We calculated the mean depth, average percent of bank erosion, average percent of undercut

Table 1. Index of biotic integrity (IBI) scoring criteria used for Wilsonville streams, 2003-2005, modified from Hughes et al. (1998). Each metric is scored on a scale from 0-10. Raw data values at low end of the ranges (high end of ranges for metrics 8, 10, and 12) are scored as 0; those at the high end (low end for metrics 8, 10, and 12) are scored as 10. Scores between the upper and lower thresholds are calculated by linear interpolation. Final IBI scores are given as a percentage of the maximum total of 120.

	Raw values	
Metric	Stream order 1	Stream orders 2 and 3
Taxonomic richness		
(1) Number of native families	0 – 4	0 – 7
(2) Number of native species	0 – 5	0 – 11
Habitat guilds		
(3) Number of native benthic species	0 – 3	0 – 7
(4) Number of native water column species	0 – 2	0 – 4
(5) Number of hider species	0 – 4	0 – 4
(6) Number of sensitive species	0 – 2	0 – 5
(7) Number of native nonguarding lithophil nester species[a]	0 – 3	0 – 3
(8) Percent tolerant individuals	10 – 0	10 – 0
Trophic guilds		
(9) Percent filter-feeding individuals	0 – 10	0 – 10
(10) Percent omnivores	10 – 0	10 – 0
Individual health and abundance		
(11) Percent of target species that include lunkers[b]	0 – 100	0 – 100
(12) Percent of individuals with anomalies	2 – 0	2 – 0

[a]Species that create nests in gravel or smaller substrates to spawn.

[b]Lunkers are relatively large individuals of the following species and sizes: prickly sculpin Cottus *asper* (100 mm), torrent sculpin *C. rhotheus* (100 mm), rainbow trout/steelhead *Oncorhynchus mykiss* (300 mm), cutthroat trout *O. clarki* (250 mm), chiselmouth *Acrocheilus alutaceus* (300 mm), northern pikeminnow *Ptychocheilus oregonensis* (300 mm), and largescale sucker *Catostomus macrocheilus* (300 mm).

banks, mean shading (0-180 degrees), and the quantity and volume of large woody debris per 100-m for each reach.

Riparian areas were surveyed at the beginning of each stream reach and once every thirty habitat units (on average once every 245-m) thereafter. Transects extending 5-m along the margin of the active stream channel and 30-m perpendicular from the stream (150-m^2) were evaluated for the % shrub cover, % grass and forb cover, % canopy closure, the number of conifers, and the number of hardwoods. The number of trees in the 150-m^2 sampling area was extrapolated into the number of trees / acre for comparison purposes.

RESULTS

Presence/Absence Sampling

We sampled a total stream area of 1,223 m^2 in Boeckman and Coffee Lake Creeks in summer 2003 and 1,274 m^2 in the remaining streams and reaches in summer 2004. We captured 1,146 fish from thirteen species (Table 2), with reticulate sculpins and unidentified sculpins composing most of the catch. Six of the thirteen species, composing 10.6% of the catch, are not native to Oregon. Native species sensitive to habitat disturbances (salmonids, lamprey) composed 11.8% of the catch. No fish were observed in the south tributary to Coffee Lake Creek or Reach 2 of Arrowhead Creek.

Seasonal Sampling

Between summer 2003 and spring 2004 we used multiple pass removal protocols to seasonally survey four reaches within two streams. Between summer 2004 and spring 2005 we surveyed an additional twelve reaches, for a total of sixteen reaches within seven streams. We captured 2,616 fish from thirteen species (Table 2), with reticulate sculpins and unidentified sculpins composing most of the catch. Four of the thirteen species, composing 22.7% of the catch, are not native to Oregon. Native sensitive species composed 8.3% of the catch. No fish were observed in the south tributary to Coffee Lake Creek or in Reach 2 of Arrowhead Creek.

Seasonal Distribution and Abundance of Sensitive Species

We found sensitive species in Boeckman, Coffee Lake, Meridian and the north fork of Meridian creeks; however, seasonal distribution varied among streams and species (Table 3). Boeckman Creek contained cutthroat trout and western brook lamprey year-round, and Chinook salmon in winter. Coffee Lake Creek contained western brook lamprey and Chinook salmon during winter only. Coho salmon and rainbow trout/steelhead occurred only in Meridian Creek (reaches 1 and 2, respectively).

Fork lengths of cutthroat trout throughout Boeckman Creek varied by season (Figure 2). Presence of fish smaller than 60 mm in spring indicates reproduction is occurring in Boeckman Creek. The lower reaches of the creek appear to support a wider size-range of cutthroat trout than the upper reaches.

Salmonid abundance estimates varied among seasons and streams. Cutthroat trout abundance was highest during spring and summer in reaches 2 and 3 of Boeckman Creek (Table 4). Chinook salmon were present in reach 1 of both Boeckman and Coffee Lake creeks in winter only. Irregular catches of salmonids during different sampling periods (e.g. Boeckman Creek in winter and spring; Coffee Lake Creek in winter) precluded population estimates.

Table 2. Fish collected during presence/absence (P/A) and the first pass of multiple-pass removal (MPR) surveys in Wilsonville streams, summer 2003 – spring 2005.

	Catch		Proportion of Total	
Family, species	P/A	MPR	P/A	MPR
Petromyzontidae				
Western brook lamprey *Lampetra richardsoni*	1	90	0.087	0.034
Unidentified lamprey *Lampetra* spp.[a]	100	54	0.001	0.021
Cyprinidae				
Goldfish *Carassius auratus*	2	0	0.002	0
Northern pikeminnow *Ptychocheilus oregonensis*	0	1	0	0.001
Speckled dace *Rhinichthys osculus*	1	1	0.001	0.001
Ictaluridae[b]				
Brown bullhead *Ameiurus nebulosus*	3	31	0.003	0.012
Salmonidae				
Cutthroat trout *Oncorhynchus clarki*	33	51	0.029	0.019
Rainbow trout/steelhead *Oncorhynchus mykiss*	1	2	0.001	0.001
Coho *Oncorhynchus kisutch*	0	1	0	<0.001
Chinook salmon *Oncorhynchus tshawytscha*	1	11	0.001	0.004
Unidentified salmonids *Salmonidae* spp.	0	9	0	0.003
Poeciliidae[b]				
Mosquitofish *Gambusia affinis*	108	546	0.094	0.209
Gasterosteidae				
Three-spined stickleback *Gasterosteus aculeatus*	60	118	0.052	0.045
Cottidae				
Reticulate sculpin *Cottus perplexus*	513	1070	0.448	0.409
Unidentified sculpins *Cottidae* spp.	315	613	0.275	0.234
Centrarchidae[b]				
Bluegill *Lepomis macrochirus*	5	7	0.004	0.003
Largemouth bass *Micropterus salmoides*	2	11	0.002	0.004
Smallmouth bass *Micropterus dolomieu*	1	0	0.001	0

[a]Ammocoetes were not keyed to species.
[b]Non-native families or species.

