Andrus, Chip, John Gabriel, and Paul Adamus. "Biological Evaluation of the Willamette River and McKenzie River Confluence Area." September 2000. McKenzie Watershed Council.
(Reviewed by Aria DalMolin)

This was an annual report of 2000 looking at the biological changes of the area where the Willamette River and the McKenzie River meet. The report looked at the changes in river flow, suspended sediment, bedload, channel morphology, water temperature, macroinvertabrates, land inundation, fish and their habitat, wildlife and their habitat, and then offered restoration principles that could be taken in order to recreate the changing habitats for native fish and wildlife that are becoming scarce. I mainly focused on the fish, wildlife, and plants aspects of the report, however all of the changes such as water temperature and such have effected the fish, wildlife and plants in the area so all of the subjects in this report were very interrelated. The report mentioned that the peak river flow has decreased since the 1950s which has in turn reduced the ability of the river to create off-channel habitats for certain species of fish and wildlife. A map of the river's vegetation showed that conifers are scarce in places that they were more common in the 1940s due to recent clear cuts. It also mentioned that the three-spine stickleback fish were once common in the Willamette Valley and are now scarce and declining in numbers. Also, the western pond turtle and the red-legged frog are declining rapidly, the latter due to the introduced species the bullfrog.

Critique

This 2000 report was very informative and written in a language so that an everyday person without a great knowledge of scientific reports and scientific terminology could understand it. The test site was clearly defined and the results of the experiments and surveys of the environment of the area were clearly displayed through many different graphs and diagrams. Some of the evidence, however was inconclusive, for instance the report mentioned that the method used for collecting data of fish species had many limitations, for instance the electrofishing method did not extend to the bottom of the river when the water depth was greater than 7feet, and very fast water and swirling eddies could have made the method less effective and precise. However, at the end of the report, rather than just summing up what was going on with the river and what was wrong with the river at the end of the year 2000, the article offered concrete ways to help restore the habitat, which I found very helpful and interesting. Overall, I think this is a reliable source since it combined the help of many different scientific organizations in order to put together the annual report, and it contained a rather long reference list at the end of the report so the information appeared concrete.

Website http://www.mckenziewatershedcouncil.org

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McKenzie Watershed Council

"The River Links Us All."

Oregon's McKenzie River flows from the crest of the Cascade mountains westward to the confluence of the Willamette River near the Eugene-Springfield metropolitan area. With headwaters in three wilderness areas, the McKenzie contains some of the purest water in America. This magnificent river and its surrounding watershed provide a multitude of benefits, including drinking water for over 200,000 Lane County residents, outstanding fish and wildlife habitat, hydroelectric generation, recreational and open space opportunities, and productive timber and agricultural lands.

It is the Mission of the Council to foster better stewardship of the McKenzie Watershed resources through voluntary partnerships and collaboration.

The Council's Vision is that the McKenzie River Watershed supports exceptional water quality and habitats in balance with human economic livelihood and quality of life.

We have developed a web page:

- to increase your interest and involvement in protecting the McKenzie Watershed
- to inform you about what the McKenzie Watershed Council is and what we're doing to allow for communication among McKenzie Watershed Council partner organizations, friends, and interested people like you.

Enjoy exploring the McKenzie Watershed Council Website. Don't forget to give us your comments. You can e-mail us directly from the website, or call 541-687-9076. We want to hear from you!

If you experience any problems, please contact us at : mckenziewc@callatg.com

Get involved in the McKenzie Watershed!
The Mckenzie Watershed Council welcomes the input of watershed residents and other interested people. The Council meets on the second Thursday of every month, and invites everyone to attend. Ten minutes at the beginning of each meeting are reserved for public comment. Contact us by E-mailing mckenziewc@callatg.com, calling 541/687-9076, or writing to P.O. Box 53, Springfield, Oregon 97477.

McKenzie Watershed Council

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The McKenzie Watershed Council developed several documents to communicate its mission, goals, and objectives for action.

View our Technical Report and Action Plans

- McKenzie Watershed Water Quality Report: 1996-2004, May 2005 (541k)
- Cedar Creek Monitoring Program: The First Five Years, January 2002 (716k)
- McKenzie River Watershed Conservation Strategy, January 2002 (1282k)
- McKenzie Macroinvertebrate Monitoring Report, September 2002 (257k)
- 1998 Storm Event Monitoring, April 2001 (216k)
- Land Use, Flood Control and Habitat Enhancement Guidelines for the Confluence Area, November 2001 (307k)
- McKenzie River Subbasin Assessment Summary Report, February 2000 (1890k)
- McKenzie Willamette Confluence Assessment Report, September 2000 (3327k)
- Action Plan for Recreation and Human Habitat, March 1997 (330k)
- Action Plan for Water Quality and Fish and Wildlife Habitat, January 1996 (143k)
- Technical Reports for Water Quality and Fish and Wildlife Habitat, February 1996 (247k)

The Council continues to produce educational and informative publications for individuals and groups interested in doing their part to protect and enhance the McKenzie Watershed.

Riparian Brochure

The Council, in conjunction with the University of Oregon's Community Planning Workshop, developed a riparian brochure for riverside property owners in the McKenzie. The brochure describes the importance of riparian areas, how to restore your riparian area, and sources of assistance for restoration projects.

View Riparian Brochure (620k)

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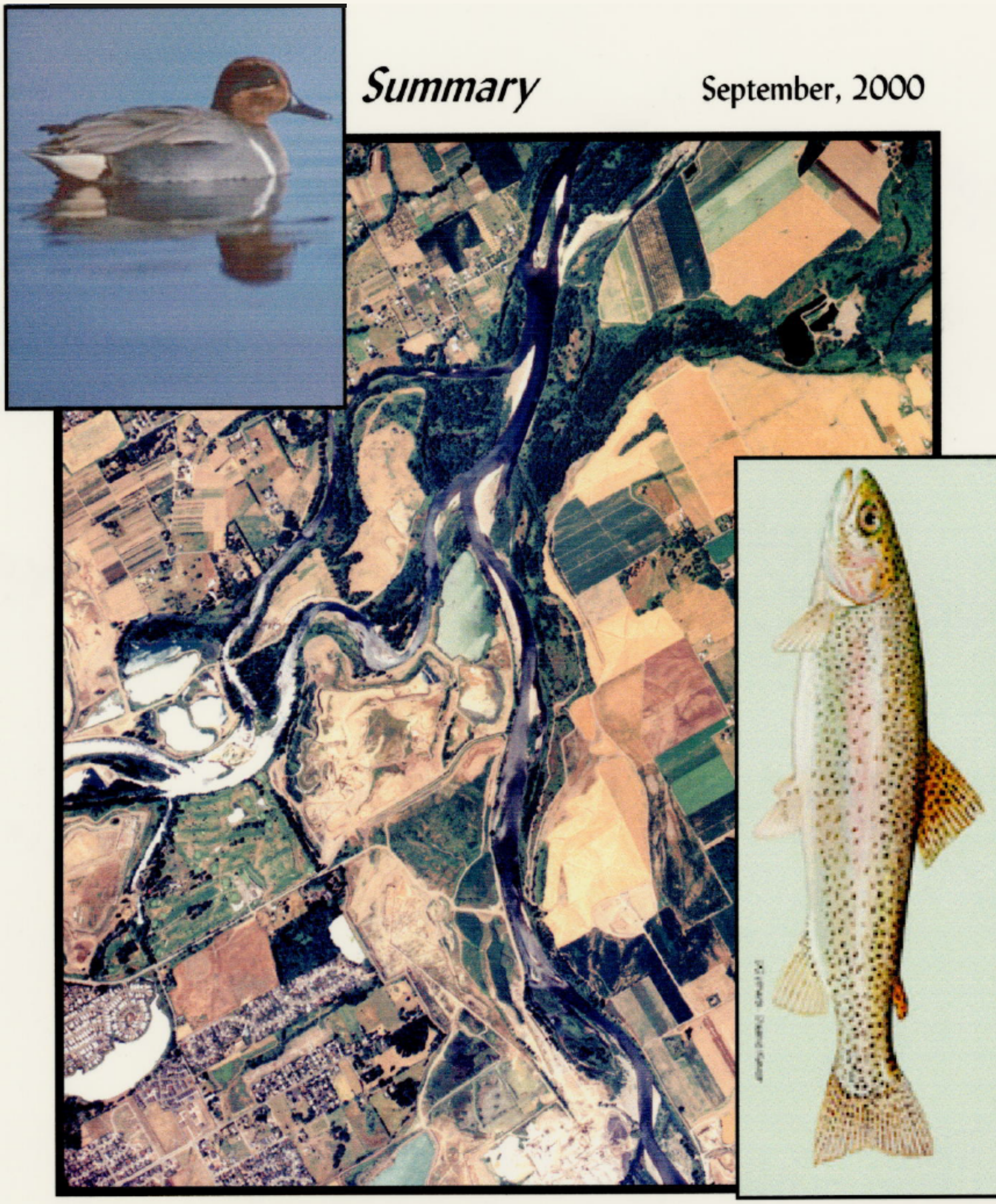
Biological Evaluation of the Willamette River and McKenzie River Confluence Area



Summary September, 2000

Prepared for the Confluence Project Steering Committee and the McKenzie Watershed Council

Prepared by Chip Andrus· WaterWork Consulting
John Gabriel, Alsea Geospatial, Inc.
Paul Adamus, Resource Assessment, Inc.