Table 3. Seasonal catch of sensitive species collected in Wilsonville, summer 2003 – spring 2005. No seasonal sampling was conducted in Reach 7 of Boeckman Creek.

Species, stream reach	Season				Total
	Summer	Fall	Winter	Spring	
Cutthroat trout					
Boeckman 2	8	4	1	9	22
Boeckman 3	3	3	1	3	10
Boeckman 4	3	0	0	4	7
Boeckman 5	3	0	1	1	5
Boeckman 6	2	0	3	2	7
Rainbow trout/steelhead					
Meridian 2	0	0	2	0	2
Chinook salmon					
Boeckman 1	0	0	2	0	2
Coffee Lake 1	0	0	6	0	6
Meridian 1	0	0	1	0	1
Meridian 2	1	1	0	0	2
Coho salmon					
Meridian 1	1	0	0	0	1
Salmonid species					
Boeckman 1	0	0	5	0	5
Boeckman 3	0	0	0	3	3
Coffee Lake 1	0	0	1	0	1
Western brook lamprey					
Boeckman 1	5	3	2	4	14
Boeckman 2	5	8	8	9	30
Boeckman 3	13	8	3	5	29
Boeckman 5	4	0	0	2	6
Boeckman 6	1	2	3	1	7
Coffee Lake 1	0	0	1	0	1
Meridian 1	26	0	2	2	30
Meridian 2	20	1	2	0	23
North Fork Meridian 1	2	0	1	1	4

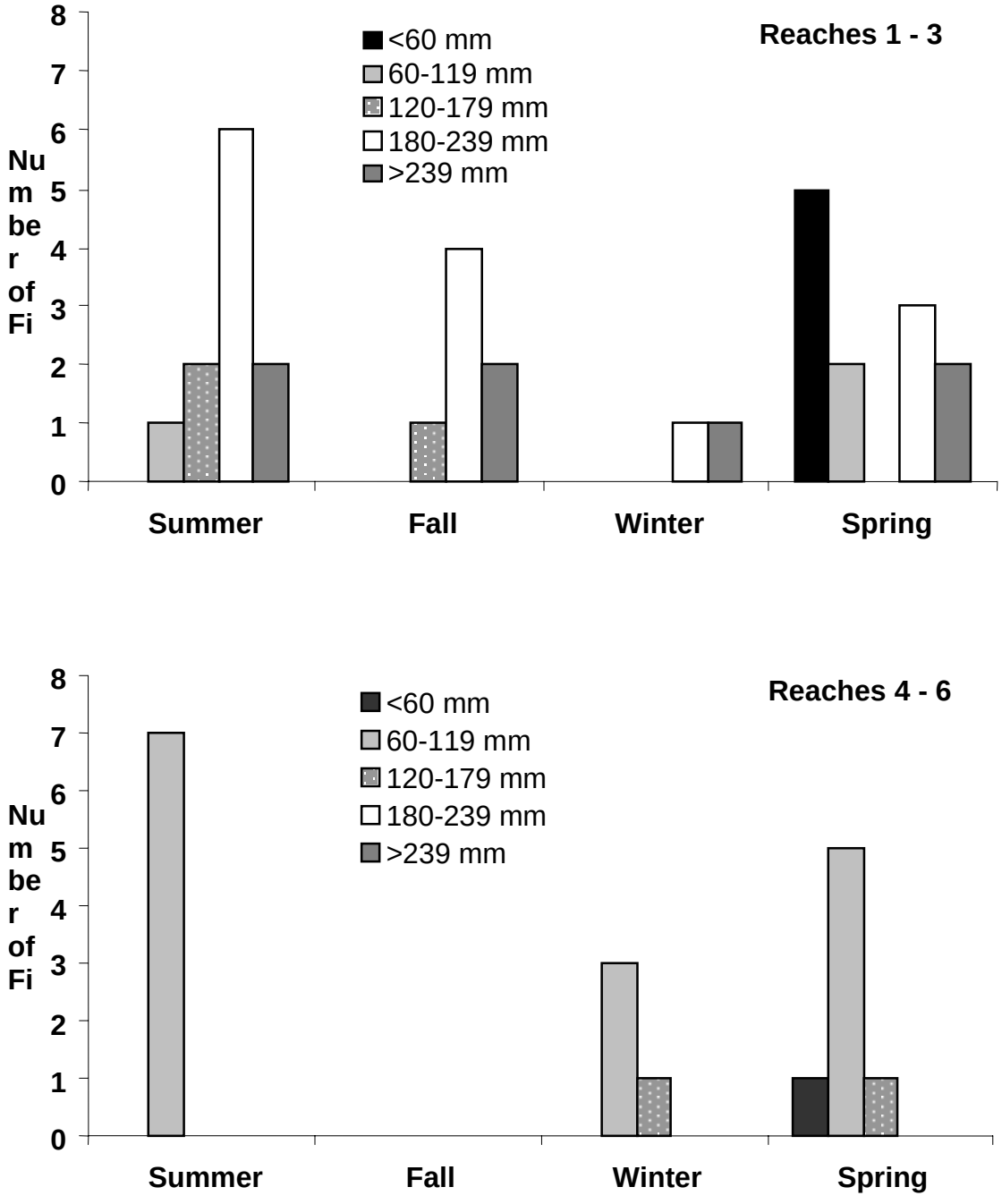

Figure 2. Fork length of cutthroat trout during each season in reaches 1 – 3 (2003-2004) and 4 – 6 (2004-2005) of Boeckman Creek. No seasonal sampling was conducted in Reach 7 of Boeckman Creek.

Table 4. Abundance estimates (and 95% confidence intervals) for salmonids within 100-m stream lengths surveyed seasonally by multiple-pass removal in Wilsonville, summer 2003 – spring 2004. N/A refers to samples with irregular catches. No seasonal sampling was conducted in Reach 7 of Boeckman Creek.

Species, stream reach	Summer	Fall	Winter	Spring
Cutthroat trout				
Boeckman 2	10 (±6)	6 (±11)	1 (±0)	N/A
Boeckman 3	3 (±0)	3 (±0)	1 (±0)	6 (±0)
Boeckman 4	N/A	0	0	5 (±3)
Boeckman 5	3 (±0)	0	1 (±0)	1 (±0)
Boeckman 6	N/A	0	2 (±0)	3 (±0)
Rainbow trout/steelhead				
Meridian 2	0	0	2 (±0)	0
Coho salmon				
Meridian 1	1 (±0)	0	0	0
Chinook salmon				
Boeckman Creek 1	0	0	N/A	0
Coffee Lake Creek 1	0	0	N/A	0
Meridian 1	0	0	1 (±0)	0
Meridian 2	1 (±0)	1 (±0)	0	0

Index of Biotic Integrity

Index of Biotic Integrity scores for all sampling efforts in Wilsonville streams ranged from 0 to 67 (Table 5). During presence/absence surveys, IBI scores were highest in the first reach of Boeckman Creek and lowest in the south tributary to Coffee Lake Creek and Reach 2 of Arrowhead Creek where no fish were observed. During multiple pass surveys, IBI scores were highest in the second and third reaches of Boeckman Creek. Mean IBI scores indicated only reaches 2 and 3 of Boeckman were marginally impaired (54 and 53, respectively). The remaining streams and reaches were severely impaired. No IBI scores were considered acceptable. The maximum IBI scores tended to occur in fall and winter although mean IBI scores varied little among seasons.

Habitat

We conducted habitat surveys on approximately two miles of Boeckman Creek (reaches 1-3) from the mouth to Boeckman Road and on approximately 0.3 mile of Coffee Lake Creek (Reach 1) from the mouth in 2004. In 2005, we surveyed an additional 0.5 miles in Boeckman Creek (reaches 4-7), 0.78 miles in Coffee Lake Creek, 0.5 miles in Meridian Creek and a combined

0.26 miles in Arrowhead Creek, the middle tributary to Coffee Lake Creek, and the north fork of Meridian Creek.

Stream geomorphology differed among streams. In Boeckman Creek, the number of glides was lowest and the number of fast water units highest in the upper reaches (Table 6). Habitat types differed markedly between upper and lower Coffee Lake Creek. The upper reach included numerous beaver dams; consequently, pools dominated the habitat types. Habitat modifications have resulted in the middle tributary to Coffee Lake Creek being dominated by glides. Habitat types were more evenly distributed in Meridian Creek. Reaches in Arrowhead Creek were short relative to other streams and lacked diversity of habitat types.

Silt was the dominant substrate, except in Reach 3 of Boeckman Creek and Reach 1 of Coffee Lake Creek where substrate compositions were more diverse (Table 7). Silt and sand made up about 69% of the substrate in Reach 3 of Boeckman Creek, whereas gravel and cobble made up about 65% of the substrate in Reach 1 of Coffee Lake Creek.

Other habitat parameters varied among reaches and streams (Table 8). Mean depths tended to be lowest in upper reaches (e.g. Boeckman, Arrowhead and Meridian creeks). Reach 3 of Coffee Lake Creek and Reach 4 of the middle tributary to Coffee Lake Creek were relatively deep due to several beaver dams distributed in upper Coffee Lake Creek. Erosion was greatest throughout Boeckman Creek, especially in reaches 1 and 4. Reaches with the least erosion were subject to lower flows (e.g. the middle tributary to Coffee Lake Creek) or were short reaches (e.g. Arrowhead Creek). Most reaches were forested and shaded, although Reach 3 of Coffee Lake and the middle tributary to Coffee Lake Creek flows through open agricultural/old field areas with very little shade.

Riparian areas varied within reaches and among streams (Table 9). The number of hardwoods and conifers per acre were inversely related to grasses and forbs; however, hardwoods and conifers did not necessarily dominate the canopy even at higher densities. In Boeckman Creek, Reach 2 had the most hardwoods/acre (270), but the lowest canopy closure (43%). Reach 2 had the second largest percent shrub cover (77%).

The quantity of large woody debris (LWD) was greatest in the lower reaches of Boeckman and Meridian Creeks and was consistent with LWD volume (Table 10). Average length of LWD varied little among reaches or streams. Average diameter of LWD was greatest in the upper reaches of Boeckman Creek and smallest in Reach 3 of Coffee Lake Creek.

DISCUSSION

Despite extensive urban development, Wilsonville streams still contain a relatively diverse assemblage of native fish species, including salmonids and lamprey. Although still a minority, exotic fish comprise a noteworthy percentage of species individuals. The persistence of native species, especially those most sensitive to habitat degradation, confirms the potential benefits of habitat protection and restoration in Wilsonville.

Table 5. Index of Biotic Integrity scores by stream reach and season, summer 2003 – spring 2005. Mean is calculated for multiple pass removal surveys only. No seasonal sampling was conducted in Reach 7 of Boeckman Creek. P/A = presence/absence.

Stream, reach	P/A	Summer	Fall	Winter	Spring	Mean
Boeckman						
1	67	42	47	50	34	43
2	52	56	60	52	49	54
3	47	52	52	60	53	55
4	48	36	30	30	44	35
5	52	52	31	42	49	43
6	51	51	42	53	51	50
7	42	--	--	--	--	--
Coffee Lake						
1	23	40	44	52	34	42
3	33	31	23	37	23	28
Middle Tributary to Coffee Lake Creek						
1	20	29	23	20	20	23
South Tributary to Coffee Lake Creek						
1	0	0	0	0	0	0
Arrowhead						
1	35	21	35	10	0	22
2	0	0	0	0	0	0
Meridian						
1	44	56	31	50	43	45
2	45	51	41	52	31	44
North Fork Meridian						
1	34	55	35	51	53	48

Although fish were distributed throughout major habitat types (fast water, glides, and pools), salmonids were rarely found in glides. Glides (37%) and fast water (35%) composed 72% of the habitat units sampled during presence/absence surveys, but held only 7% of the salmonids. Glides actually compose more than 37% of the habitat, because they tend to be longer units than fast water or pools. Because glides in urban streams generally exhibit little habitat complexity, future restoration actions should strive to minimize glide habitat.