Table of contents

Introduction

The McKenzie River and Willamette River, like most large rivers in the United States, have been altered considerably during the last century. Aerial photographs from 1944 show the McKenzie / Willamette confluence area as a maze of channels and ponds with a wide range of vegetation types and ages. Maps from 1910 illustrate the confluence area prior to human disturbance and show an even greater labyrinth of channels (Figure 1). The confluence area, as defined in this discussion, includes the Willamette River from the Beltline Road bridge in Eugene to a point about 4 miles downstream of the McKenzie River confluence, where the old McKenzie River channel intersects with the Willamette River. The confluence area also includes the McKenzie River downstream of the Highway I-5 bridge to its current confluence with the Willamette River (Figure 2).

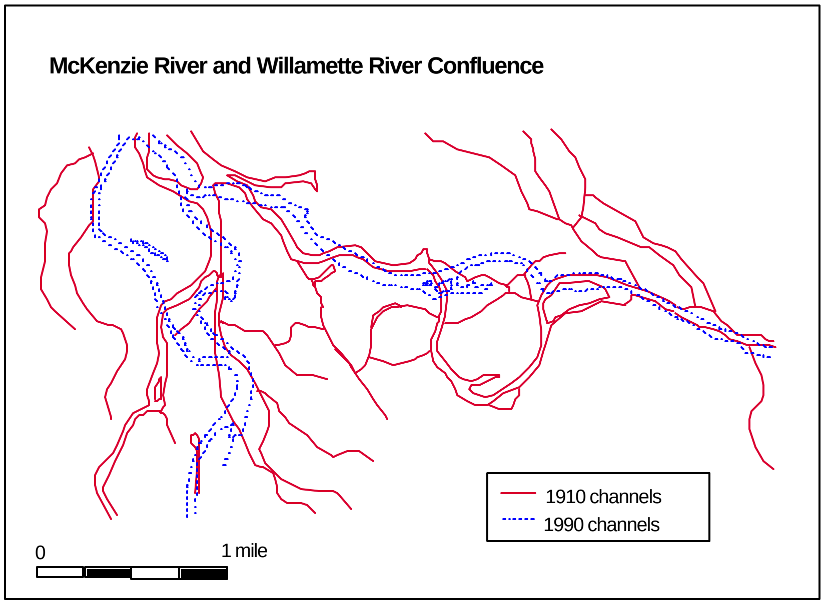


Figure 1. Channels of the Willamette River and McKenzie River near their confluence for 1910 and 1990. From Ligon (1991).

The changes in the confluence area have included log removal to allow boat navigation, channelization, conversion of riparian forest to farm land and house sites, wastewater disposal, gravel extraction, and construction of upstream reservoirs. Yet, in spite of these changes, the confluence area provides some of the best remaining habitat for fish and wildlife in the upper Willamette basin. Furthermore, there are considerable opportunities for restoring many of the ecological functions that have been altered over the decades.

Interest in fish and wildlife in the confluence area heightened following high water in 1996. High water threatened or breached dikes surrounding some gravel extraction areas. As flows peaked, gravel operators responded by elevating or armoring dikes at various locations to prevent flooding of their operations. Required fill permits were not obtained prior to these activities and, due to a local shortage of large rock, concrete rubble was used to armor some threatened banks and local

River Channel and Vegetation Study
McKenzie and Willamette River Confluence Area
Figure 2

N

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/u2/mckz/confluence/scan/maps/riv2000_loc2.aml materials were used to elevate some dikes. Agencies that have jurisdiction of fill activities responded with citations for some of these activities. Subsequently, a joint agreement was made to conduct a comprehensive look at fish and wildlife and flood susceptibility in the confluence area.

Out of this agreement came two studies. One study focused on the flood protection needs by gravel operators and was conducted by Northwest Hydraulics, Inc. with funding provided by the four gravel extraction companies in the confluence area. The other, summarized here, was a biological evaluation of the confluence area and was funded by the Oregon Watershed Enhancement Board. The intent was to incorporate these two studies into a unified plan for restoring and protecting fish and wildlife habitat, while providing appropriate levels of flood protection to gravel operations.

The biological study received oversight from the Confluence Steering Committee which consisted of representatives from the McKenzie Watershed Council, McKenzie River Flyfishers, Oregon Department of Fish and Wildlife, Corps of Engineers, Oregon Division of State Lands, National Marine Fisheries Service, Oregon Division of Geology and Mineral Industries, and the four gravel companies.

The biological evaluation in the confluence area had several objectives. One was to characterize current and historic river, land, and water conditions. Another objective was to describe the current status of fish, wildlife, and their habitat in the area using surveys associated with this study and information developed by others. A third objective was to identify restoration and protection principles that would be effective for improving fish and wildlife habitat in the confluence area.

River flow

Storage reservoirs constructed in the upper McKenzie River basin (during the 1960's) and Willamette River basin (1950's and 1960's) have decreased the frequency and magnitude of peak flows in the confluence area. A gage near Vida (river mile 48), indicates that post-reservoir annual peak flows average only about 60% of those prior to reservoir construction (Figure 3). Furthermore, flows greater than the 1996 flood (30,900 cfs) occurred about four times per decade prior to reservoir construction. The 1996 flood was the highest flow on record for the 31-year period following completion of both reservoirs.

Peak flows have been muted even greater in the upper Willamette River basin. Records from a gage on the Middle Fork Willamette River at Jasper indicates that the annual peak flow after reservoir construction averaged only 30% of pre-reservoir values. The highest fow of record (94,000 cfs in 1910) was nearly four times

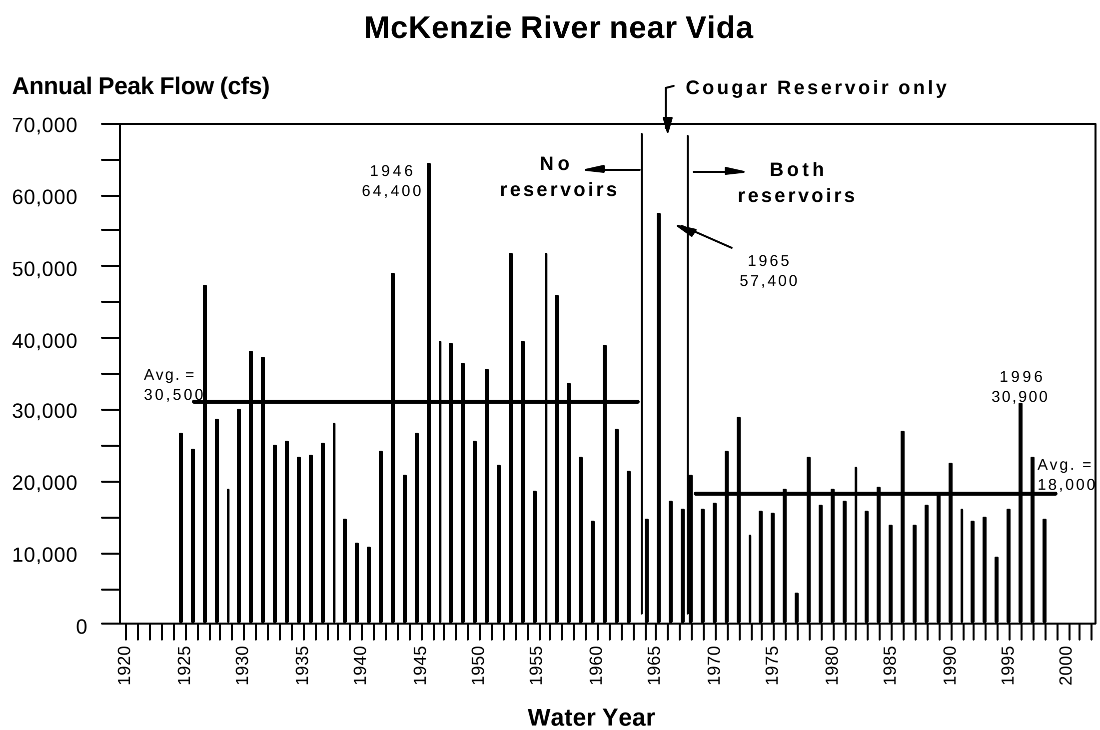


Figure 3. Annual peak flows for the McKenzie River near Vida before and after reservoir construction.

greater than the highest flow for the post-reservoir period.

The biological consequences of peak flow dampening in a river are indirect, yet potentially important. A decreased frequency of peak flows reduces the ability of a river to meander and create (or modify) off-channel features (Van Steeter and Pitlick 1998). These off-channel features include ponds, side channels, and alcoves (same as side channels but with only one end connected to the river at lower flows). Off-channel features provide unique habitat for certain species of fish and wildlife. Without the process in place to create these features, the populations that depend on them would be expected also to decline.

Monthly flows for the McKenzie River and Willamette River have also been altered by upstream reservoirs. From July through January, average monthly flows for these rivers following construction of reservoirs has been greater than pre-reservoir flows. Reversely, because reservoirs are filled from February through June, monthly flows during this period have been lowered compared to historic conditions.

The biological consequences of lower monthly flows from late winter through early summer have not been evaluated for the Willamette River but could include the isolation of fish in off-channel features as they attempt to complete migrations. On the positive side, increased flow during the summer can improve water quality in rivers by diluting pollution, checking algal growth, and decreasing water temperature.

Suspended sediment

The amount of suspended sediment transported by a river depends on the supply of fine sediments available for transport and the energy available to entrain and move the sediment downstream. We looked for evidence that either sediment supply or energy has changed in the last century for the McKenzie and Willamette Rivers.

A comparison of data collected from 1948 to 1951 (before reservoirs) by the Corps of Engineers and from 1991 to 1993 (after reservoirs) by the U.S. Geological Survey indicates that the relationship between daily sediment load and day flow is not different for the two time periods. This suggests that the net supply of sediment available for movement has not changed during the last 50 years. The no net change in sediment supply may be due to a number of factors. Roads were more numerous in 1991 than in 1948, however, current roads are usually built in a way that minimizes sediment production. Also, in recent years, bank hardening and channelization has reduced bank sources of sediment and river meandering, while urban runoff and farming close to the river probably increases sedimentation.