Urban stream surveys have been conducted in several Clackamas County streams, which include tributaries to the Willamette River (Friesen and Zimmerman 1999, Tinus et al. 2003). In all studies, reticulate sculpin was the most abundant and widely distributed fish species, which we

Table 6. Summary of percent habitat units for each stream reach surveyed in summer 2003 or summer 2004.

Stream, reach	% Pool	% Glide	% Riffle
Boeckman			
1	45.4	41.7	12.9
2	34.0	49.8	16.2
3	31.2	43.4	25.4
4	27.3	51.6	21.1
5	43.1	27.2	29.7
6	45.7	15.2	39.1
7	25.6	23.1	51.3
Coffee Lake			
1	13.1	28.0	58.9
3	93.4	6.3	0.4
Middle Tributary to Coffee Lake Creek			
1	3.2	96.8	0.0
Arrowhead			
1	0.0	42.0	58.0
2	25.9	74.1	0
Meridian			
1	35.1	29.6	35.3
2	44.4	31.1	24.5
North Fork Meridian			
1	17.0	39.0	43.9

found to be true in Wilsonville streams as well. All fish species observed in Wilsonville streams were also observed in the other surveys. Native fish species from other surveys in Clackamas County that were not observed in Wilsonville include longnose dace *Rhinichthys cataractae,* redside shiner *Richardsonius balteatus,* largescale sucker *Catostomus macrocheilus,* prickly sculpin *Cottus asper,* riffle sculpin *Cottus gulosus,* and torrent sculpin *Cottus rhotheus.*

Low IBI scores throughout Wilsonville streams can probably be attributed to barriers and environmental disturbances, although some small watersheds may have inherently low IBIs, even when relatively intact (Reynolds et al. 2003). In Boeckman Creek, IBIs are low and considered marginally impaired, even though the stream supports a reproducing population of cutthroat trout. It is possible that small tributaries of the Willamette River might naturally have few fish species and therefore low IBIs.

Table 7. Summary of percent substrate compositions for each stream reach surveyed in summer 2003 or summer 2004.

Stream, Reach	Silt	Sand	Gravel	Cobble	Boulder	Bedrock
Boeckman						
1	69.4	12.0	8.9	1.2	0	8.5
2	54.8	25.1	20.2	0	0	0
3	31.1	37.5	24.7	2.8	0	4.0
4	50.0	15.0	0	35.0	0	0
5	51.5	40.1	5.5	2.9	0	0
6	84.6	13.1	0	2.3	0	0
7	50.0	45.0	5	0	0	0
Coffee Lake						
1	23.6	7.5	31.3	33.3	0	0
3	55.9	43.5	0	0	0.6	0
Middle Tributary to Coffee Lake Creek						
1	100	0	0	0	0	0
Arrowhead						
1 [a]	-	-	-	-	-	-
2	50.0	40.0	0	10.0	0	0
Meridian						
1	50.6	42.2	2.8	4.5	0	0
2	52.8	41.1	5.0	0.2	0	0.9
North Fork Meridian						
1	50.0	48.2	1.8	0	0	0

[a] Reach with <10 habitat units

Seasonally varying IBI scores may be a result of fish behavior. Differential habitat or even whole-stream use may vary by species among seasons (Healy 1991). Such is apparently the case with juvenile Chinook salmon in Boeckman and Coffee Lake Creeks during winter. Juvenile Chinook salmon rearing in freshwater will often seek out different habitats in the winter (Healy 1991). These habitats provide refuge from extreme flow events and predation, and offer better cover food opportunities.

Seasonal surveys are a snapshot in time taken four days a year over a relatively short distance within each stream reach. Although we believe presence and distribution of most species have been adequately determined, detection of uncommon or rare fish, particularly alien species, is subject to bias associated with minimal effort in each stream. Furthermore, we recognize that relative abundance of species collected may not reflect actual relative abundance because

Table 8. Summary of measured habitat parameters for each stream reach surveyed in summer 2003 or summer 2004. Depth, % erosion, % undercut banks, and shade all represent means for the entire stream reach. Shade values range from 0^{o} to 180^{o}.

Stream, Reach	Length (m)	Depth (m)	Erosion (%)	Undercut bank (%)	Shade (^{o})
Boeckman					
1	1066	0.39	89	17	160
2	260	0.31	56	16	147
3	1813	0.26	71	6	174
4	88	0.21	89	3	144
5	303	0.19	87	58	158
6	154	0.20	83	85	155
7	308	0.17	80	47	163
Coffee Lake					
1	450	0.22	23	9	151
3	1253	0.28	34	0	73
Middle Tributary to Coffee Lake Creek					
1	239	0.40	7	15	14
Arrowhead					
1	26	0.21	7	3	121
2	137	0.13	64	1	165
Meridian					
1	125	0.24	39	13	155
2	615	0.16	77	3	156
North Fork Meridian					
1	86	0.17	25	10	175

behavior and vulnerability to sampling gear vary among species. For example, benthic species such as sculpins and lampreys can be more difficult to capture than water column species such as salmonids.

Boeckman Creek supports a year-round population of cutthroat trout, most likely a resident population because of two culverts located in the Reach 1. Collection of cutthroat trout less than 60 mm in length indicates recruitment and a naturally producing population. Cutthroat trout were mostly found in pools that provided some type of cover, such as overhanging branches, undercut banks, and woody debris.

Table 9. Summary of riparian transect data for each stream reach surveyed in summer 2003 or summer 2004. Canopy closure, shrub cover, and grass/forb cover all represent means for the entire stream reach. N = number of riparian samples for each reach.