The dampening of peak flows at reservoirs has reduced the energy available to transport sediment. The suspended sediment vs. flow relationship was combined with actual daily flow data for the two time periods, and an estimate of annual sediment load was calculated. The results indicate that the current annual suspended load averages only 60% of that prior to reservoir construction (Figure 4). Consequently, deposition of fine sediments along the river is probably less now than before the reservoirs.

Bedload

Bedload includes that material ranging in size from larger sand particles to boulders. This size class bumps along the river bottom when transported downstream by higher flows. The amount of bedload material transported is also determined by the amount that can be entrained from river banks and bottoms.

While no measurements of bedload movement have ever been made for the lower McKenzie and upper Willamette Rivers, Ligon et al. (1995) indirectly demonstrated how the combination of dampened peak flows at reservoirs, intentional channelization, bank stabilization with riprap, and vegetation invasion of low-lying river bars has changed bedload composition along the McKenzie River.

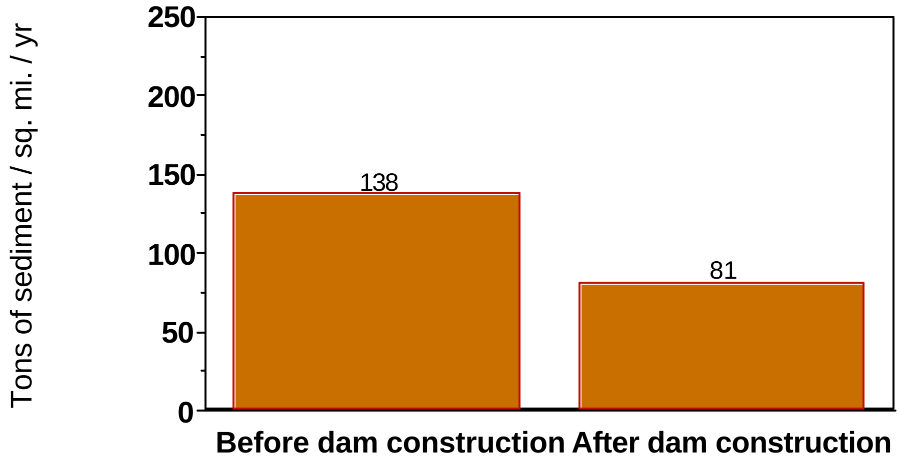


Figure 4. Modeled average unit annual load of suspended sediment for the McKenzie River at Coburg before dam construction (1940-1963) and after dam construction (1969-1998).

Using current and historic topographic maps, they determined that total wetted area of the McKenzie River decreased 28% and island perimeter decreased 41% from 1930 to 1990. They argued that by reducing peak flows, and thereby curtailing the river's ability to meander, create new courses across the flood plain, undercut banks, and locally deposit excess bedload at mid-river locations, a river eventually forms into a single thread with few islands or other off-channel areas. In support of this theory, our surveys of substrate size along the lower McKenzie River indicated that cobble-sized material dominates the channel except in some off-channel features.

A lack of variability in substrate size in the main channel can limit spawning and rearing opportunities for fish, leaving only the option of migration into tributaries as a means for fish to find gravels of a suitable size.

Channel morphology

Channel traces from 1850, generated from general land survey maps, were compared to current channel traces by Gregory et al. (1998). They calculated that the area of channels and islands is now only 20% of what it was in 1850 for a segment of the Willamette River from the McKenzie River confluence to Harrisburg.

Aerial photographs from 1944 show the McKenzie River downstream of the Hwy I-5 bridge occupying a flood plain between one-half to one mile wide. In the upper one-half, the river had a single main channel with many high-water channels branching to the south and north. Further downstream, the river split into two major channels flowing parallel to each other at a distance of one-quarter mile. In addition, numerous small side channels dissected this lower delta. Currently the McKenzie River flood plain is about 900 feet wide and consists mostly of a single channel.

The McKenzie River once flowed in a channel that paralleled the Willamette River and did not join up with the Willamette River until four miles downstream of its current confluence. By 1960, most of the lower McKenzie River had been diverted into its north channel and by-passed the lower section. Instead, it flowed directly into the Willamette River. The "old" McKenzie channel plugged and now flows only during high water. Over the next 20 years the McKenzie was further channelized and by 1979 aerial photographs show the course of the river to be about what it is today.

Most of the higher terraces next to the river had been converted to farm land by 1936. Yet, most of the bottom land was still vegetated with a variety of trees or was exposed gravel bars. A striking difference between channel conditions in the 1930's compared to today is the dominance of bare gravel. The large proportion of bare gravel in the active flood plain was likely a result of unfettered peak flows and a lack of intentional channelization. The river jumped back and forth across its flood plain over the decades, as evidenced by aerial photographs from 1944 and 1960.

Today, little bare gravel exists in the active flood plain of the confluence area. The two rivers are mainly a single thread, confined by riprap banks at many locations, and fringed by reed canary-grass in low areas. Reed canary-grass is a tall, dense grass introduced to Oregon for purposes of controlling soil erosion along ditches. Unfortunately, the grass has spread throughout the river system and now quickly invades most bare areas near the river. It commonly prevents reproduction of native vegetation and no practical tools are available to eradicate the grass. Other introduced species, such as Himalaya blackberry and Scotch broom, also readily occupy bare substrate along the river.

Banks of the main channels and major side channels within the confluence area are patchwork of natural and hardened banks, with hardened banks (usually riprap) found mostly on the outside bends of curves in the channel. We conducted a survey of bank types throughout the confluence area and found that 12% of the Willamette River’s banks and 25% of the McKenzie River’s banks had riprap, rock barbs, or riprap and barbs. Barbs are rock structures that extend about 25 feet into the river at right angles to the bank. They are intended to provide fish with areas of slackwater that is usually missing along the outside bends of riprapped curves in rivers. Results for each of six reaches in the confluence area and for each river side are shown in Figure 5. Boundaries of the river reaches and bank hardening locations are shown in Figure 6.

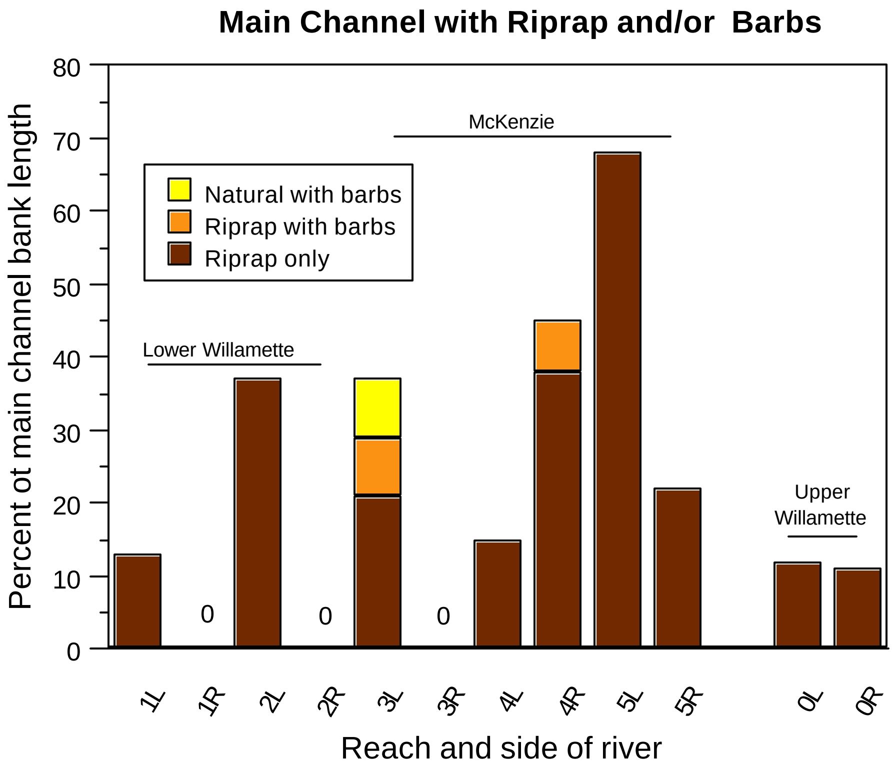
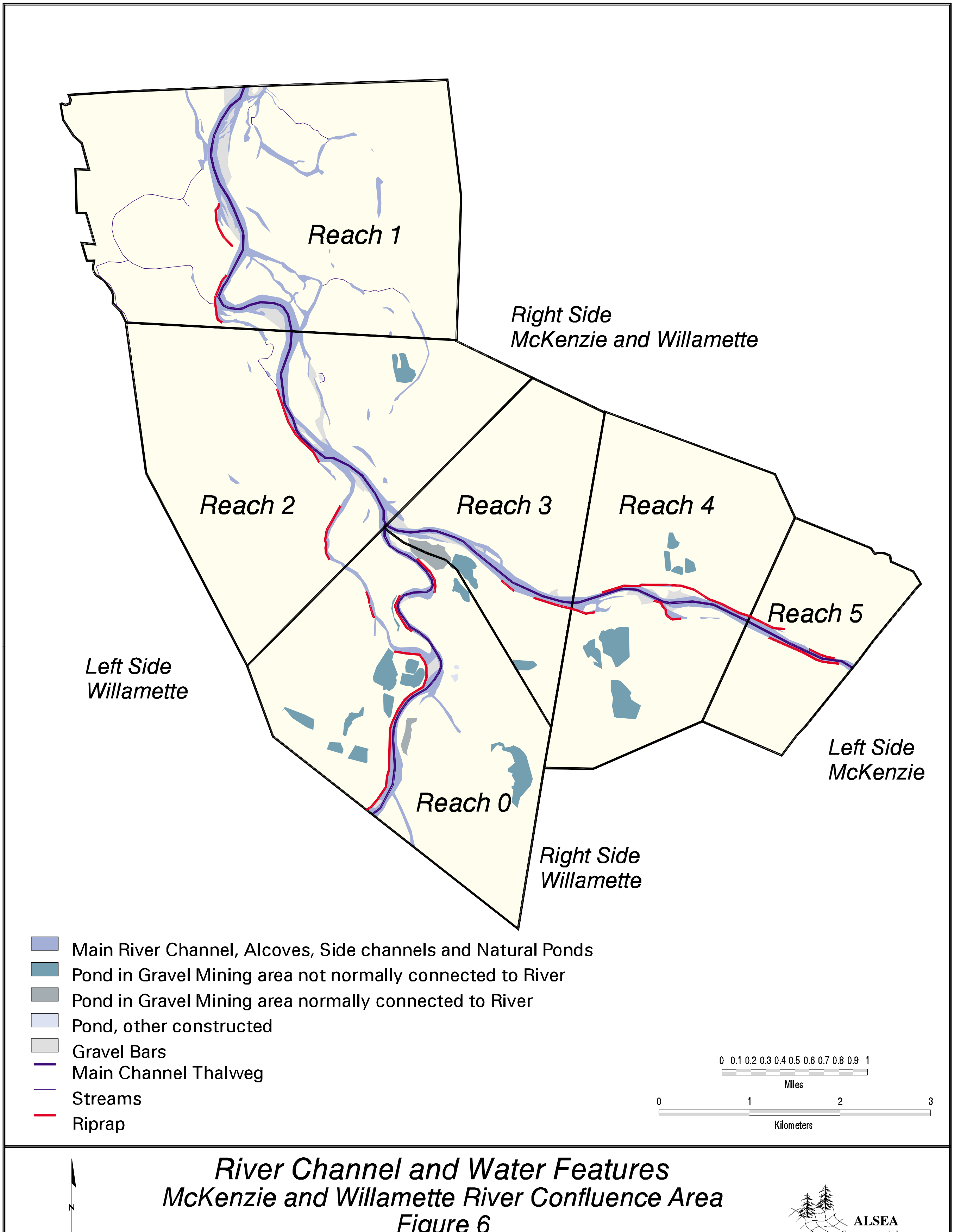


Figure 5. Percent of main channel banks with riprap and/or barbs by river reach and side of river.



River Channel and Water Features

McKenzie and Willamette River Confluence Area

Figure 6

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Water temperature

The upper Willamette River and McKenzie River are known for their cool water during the summer. Originating in the high Cascade Mountains and traveling much of their length through fractured volcanic rock, the supply of cool groundwater to these rivers is abundant. Release of cool water from the lower depths of reservoirs, for the purpose of augmenting summer flow, also contributes to river cooling. However, it is unknown how far downstream this influence extends.

Gages were established by the EPA Research Laboratory within the Willamette River and its major tributaries during an August warm spell in 1996 for the purpose of detecting downstream patterns of river warming in the Willamette River from the McKenzie River confluence to the Yamhill River. Maximum water temperatures for the Willamette River and McKenzie River near their confluence were 64 deg F or cooler (Figure 7), with the McKenzie River about 2 deg F cooler than the Willamette River. Relatively cool water from the combined rivers continued downstream to Harrisburg, where the Willamette River began warming in a downstream direction. Maximum temperature reached 72 deg F at the Yamhill River confluence. Nighttime minimum temperatures of the McKenzie River were about 3 deg F cooler than maximum temperatures.

Water temperature data gathered by the EPA Research Laboratory in conjunction with an evaluation of other water characteristics in the Willamette River indicates that the McKenzie is slightly cooler than the upper Willamette River during winter and spring, as well as during summer.

Other water characteristics

Phosphorus is cycled tightly in the McKenzie River and upper Willamette River with soluble reactive phosphorous concentrations less than 30 ug/L in both spring and summer (unpublished EPA Research Laboratory data). Nitrogen also is cycled tightly in the McKenzie River with levels of nitrate less than 0.09 mg/L-N, regardless of season. While the upper Willamette also has low nitrate levels in the summer it has relatively high levels in winter and spring.

The sewage treatment plant with its outfall immediately upstream of the Beltline Road bridge, may be a source of nutrients. Yet, quarterly data collected by the City of Eugene at various points along the Willamette River within the city limits shows that the sewage treatment plant has only a small influence on nitrate and ortho phosphorus concentrations in the river.

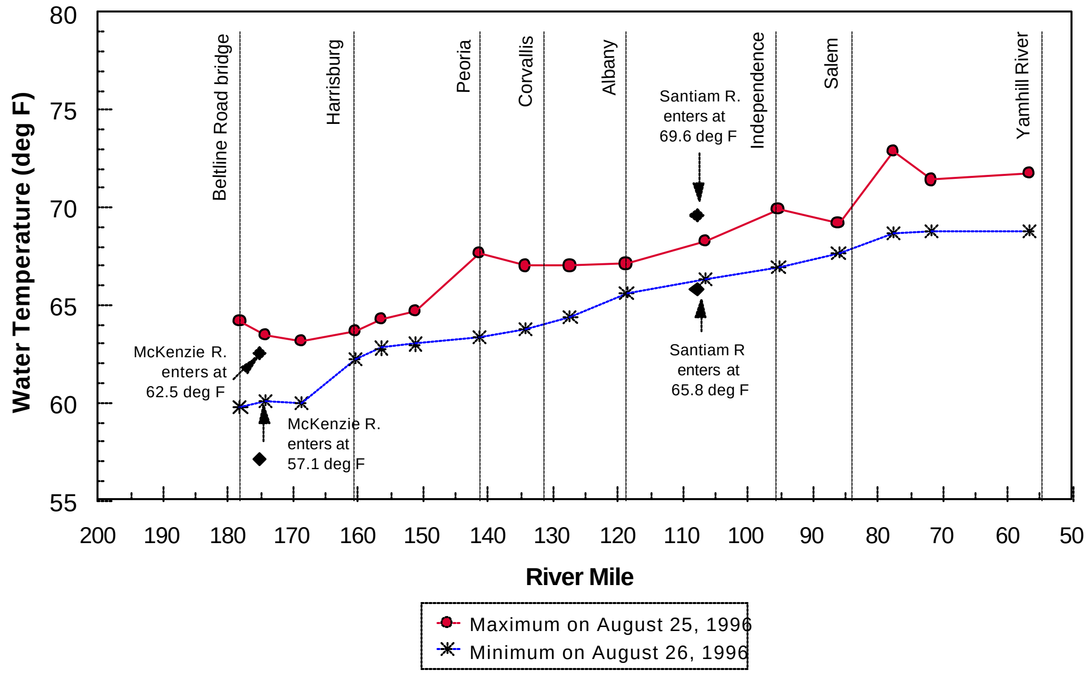


Figure 7. Water temperature trend for the Willamette River from the Mckenzie River confluence to the Yamhill River confluence.

A variety of other water characteristics are tested by the city during their ambient river monitoring but none show a consistent increase downstream of the sewage treatment plant outfall, nor are the values suggestive of water quality problems. Testing of the sewage treatment plant effluent for a long list of organic compounds indicates that all are at non-detectable levels. The effluent is also tested regularly for a variety of toxic compounds and these are consistently low.

Relatively high ammonium values in the upper Willamette River have been measured during the winter (unpublished data, EPA Research Laboratory). Ammonium values in the McKenzie River were only 4% of McKenzie River values at the time, suggesting a point source of ammonium in the upper Willamette River. Effluent from the sewage treatment plant has an ammonia concentration of about 5 mg/L-N in the winter and could be the source. Quick uptake or conversion of ammonia and ammonium by aquatic organisms during the non-winter months may explain why such high values have not been observed during other times of the year.

The upper Willamette River is usually more turbid than the McKenzie River. This is supported by direct measurement and is visible in aerial photographs and when in the field for all but late summer months. For over a mile downstream of the confluence, moderately turbid water of the upper Willamette River main channel and the Whitely side channel remain segregated from the low turbidity water of the McKenzie River. Historic aerial photographs indicate that when the old McKenzie River channel flowed regularly, most of its water came from the McKenzie River. However, historic channel maps show both rivers feeding into the old McKenzie River channel in 1910. The current chronic turbidity of the upper Willamette River probably originates at Hills Creek Reservoir, where a certain type of clay along the banks becomes suspended in the water due largely to lapping of waves. The clay stays in suspension, thereby creating the turbidity far downstream.

Macroinvertebrates

The relative abundance and community structure of macroinvertebrates can be an indicator of water quality in a river. Unlike direct measures of water characteristics, the structure of macroinvertebrate communities can reflect both episodic and chronic water degradation events. Samples are usually taken in the fall, a time when organisms have reached a steady-state, individual organisms are large, and species richness is greatest.

The only macroinvertebrate data available for the confluence area is that gathered each year by the City of Eugene. Samples are taken at two to three specific locations upstream of the sewage treatment plant outfall and four specific locations downstream of the outfall. Metrics are determined for evaluating community structure as shown below:

Table 1. Metrics determined for 1997 and 1998 macroinvertebrates sampled by the City of Eugene.