Stream, Reach	N	Canopy closure (%)	Shrub cover (%)	Grass/forb cover (%)	Conifers/ acre	Hardwoods/ acre
Boeckman						
1	4	61.5	44.5	46.5	0	94
2	1	43.3	76.7	16.7	27	270
3	8	83.4	44.1	32.1	17	226
4	1	60.0	80.0	8.3	0	162
5	3	71.1	55.6	44.4	9	63
6 [a]	-	-	-	-	-	-
7	2	87.0	72.0	63.0	41	41
Coffee Lake						
1	2	41.7	13.3	60.0	0	40
3		16.7	45.0	47.5	0	41
Middle Tributary to Coffee Lake Creek						
1	1	63.3	36.7	35.0	0	189
Arrowhead						
1	1	58.3	75.0	10.0	54	54
2	1	81.7	20.0	53.3	135	108
Meridian						
1	1	76.7	50.0	30.0	0	0
2	4	85.0	60.0	3.3	101	94
North Fork Meridian						
1 [a]	-	-	-	-	-	-

[a] Reach with <30 habitat units, riparian transect data not taken

Western brook lamprey adults and ammocoetes occurred year-round throughout Boeckman Creek. The presence of lamprey ammocoetes indicates adult lamprey spawn throughout the stream.

Non-native species occurred during most of the year in all streams creeks except Meridian Creek. Zaroban et al. (1999) classified all of the non-native species we collected as tolerant. Because tolerant species are able to persist in warm temperatures, sedimentation, and organic pollution (Hughes et al. 1998), non-native species may be able to out-compete native species in degraded streams. Further habitat degradation may therefore result in wider distribution of non-native species.

Table 10. Summary of woody debris data for each stream reach surveyed in summer 2003 or summer 2004. LWD = large woody debris (> 15 cm in diameter). Channel width, LWD length, and LWD diameter all represent means for the entire stream reach.

Stream, Reach	Active channel width (m)	LWD quantity/ 100m	LWD volume (m^3)/100m	LWD length (m)	LWD diameter (m)
Boeckman					
1	3.1	12.7	10.8	6.3	0.34
2	3.3	15.5	6.4	6.3	0.28
3	3.8	17.4	11.6	6.4	0.32
4	3.0	9.1	5.5	4.1	0.36
5	2.9	7.3	4.7	4.4	0.45
6	2.5	1.3	1.4	6.0	0.45
7	2.1	4.9	2.6	5.2	0.38
Coffee Lake					
1	3.3	3.8	3.3	6.7	0.35
3	12.3	0.5	0.05	3.0	0.20
Middle Tributary to Coffee Lake Creek					
1	4.0	0	0	0	0
Arrowhead					
1	1.5	0	0	0	0
2	2.0	6.6	6.2	8.1	0.33
Meridian					
1	3.0	31.1	14.8	4.4	0.33
2	3.2	19.5	13.5	6.4	0.36
North Fork Meridian					
1	1.4	10.5	2.7	4.1	0.28

HABITAT PROTECTION AND RESTORATION

Final priorities for habitat protection and restoration in Wilsonville streams should be developed in conjunction with other stakeholders. Priorities should include short-term (instream improvements), medium-term (habitat protection), and long-term (land-use planning) objectives, strategies, and actions. Recommendations provided here can serve as a basis for discussion by stakeholders.

Habitat degradation and loss is a serious threat to the maintenance of healthy fish populations; therefore, planning often emphasizes protection of healthy habitats over restoration and enhancement of degraded habitats. Protection from further degradation is indeed important for Wilsonville streams; however, our findings indicate that restoration is required to ensure

continued existence of native fish populations. Boeckman Creek sustains the largest and most diverse assemblage of native fish, and should at the least be protected from further degradation; however, no reach of Boeckman Creek exhibited excellent habitat or supported an "acceptable" fish assemblage. Benefits of restoration actions in remaining streams are unlikely to match benefits of actions within Boeckman Creek; therefore, they should be considered lower priority. Possible exceptions are restoration activities targeting the lowest reaches of Meridian and Coffee Lake creeks, which may provide winter habitat for juvenile anadromous salmonids.

Boeckman Creek

Reach 1

This reach is probably the highest priority for protection and restoration. During summer surveys this was the only reach to contain western brook lamprey, cutthroat trout, and anadromous salmonids. In winter we found several anadromous salmonid fry about 250-m upstream from the mouth. In addition to providing possible refuge from the Willamette River for juvenile anadromous salmonids, this reach connects the Willamette River and the remainder of Boeckman Creek, which will likely remain the Wilsonville stream with the highest-quality habitat.

The first 30 m of this stream reach is deeply incised and severely eroded; the active channel height is over 3 m, active erosion is 100%, and silt is the dominant substrate (90%) of pools and glides. These conditions may impede passage by some salmonids to the upper sections of the stream reach during some seasons. After the first 30 m, the active channel height lowers to about 0.5 m; however, the amount of active erosion is still quite high. Riparian vegetation is primarily grasses and shrubs, which may not serve as good bank stabilizers. We found no anadromous salmonids above the first culvert, which is about 300 m upstream from the mouth. As described by Pribyl et al. (2004), this culvert is likely a barrier to fish passage during most times of the year. Other areas for improvement include the amount of large woody debris. Large woody debris content in this reach averages 12.7 pieces/100 m compared to healthy streams in unmanaged forests that contain 25-40 pieces/100 m.

- Improve bank stability and fine sediment control through increased planting of native riparian vegetation.
- Consider increasing the number of large trees along the stream to increase shade and input of large woody debris.
- Determine if more extensive measures are needed to restore natural channel morphology.
- Investigate feasibility of improving passage through the first culvert.

Reaches 2-7

Although differences exist among reaches 2 through 6, the relative importance of protection and restoration is similar among these reaches. These reaches all contain cutthroat trout year-round in higher numbers than observed in other streams. In reaches 4 through 6, cutthroat trout

distribution was limited to the larger pools. These fish are likely residents, making it important to maintain stream habitat for their continued survival.

Current physical habitat varies somewhat among reaches. Reach 2 suffers from riparian vegetation being dominated by Himalayan blackberry, with relatively low levels of canopy closure and high levels of silt substrate. Reach 3 has extensive canopy closure, the greatest amount of large woody debris (17.4 pieces/100 m), and relatively little silt substrate. Reaches 4 through 6 have high levels of erosion and very low amounts of large woody debris (1.3 to 9.1 pieces/100 m), with varying levels of canopy closure and silt substrate.