PRIMARY METRICS	POSITIVE INDICATORS	NEGATIVE INDICATORS
Total abundance	Predator richness	%Collector-gatherer
Total taxa richness	Scraper richness	% Collector-filterer
EPT Taxa richness	Shredder richness	%Parasite
% Dominant taxa	% Scrapers	%Oligochaeta
Brillouin H	% Shredders	%Tolerant molluscs
Community Tolerance (HBI)	% Intolerant taxa	%Tolerant crustacea - Gam
EPT/Chironomidae	Intolerant taxa richness	%Tolerant mayflies
Hydropsychidae/Trichoptera		%Tolerant caddisflies
Baetidae/Ephemeroptera		%Tolerant beetles
		%Tolerant dipterans
		%Simuliidae (blackfly)
		%Chironomidae (midge)

Most of these metrics in 1997 and 1998 indicated that macroinvertebrate communities downstream of the outfall were no different than upstream. Four metrics showed significant differences in one year but not the other. Overall macroinvertebrate abundance was greatest upstream of the outfall in 1998 but not in 1997. The percent of individuals consisting of collectors and filterers (higher percentage suggests nutrient enrichment) was greater downstream of the outfall in 1997 but not in 1998. In addition, the percent of individuals comprised of tolerant molluscs was high downstream of the outfall at two sites in 1998 but was low elsewhere in 1998 and throughout the study area in 1997. Tolerant organisms are those that are better adapted to withstand increases in water temperature, nutrients, and other water characteristics. Blackfly larvae were high at all four downstream sites in 1997 but not in 1998. These data suggest that the influence of the sewage treatment plant outfall has minimal and sporadic influence on the macroinvertebrate community in the Willamette River.

Land and water classes

We created a rectified land and water features mosaic of the study area using aerial photographs from April, 2000 and classified land and water features up to about 1 mile from the river. We next delineated buffers of 500 feet and 2640 feet (one-half mile) from the river edge. These buffers were allowed to wrap around the outermost extent of water features, whether they be side channels, alcoves, or the main channel.

Areas were determined for all features in each reach and side of stream and then normalized by dividing area by the length of the river thalweg for each reach. This allowed us to compare reaches, as well as river sides (Figure 8).

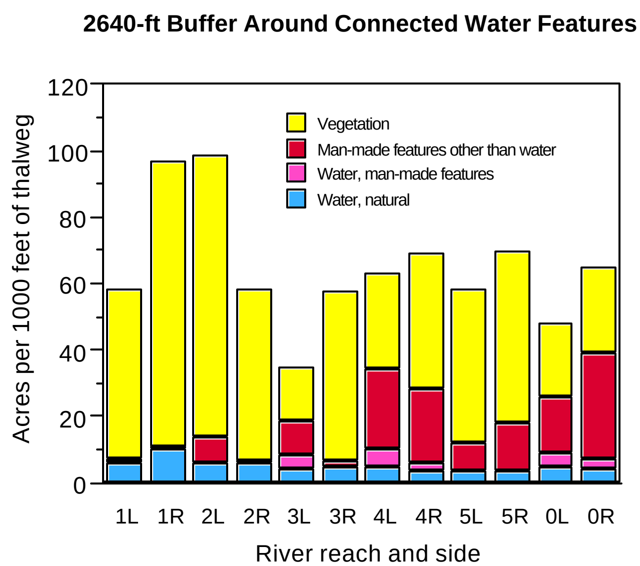


Figure 8. Major classes of land and water in the study area by reach and side of river.

Results are graphed in an upstream (1L to 5R) direction starting from the most downstream end of the study area (Reach 1) and continuing upstream to the Hwy I-5 bridge on the McKenzie River (Reach 5). Reach 0 is the Willamette River upstream of the McKenzie confluence to Beltline Bridge Road. A "L" indicates left bank facing downstream while "R" indicates right bank.

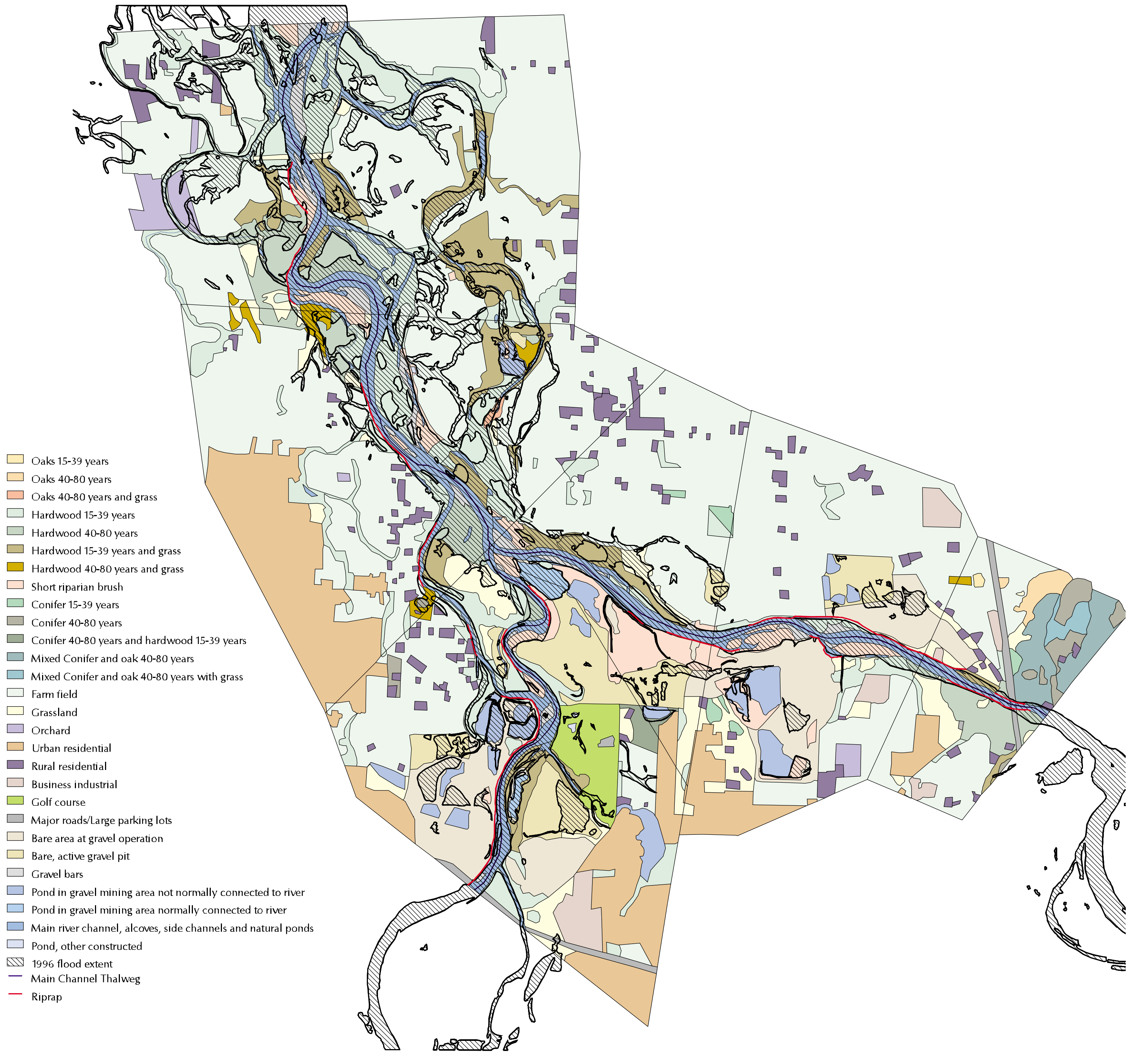
For the one half-mile buffering, the majority of land in the reaches was vegetated (Figure 8). This included farmed land and orchards, as well as, natural vegetation. Man-made features were relatively rare in the lower Willamette (Reaches 1L to 2R) and along the right bank of the lowest reach in the McKenzie River (3R) with most of these features consisting of homes and their yards. The remainder of upstream reaches in the McKenzie and Willamette Rivers have a sizable component of man-made features, including gravel pits, gravel operations, residences, business/industrial areas, and highways. The relative area of natural water features was greatest in the lower Willamette reaches where the flow was greatest and constricting features such as riprap were least common (Figure 6 and 8).

Vegetation was mapped in broad types and age classes (Figure 9). Note that the left bank of Reach 3 is unusually small due to the partitioning of area at the confluence. Consequently, values derived for this slice of land should not be compared directly to other reaches and sides of river.

Vegetation within one-half mile of the river edge was predominantly farm fields for the lower Willamette River and the north side of the McKenzie River (Figure 10). Hardwoods between 15-39 years were the most common tree type with older hardwoods only in the lower Willamette reaches and the left side of Reach 5 (dominated by Armitage Park). Conifers were scarce except on steep basalt slopes on the right side of Reach 5. The 1944 aerial photographs indicate that older conifers grew on some large islands near the confluence. Recent clearcuts at other spots in the study area also suggest that conifers were more common than they are today. Orchards were scarce in 2000 but common in 1944. Most of the orchards were converted to grass seed fields or to residential areas. Short riparian vegetation, consisting largely of willow and small ash trees, grew close to the river in low-lying areas that were annually flooded.

Few areas of bare river substrate now exist. The 1944 photographs indicate a much wider area of substrate that was bared by high flows. The short riparian vegetation was set back accordingly.

Using diameter of dominant trees as a guide, many cottonwood trees near the river seemed to be of the same age (about 30 years old). Peak flow records from the Harrisburg gage on the Willamette River (about 10 miles downstream of the study area) indicated that the highest flow on record following reservoir construction occurred in 1972. If these cottonwood trees originated following this peak flow the trees would now be 28 years old.



River Channel and Vegetation Characteristics
McKenzie and Willamette Confluence Area ca 2000
Figure 9

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Miles
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Kilometers

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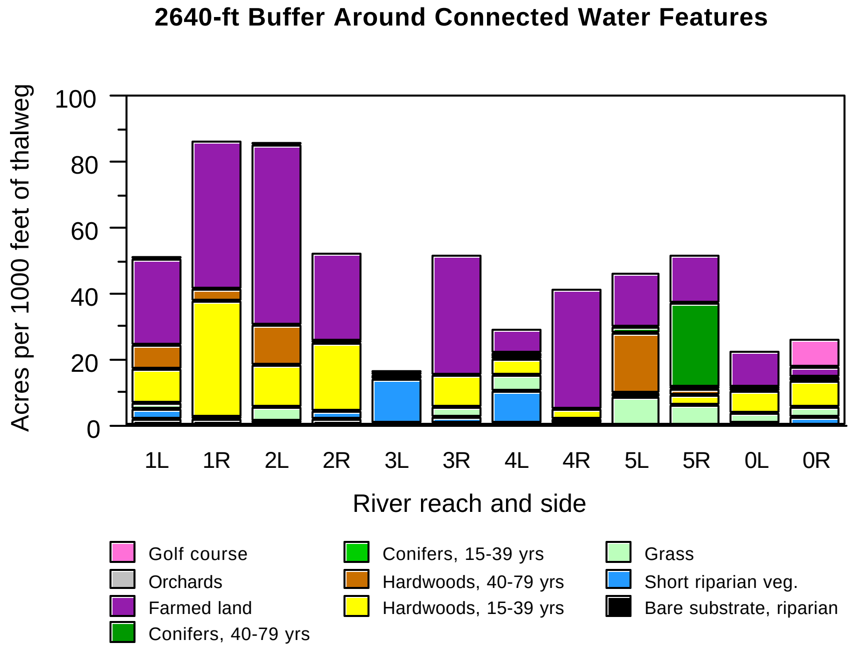


Figure 10. Vegetation classes within one-half mile of the river by reach and side of river.

Land inundation

In the companion study to this study, low spots in the series of dikes and embankments around gravel operations were evaluated for the 100-year flow. However, there was no determination of which areas would be inundated during a flow of that magnitude. Also, there was no mapped boundary of inundated land determined after the 1965 flood, which was about a 50- to 100-year post-reservoir event for the confluence area. Therefore, in an attempt to illustrate lands that are prone to flooding during high flows, we used a flood extent coverage compiled by the U.S. Geologic Survey for the February for the 1996 high flow. The 1996 flow was only about a 5-year event (measured at Harrisburg) and so it provides only a partial indicator of potential flooding in the confluence area.

The greatest percent inundated land was in Reach 1 and the right side of Reach 2. Here, the river includes many off-channel features and is not bounded by riprap or dikes (Figure 11).

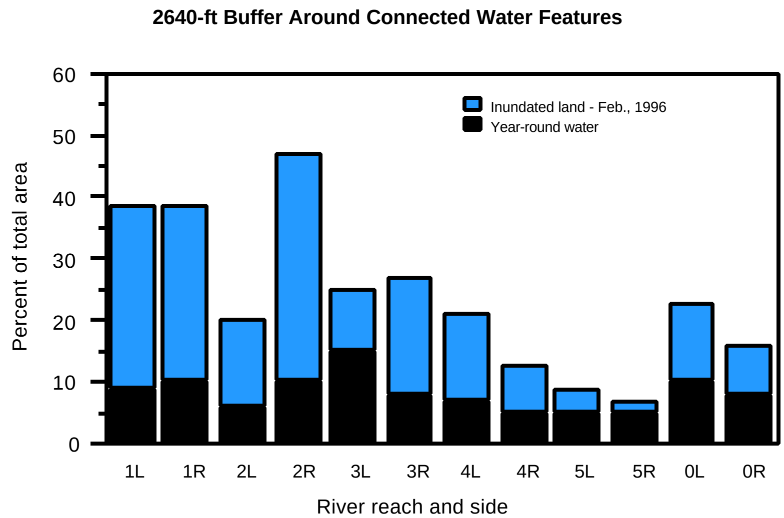


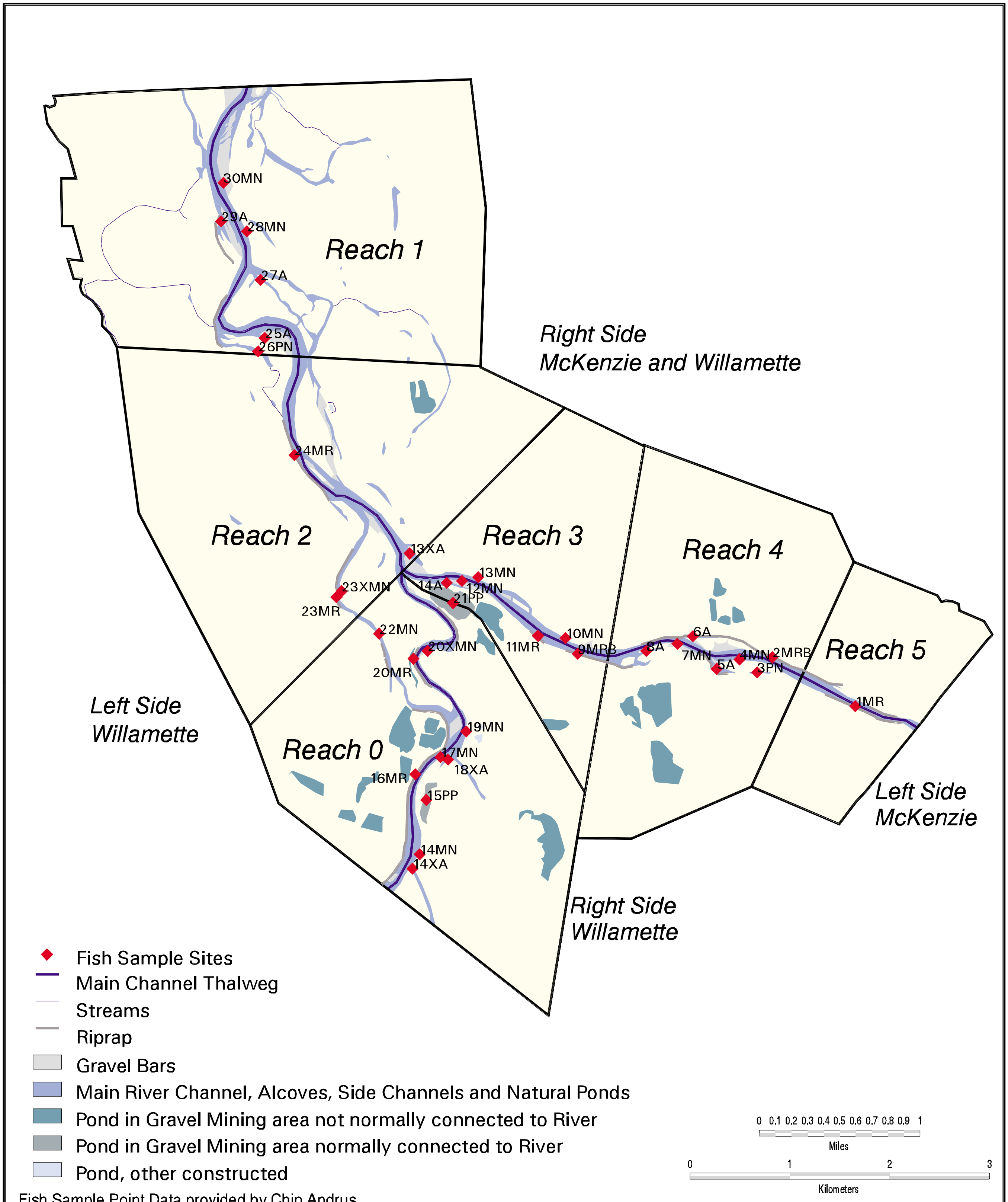
Figure 11. Percent area of year-round water and land inundated by water during the February, 1996 high flow within one-half mile of the main channel or any connected off-channel waters.

Fish and their habitat

We used several data sets (this study, EPA, ODFW, and City of Eugene) to evaluate fish in the lower McKenzie River and the Willamette River. We also referred to published studies and the experience of local biologists to further understand fish and fish habitat relationships in the confluence area.

For the current study, we established 30 sites in the confluence area and electrofished segments in September, 1999 (Figure 12). These sites included main channel reaches with natural banks (MN), riprap banks (MR), banks with riprap and barbs (MRB), alcoves (A), and both natural (PN) and gravel pit (PP) ponds near the river. We sampled most of these sites again in March, 2000. Some were skipped due to fast water.

We also included a data set funded by the City of Eugene for which main channel fish communities were electrofished from the confluence of the Middle Fork and Coast Fork of the Willamette River, through the City of Eugene, and to the Beltline Bridge Road. This data set included 12 sites and field data was gathered in March, 2000. A third data set was from a research program established by the EPA Research Laboratory to evaluate main channel and alcove fish communities in the Willamette River from the McKenzie River confluence to Corvallis. These data include electrofishing results from 20 sites in March, 2000 and 54 sites from July,



Fish Sample Sites
McKenzie and Willamette River Confluence Area
Figure 12

ALSEA Geospatial, Inc.
www.ageospatial.com

October 10, 2000

/u2/mckz/confluence/scan/maps/riv2000_fish.aml

1998. The sites from these three studies were all sampled at night by our team using the same crew chief, boat, equipment, and techniques.