- Remove undesirable exotic riparian vegetation. Site-specific evaluations should be completed to determine the most effective removal methods.
- Improve bank stability and fine sediment control through increased planting of native riparian vegetation.
- Where appropriate, increase the number of large trees along the stream to increase shade and input of large woody debris.
- Consider placement of large woody debris to reload the stream channel until this occurs through natural processes.

Coffee Lake Creek

Reach 1

Although a lower priority than Boeckman Creek, the lowest reach of Coffee Lake Creek should be considered for restoration because it may provide winter habitat for juvenile anadromous salmonids. We found juvenile Chinook salmon (and western brook lamprey) in this reach during winter only.

This stream has some good qualities that may make it good salmonid habitat, primarily gravel/cobble substrate and little erosion. Primary problems include a predominance of fast water habitat units (which make it difficult for salmonids to find resting areas), very low amounts of woody debris, few trees (little canopy closure), and a riparian area of mostly grass.

- Increase the number of large trees along the stream to increase shade and input of woody debris.
- Consider placement of large woody debris to reload the stream channel with large wood until this occurs through natural processes.

Meridian Creek

Reaches 1 and 2

Reach 1 is very short (125 m), so both reaches are considered together. Also a lower priority than Boeckman Creek, Meridian Creek should be considered for restoration because it may provide refuge for juvenile anadromous salmonids. We found juvenile Chinook salmon every season except fall, rainbow trout/steelhead in winter, and coho salmon in summer. Meridian Creek also supports western brook lamprey.

This stream has a relatively diverse composition of major habitat types, good shade, and more woody debris than any other Wilsonville stream. The primary problem is substrate, which is dominated by silt and sand. Relatively high levels of erosion likely contribute to this problem.

- Improve bank stability and fine sediment control through increased planting of native riparian vegetation.

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APPENDIX A

Fish Collected in Summer Presence/Absence Surveys

Appendix Table A-1. Number of fish collected during summer 2003 presence/absence sampling in Wilsonville streams.

	Stream, reach			
	Boeckman			Coffee Lake
Species	1	2	3	1
Western brook lamprey	1	0	0	0
Unidentified lamprey	3	9	14	0
Speckled dace	1	0	0	0
Cutthroat trout	2	1	10	0
Rainbow trout/steelhead	1	0	0	0
Chinook salmon	1	0	0	0
Western mosquitofish[a]	0	0	0	2
Reticulate sculpin	133	41	124	68
Unidentified cottids	25	40	137	38
Bluegill[a]	0	0	0	5
Smallmouth bass[a]	1	0	0	0

[a]Non-native species

Appendix Table A-2. Number of fish collected during summer 2004 presence/absence sampling in Wilsonville streams.

	Stream, reach									
	Arrow-head	Boeckman				Coffee Lake	Middle Tributary to Coffee Lake Creek	Meridian		North Fork Meridian
Species	1	4	5	6	7	3	1	1	2	1
Western brook lamprey	0	0	0	0	0	0	0	0	0	0
Unidentified lamprey	0	15	7	1	0	0	0	17	34	0
Goldfish[a]	0	2	0	0	0	0	0	0	0	0
Brown bullhead[a]	0	0	0	0	0	3	0	0	0	0
Cutthroat trout	0	1	4	11	4	0	0	0	0	0
Western mosquitofish[a]	0	0	0	0	0	93	0	0	0	0
Threespine stickleback	1	0	0	0	0	12	0	0	0	0
Reticulate sculpin	0	19	70	13	0	0	0	14	26	0
Unidentified cottids	0	19	12	6	0	0	0	9	24	1
Largemouth bass[a]	0	0	0	0	0	2	0	0	0	0

[a]Non-native species

APPENDIX B

Fish Collected in Multiple-Pass Removal Surveys

Appendix Table B-1. Number of fish collected in 2003 and 2004 during multiple-pass removal sampling in Boeckman Creek.

	Season, reach																							
	Summer						Fall						Winter						Spring					
Species	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Western brook lamprey	4	3	6				3	8	6				2	8	1			2	1				2	
Lamprey spp	1	2	7		4	1			2			2			2			1	3	9	5			1
Northern pikeminnow																								
Speckled dace							1																	
Brown bullhead																								
Cutthroat trout		8	3	3	3	2		4	3					1	1		1	3		9	3	4	1	2
Rainbow trout																								
Coho salmon																								
Chinook salmon													2											
Salmonid species													5								3			
Mosquitofish																								
Three-spined stickleback																								
Reticulate sculpin	39	82	77		64	32	18	37	40	2	27	11	20	43	23	3	31	8	42	59	58	7	26	29
Sculpin spp	10	30	164		10	7	4	31	92		10	2	2	33	15		6	3	1	23	9		8	5
Bluegill																								
Largemouth bass																								
Total Fish	54	125	257	3	81	42	26	80	143	2	37	15	31	85	42	3	38	17	47	100	78	11	37	37

Appendix Table B-2. Number of fish collected in 2003 and 2004 during multiple-pass removal sampling in Coffee Lake and Arrowhead creeks, and in the middle tributary to Coffee Lake Creek, by season and reach.

	Coffee Lake								Arrowhead			Middle Tributary to Coffee Lake Creek			
	Summer		Fall		Winter		Spring		Summer	Fall	Winter	Summer	Fall	Winter	Spring
Species	1	3	1	3	1	3	1	3	1	1	1	1	1	1	1
Western brook lamprey					1										
Lamprey spp															
Northern pikeminnow					1										
Speckled dace															
Brown bullhead	3		15		8		3	1					1		
Cutthroat trout															
Rainbow trout															
Coho salmon															
Chinook salmon					6										
Salmonid species					1										
Mosquitofish	5	5		10			8	7	2		1	222	100	148	38
Three-spined stickleback	1	25	2	34	1	11	14	16		1		1	1	10	1
Reticulate sculpin	66	1	32		12	1	93		1			4	1		
Sculpin spp	47		18		1		4		2			1			
Bluegill	1		1			1	4								
Largemouth bass		5		3								3			
Total Fish	120	39	53	62	23	21	126	24	5	1	1	231	103	158	39

Appendix Table B-3. Number of fish collected during multiple-pass removal sampling in Meridian and north

fork of Meridian creeks, by season and reach.

	Meridian								North Fork Meridian			
	Summer		Fall		Winter		Spring		Summer	Fall	Winter	Spring
Species	1	2	1	2	1	2	1	2	1	1	1	1
Western brook lamprey					2	2	2					1
Lamprey spp	26	20		1					2		1	
Northern pikeminnow												
Speckled dace												
Brown bullhead												
Cutthroat trout												
Rainbow trout						2						
Coho salmon	1											
Chinook salmon		1		1	1							
Salmonid species												
Mosquitofish												
Three-spined stickleback												
Reticulate sculpin	5	27	5	16	7	7	8	1	1	3		1
Sculpin spp	1	33	8	20	2		3	4		3	1	
Bluegill												
Largemouth bass												
Total Fish	33	81	13	38	12	11	13	5	3	6	2	2

APPENDIX C

Index of Biotic Integrity Scores

Appendix Table C-1. Data used to calculate Index of Biotic Integrity Scores for Wilsonville streams. PA = presence-absence, Su = summer, Fa=fall, Wi = winter, Sp = spring, NLN = nonguarding lithophil nester.

Presence/absence, or season	Stream	Reach	Stream Order	Fish handled	Native families	Native species	Native benthic species	Native water column species	Hider species	Sensitive species	Native NLN species	Tolerant individuals	Filter feeders	Ominvores	Lunker species individuals	Lunkers	Fish not examined for anomalies	Anomalies
PA	Boeckman	1	2	168	4	8	3	3	5	4	4	0	4	0	2	0	0	1
PA	Boeckman	2	2	91	3	4	2	1	3	2	2	0	9	0	1	0	0	0
PA	Boeckman	3	2	285	3	4	2	1	3	2	2	0	14	0	1	0	0	3
PA	Boeckman	4	2	56	3	4	2	1	3	2	2	2	15	2	1	0	0	0
PA	Boeckman	5	2	93	3	4	2	1	3	2	2	0	7	0	1	0	0	0
PA	Boeckman	6	2	31	3	4	2	1	3	2	2	0	1	0	1	0	0	0
PA	Boeckman	7	1	4	1	1	0	1	1	1	1	0	0	0	1	0	0	0
PA	Coffee Lake	1	2	113	1	2	1	0	2	0	0	7	0	2	0	0	0	1
PA	Coffee Lake	3	1	74	2	3	1	1	4	0	0	18	0	16	0	0	0	0
PA	Arrowhead	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0
PA	Arrowhead	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PA	Meridian	1	2	40	2	3	2	0	2	1	1	0	17	0	0	0	10	0
PA	Meridian	2	2	84	2	4	2	0	2	1	1	0	34	0	0	0	0	0
PA	North Fork Meridian	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0
PA	Middle Tributary to Coffee Lake Creek	1	1	105	1	1	0	1	2	0	0	93	0	93	0	0	0	0
Su	Boeckman	1	2	54	2	4	2	0	2	1	1	0	5	0	0	0	0	0
Su	Boeckman	2	2	121	3	5	2	1	3	2	2	0	5	0	1	1	31	1
Su	Boeckman	3	2	257	3	5	2	1	3	2	2	0	13	0	1	0	144	0
Su	Boeckman	4	2	1	1	1	0	1	1	1	1	0	0	0	1	0	0	0
Su	Boeckman	5	2	81	3	4	2	1	3	2	2	0	4	0	1	0	0	0
Su	Boeckman	6	2	41	3	4	2	1	3	2	2	0	1	0	1	0	0	0
Su	Coffee Lake	1	1	120	2	3	1	1	3	0	0	6	0	5	0	0	16	0
Su	Coffee Lake	3	1	39	2	2	1	1	4	0	0	13	0	8	0	0	0	0
Su	Arrowhead	1	1	5	1	2	1	0	2	0	0	2	0	2	0	0	0	0
Su	Arrowhead	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Su	Meridian	1	2	33	3	4	2	1	2	2	2	0	26	0	0	0	0	0
Su	Meridian	2	2	81	3	4	2	1	2	2	2	0	20	0	0	0	0	0
Su	Middle Tributary to Coffee Lake Creek	1	1	3	2	3	1	1	3	0	0	225	0	222	0	0	0	1
Su	North Fork Meridian	1	1	231	2	2	2	0	2	1	1	0	2	0	0	0	0	0
Fa	Boeckman	1	2	26	3	4	3	0	3	1	1	0	3	0	0	0	0	0
Fa	Boeckman	2	2	72	3	4	2	1	3	2	2	0	2	0	1	1	0	0
Fa	Boeckman	3	2	143	3	5	2	1	3	2	2	0	8	0	1	0	0	0
Fa	Boeckman	4	2	2	1	1	1	0	1	0	0	0	0	0	0	0	0	0
Fa	Boeckman	5	2	37	1	2	1	0	1	0	0	0	0	0	0	0	0	0
Fa	Boeckman	6	2	15	2	3	2	0	2	1	1	0	2	0	0	0	0	0
Fa	Coffee Lake	1	1	53	2	3	1	1	2	0	0	1	0	0	0	0	0	0
Fa	Coffee Lake	3	1	62	1	1	0	1	3	0	0	28	0	25	0	0	0	0
Fa	Arrowhead	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0
Fa	Arrowhead	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fa	Meridian	1	2	13	1	2	1	0	1	0	0	0	0	0	0	0	0	0
Fa	Meridian	2	2	38	3	4	2	1	2	2	2	0	1	0	0	0	0	1
Fa	Middle Tributary to Coffee Lake Creek	1	1	6	2	2	1	1	4	0	0	101	0	101	0	0	0	3
Fa	North Fork Meridian	1	1	103	1	2	1	0	1	0	0	0	0	0	0	0	0	0
Fa	South Tributary to Coffee Lake Creek	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table C-1. Continued.