We also used seining data collected each year in August by the Oregon Department of Fish and Wildlife (Corvallis) from pools immediately downstream of riffles at 4 to 14 locations between the McKenzie River confluence and Harrisburg. These data were gathered each year from 1993 to the present.

No fish sampling method provides an unbiased portrayal of fish communities in a river. Boat electrofishing, the method we used in our sampling, has the benefit of being effective in a wide variety of habitat types and over a wide range of fish sizes. Yet, it has its limitations. The electrical field does not extend to the bottom of the river when water depth is greater than 7 feet and this often results in an undercount of those fish which normally reside at the bottom of the water column. Very fast water can also complicate boat electrofishing by providing little time to net fish. Large numbers of stunned fish in fast water can overwhelm the netter. Furthermore, swirling eddies at the bank edge frustrate attempts to keep the boat facing downstream. We sampled at night because catches are considerably higher than sampling fish during the day (Andrus, unpublished data; Grost and Prendergast, 1999). Sampling was along the margins of banks for a measured distance.

We have minimized bias through site selection and sampling technique but have concerns about under-representation of fish that find cover under rocks (dace and sculpin), juvenile lamprey that rear within fine sediments, and largemouth bass that are often spooked by the leading edge of the electrical field. Boat electrofishing effectiveness decreases with fish size, especially for fish less than 3 inches long. As a result, we have limited our reporting to only those fish 2.4 inches (60 mm) and longer. Limited seining of the lower McKenzie River by Oregon Department of Fish and Wildlife in late April, 2000 indicated that young-of-the-year chinook salmon were common at some locations. These fish were about 2.4 inches long in late April and so would have been less than 1.6 inches long in March the time when we conducted our boat electrofishing. We did not catch any of these fish, because either the fish were too small or they had not yet moved downstream into lower reaches of the McKenzie River.

Seining also has inherent bias. Catches can be successfully brought to shore only where a debris-free beach of gravel or small cobbles exists. Seining is best suited for shallow areas with lower velocity flow. The river bottom must be free of large objects such as wood and shopping carts. Furthermore, seining success his highly dependent on the skills of those who operate the nets.

In the following discussion, sampling results are expressed in two fish size classes. "Small" fish are those between 2.4 and 7.9 inches (60-200 mm) long and "large" fish are greater than 7.9 inches. This size class distinction was important because it corresponded with maximum fish size and transitions in diet for some species.

Overall fish community composition

The number of fish genera encountered at a site can be an indicator of its ability to provide a range of habitat conditions for fish. Presumably, sites with more genera of fish have a greater diversity of habitat features and conditions. Results from our sampling indicates that genera abundance of large fish in March was greatest at main channel sites. Differences among reaches and habitat types were small, except that gravel pit ponds and alcoves between Harrisburg and Corvallis averaged fewer genera. Genera abundance of small fish was greater than for large fish in March. Sites with natural banks had the fewest genera, especially those located in the McKenzie River. Sites from the Springfield bridge to the McKenzie confluence, both main channel segments and alcoves, had the highest genera of small fish in March.

Genera abundance of large fish was about the same for September and March but small fish genera decreased for most habitat types in September. This decrease in the number of genera was most pronounced at sites with riprap or riprap with barbs. Alcoves had the greatest diversity of small fish in September for both the McKenzie River and the Willamette River downstream of the confluence. Gravel pit ponds saw a decrease in genera for both large and small size classes from spring to summer.

Three-spine stickleback were found only at one site during the study; three fish were captured in a natural pond next to the McKenzie River. Stickleback were once common in the Willamette Valley but now appear to be uncommon and declining (personal communication, Stan Gregory, Oregon State University, Corvallis and Paul Scheerer, Oregon Department of Fish and Wildlife, Corvallis).

Fish assemblages were divided into four groups; salmonids, scrapers, “other” native, and introduced. Salmonids included juvenile chinook salmon, cutthroat trout, rainbow trout, and mountain whitefish. A single large bull trout (also a salmonid) was seined by the Oregon Department of Fish and Wildlife in the McKenzie River near the confluence last year but none have been encountered during other studies. Also, fishermen have not reported catching bull trout in the confluence area. Scrapers included fish that feed by scraping periphyton from rocks. These were predominantly largescale suckers with some mountain suckers and chiselmouth. Other native fish included northern pikeminnow (formerly called northern squawfish), peamouth, redside shiner, dace, sculpin, sand roller, and three-spine stickleback. Introduced fish were predominantly bluegill and largemouth bass with some crappie, yellow bullhead, pumpkinseed, carp, goldfish, and green sunfish.

In March, large salmonids were most abundant in the McKenzie River for natural and riprapped main channel sites (Figure 13). Large salmonids catches in the Willamette River were lower and somewhat uniform among segments. Many of the large trout we caught this time of year had spawning colors which suggested that a number of large trout might have already moved upstream to spawn. The Mohawk River basin, a lower tributary of the McKenzie River, is heavily used by trout for spawning. Catches of larger salmonids were greater at sites with natural banks than riprapped banks except for a single riprapped site in the McKenzie River. Here, a long glide with moderate water velocity, moderate depth, and a cobble/gravel substrate provide high quality conditions for trout and their food supply.

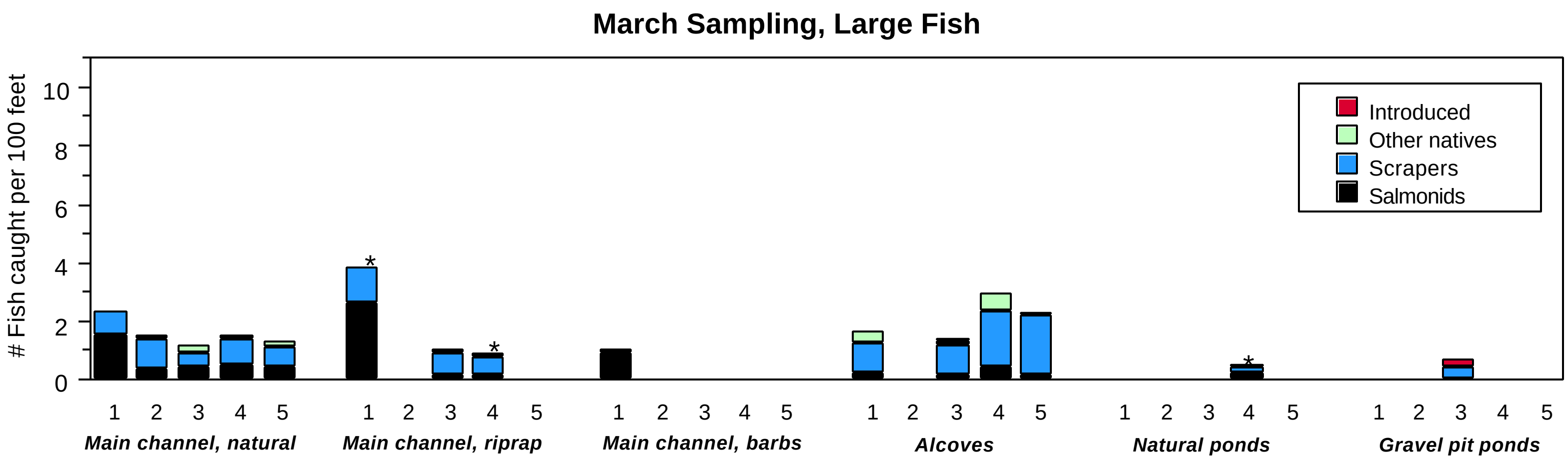
The density of large salmonids at McKenzie main channel sites with barbs was not much different than elsewhere in the McKenzie main channel. However, in September, the barbs had higher densities of large salmonids than natural or riprapped banks. The barbs were particularly attracted to large rainbow trout. Most fish near barbs were caught in the relatively slack water downstream of the barbs.

Catches of large salmonids in the main channel were higher in September than in March. Large salmonids, mostly cutthroat trout, were found at low densities in alcoves and natural ponds for both seasons, yet were present in gravel ponds only in March. Large scrapers were common in main channel segments, except for main channel segments with barbs. Large scrapers were abundant within alcoves, with Willamette alcoves downstream of the confluences having the highest densities. During the EPA Research Laboratory study conducted during the summer in 1998 we found that few large scrapers used alcoves during the day but then entered alcoves at night in large numbers. Both natural ponds and gravel pits had large scrapers, although densities were relatively low.

“Other” large native fish were found mostly in alcoves and natural ponds during September but were mostly absent from all features in March. Northern pikeminnow belong to this group and have a diet that includes small fish. They are probably attracted to alcoves in the summer because of the large number of small fish.

Large introduced fish were absent from main channel sites and natural ponds for both seasons and were infrequently found in alcoves during September. Gravel pits had largemouth bass during both seasons. Individual bass we caught sometimes exceeded four pounds.

Small salmonids in March were most abundant within the McKenzie River (Figure 14), especially at main channel sites with barbs. Small salmonids were considerably more abundant in March than in September. Small salmonid abundance during March within the Willamette River did not vary much between upstream and downstream sites.