Season	Stream	Reach	Stream Order	Fish handled	Native families	Native species	Native benthic	Native water column	Hider species	Sensitive species	Native NLN species	Tolerant individuals	Filter feeders	Ominvores	Lunker species individuals	Lunkers	Fish not examined for anomalies	Anomalies
Wi	Boeckman	1	2	27	3	5	2	1	2	2	2	0	2	0	0	0	0	0
Wi	Boeckman	2	2	85	3	4	2	1	3	2	2	0	8	0	1	0	0	0
Wi	Boeckman	3	2	41	3	4	2	1	3	2	2	0	2	0	1	1	0	0
Wi	Boeckman	4	2	3	1	1	1	0	1	0	0	0	0	0	0	0	0	0
Wi	Boeckman	5	2	38	2	3	1	1	2	1	1	0	0	0	1	0	0	0
Wi	Boeckman	6	2	17	3	5	2	1	3	2	2	0	3	0	1	0	0	0
Wi	Coffee Lake	1	1	16	3	4	1	2	2	1	1	9	0	0	0	0	0	0
Wi	Coffee Lake	3	1	21	2	2	1	1	3	0	0	0	0	8	0	0	0	0
Wi	Arrowhead	1	1	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0
Wi	Arrowhead	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wi	Meridian	1	2	11	3	4	2	1	2	2	2	0	1	0	0	0	0	0
Wi	Meridian	2	2	11	3	3	2	1	3	2	2	0	2	0	1	0	0	0
Wi	Middle Tributary to Coffee Lake Creek	1	1	2	1	1	0	1	2	0	0	148	0	148	0	0	0	0
Wi	North Fork Meridian	1	1	158	2	2	2	0	2	1	0	0	1	0	0	0	1	0
Wi	South Tributary to Coffee Lake Creek	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sp	Boeckman	1	2	47	2	4	2	0	2	1	1	0	4	0	0	0	0	1
Sp	Boeckman	2	2	93	3	4	2	1	3	2	1	0	9	0	1	0	0	0
Sp	Boeckman	3	2	77	3	4	2	1	3	3	2	0	5	0	1	0	0	0
Sp	Boeckman	4	2	10	2	2	1	1	2	1	2	0	0	0	1	0	0	0
Sp	Boeckman	5	2	37	3	4	2	1	3	2	1	0	2	0	1	0	0	0
Sp	Boeckman	6	2	37	3	4	2	1	3	2	2	0	1	0	1	0	0	0
Sp	Coffee Lake	1	1	126	2	3	1	1	4	0	0	15	0	11	0	0	0	0
Sp	Coffee Lake	3	1	24	1	1	0	1	3	0	0	8	0	8	0	0	0	0
Sp	Arrowhead	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sp	Arrowhead	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sp	Meridian	1	2	13	2	3	2	0	2	1	2	0	2	0	0	0	0	0
Sp	Meridian	2	2	5	1	2	1	0	1	0	0	0	0	0	0	0	0	0
Sp	Middle Tributary to Coffee Lake Creek	1	1	2	1	1	0	1	2	0	0	38	0	38	0	0	0	0
Sp	North Fork Meridian	1	1	39	2	2	2	0	2	1	1	0	1	0	0	0	0	0
Sp	South Tributary to Coffee Lake Creek	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX D

Stream Reach Locations

Appendix Table D-1. Approximate locations of Wilsonville stream reaches surveyed from summer 2003 through spring 2005.

Stream	Reach	Description
Boeckman	1	From mouth to Kolbe Lane.
	2	Kolbe Lane to confluence with tributary stream
	3	From tributary stream to Boeckman Rd.
	4	From Boeckman Rd. north to first tributary (near end of SW Frog Pond Ln.)
	5	North of tributary to next tributary approximately 70 meters below old culvert.
	6	North of tributary to next tributary approximately 100m north of culvert
	7	From tributary mouth to Colvin Ln.
Coffee Lake Creek	1	From mouth to confluence with first tributary stream (Arrowhead Creek)
	3	North of Wilsonville Rd. to the middle tributary to Coffee Lake Creek.
Middle Tributary to Coffee Lake Creek	1	Runs east of Coffee Lake Creek towards G.I. Joe's warehouse at end of Boeckman Rd.
South Tributary to Coffee Lake Creek	1	Ditch directly north of the corner at Kinsman Road and SW Barber.
Arrowhead	1	Confluence with Coffee Lake Creek to pump house along Industrial Way.
	2	Approximately 100m NW of pump house, across Industrial Way from culvert pipe to new bridge crossing.
Meridian	1	Confluence with Willamette River to tributary (North Fork Meridian)
	2	North from confluence with North Fork Meridian to Wilsonville Rd.
North Fork Meridian	1	Confluence with Meridian north to Montgomery Way Rd.

Appendix Table D-2. Approximate locations of 100-m multiple pass survey reaches sampled in Wilsonville streams from summer 2003 through spring 2005.

Stream	Reach	Description
Boeckman	1	Sample reach extends from approximately 10-m downstream of scour pool formed below the first culvert (located in Memorial Park), to 100-m downstream.
	2	Sample reach extends from Wilsonville Rd. to 100-m upstream.
	3	City-owned property above Meadows Ct. along Meadows Lp. Take Boeckman Creek crossing trail to bridge across creek. Sample reach extends from bridge crossing to 100-m upstream.
	4	Sample reach extends from approximately 10-m downstream of confluence with first tributary to 100-m downstream (access from Canyon Creek Rd.).
	5	Access from Thornton Dr. Use trail and start approximately 50-m downstream from point where trail meets creek. to 100-m upstream..
	6	Approximately 75-m upstream from end of transect 5 sample to tributary confluence then sample to culvert
	7	Reach not sampled due to poor access and limited flow.
Coffee Lake Creek	1	Sample reach extends from approximately 15-m downstream of confluence with Arrowhead Creek to 100-m downstream.
	3	North of Wilsonville Rd. to the middle tributary to Coffee Lake Creek.
Middle Tributary to Coffee Lake Creek	1	First accessible 100-m from GI Joe's warehouse parking lot access point.
South Tributary to Coffee Lake Creek	1	Confluence with ditch to 100-m upstream.
Arrowhead	1	Confluence with Coffee Lake Creek to pump house (<100-m).
	2	100-m upstream from culvert.
Meridian	1	50-m upstream from mouth (above log jams) to 100-m upstream.
	2	From confluence with north fork of Meridian to large beaver dam (<100-m).
North Fork Meridian	1	Confluence with Meridian Creek to culvert at Montgomery Way.