1. McKenzie River
2. Willamette River upstream of Springfield bridge
3. Springfield bridge to the McKenzie confluence
4. McKenzie confluence to Harrisburg
5. Harrisburg to Corvallis

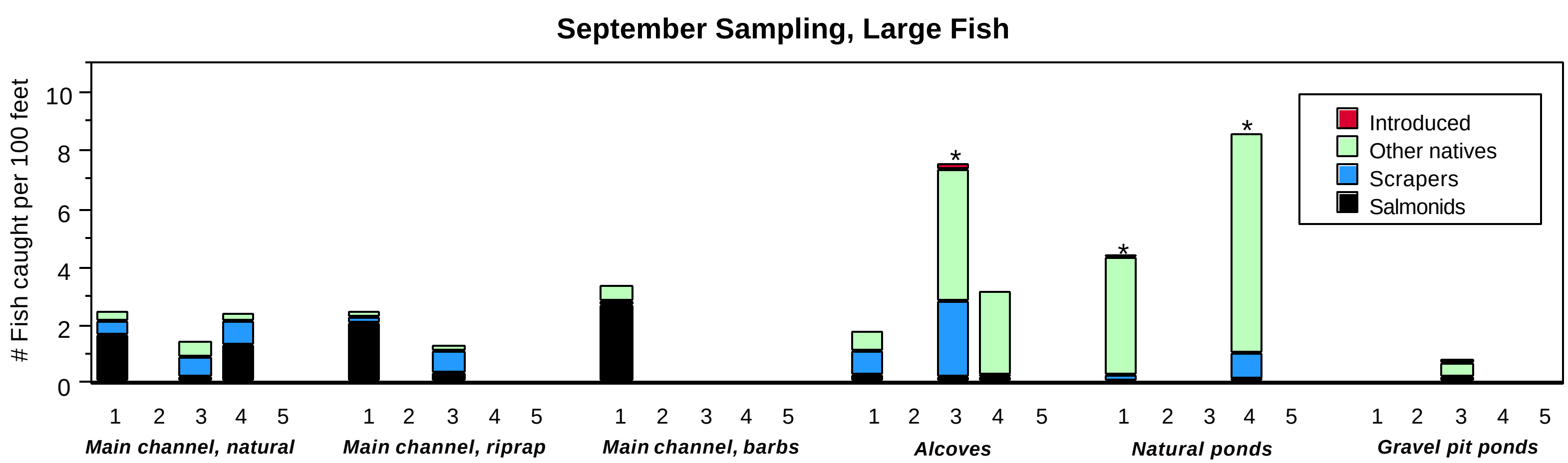


Figure 13. Large fish community structure for March and September sampling. Includes electrofishing results from this study, City of Eugene study, and EPA study. Bars with an asterisk indicates that only one site was sampled and therefore, results are less reliable than the other bars which have replication.

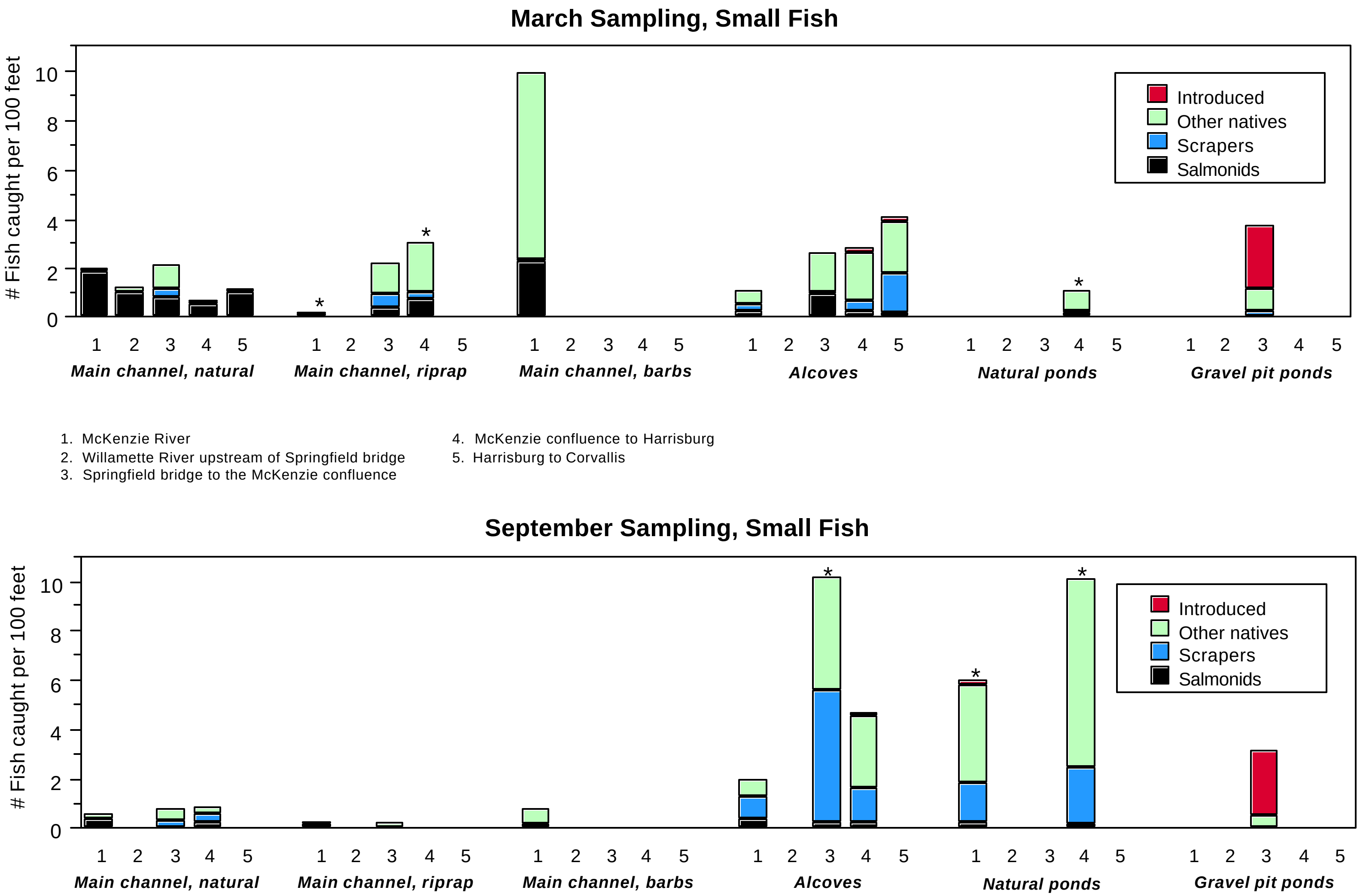


Figure 14. Small fish community structure for March and September sampling. Includes electrofishing results from this study, City of Eugene study, and EPA study. Bars with an asterisk indicates that only one site was sampled and therefore, results are less certain than the other bars which have replication.

Small scrapers were uncommon at main channel sites but abundant in alcoves, especially in September. Small scrapers were also abundant in natural ponds during September but uncommon within gravel pit ponds. Small “other” fish had their highest densities at sites with barbs in March and were predominantly redside shiner. Yet, they were uncommon at these sites in September, possibly due to predation by the high density of large salmonids. Small “other” fish in the Willamette River were common at riprap sites downstream of the McKenzie confluence during March but were mostly absent in September. Small “other” were found within alcoves and natural ponds at high densities for both seasons. Lesser densities were found in gravel pits.

Small introduced fish dominated gravel pits during both seasons. The decline of salmonids and other native species from March to September suggests that these ponds, in their current form, do not benefit native fish. Likely factors that make gravel ponds unfavorable to native fish include high water temperature, low nighttime dissolved oxygen, lack of suitable food, predation by largemouth bass, and competition for food by small introduced fish.

Overall, the combined data sets indicated highly specialized uses of habitat based on fish group and size classes. Generally, natural banks supported higher densities and a greater diversity of native fish than did riprap banks. The high seasonal use of barbs was intriguing in that the barbs probably mimic a type of habitat that is no longer present in the rivers. Most likely, large trees with rootwads previously provided this habitat type in which low velocity flow is adjacent to high flow (for effective feeding) and many crevasses exist to avoid predation. Large wood is now nearly absent from the McKenzie River and Willamette River.

Alcoves and natural ponds provide a specialized habitat that support high densities of native fish. While introduced fish are sometimes found in alcoves, they are usually found in only small numbers. These off-channel features are not common today probably due to channelization and reduction of peak flows. Aerial photographs from 1944 show a much higher density of off-channel features than exist today. If alcoves and natural ponds are indeed the nurseries of many native fish then their decline has likely affected the reproductive success of the native species using these features.

The McKenzie River stands out as exceptional for salmonids, in spite of its highly altered state. Prior to channelization, the McKenzie River probably supported even greater population of salmonids. The loss of complex habitat features (braided main channels, side channels, gravel bars, large wood) is obvious when comparing 1944 to current aerial photographs. Nevertheless, the McKenzie River probably still has great potential for recovery of this lost potential.

Salmonid community composition

Salmonids in the McKenzie River and Willamette River have become high profile, largely due to the federal listing of the spring chinook salmon that still spawn in the upper McKenzie River. In addition, fly fishermen highly value the wild rainbow trout and cutthroat trout. Consequently, the following provides a more detailed examination of the salmonid community in the study area.

Naturally-reared salmonids in the confluence area include spring chinook, rainbow trout, cutthroat trout, and mountain whitefish. There are also hatchery fish that include fall chinook (recently discontinued, yet there is still natural rearing of a small number of residual fish), steelhead, and a hybrid rainbow trout. Only one hatchery rainbow was encountered during our sampling (it was diseased) and only a few hatchery steelhead juveniles (near Corvallis in March) were caught during the studies so these two stocks probably have no impact on resident fish beyond the short time after placement in the river. Most hatchery rainbow are caught within a few weeks after placement and the steelhead readily move downstream after release.

A number of hatchery-reared chinook salmon were caught as evidenced by a clipped adipose fin. Another group of juvenile hatchery chinook are not marked and cannot be distinguished from naturally-reared juvenile chinook. This group of fish are unfed fry from eggs of hatchery spawners that are released into upriver reservoirs. While intended to provide a source of food for bull trout and angling opportunities within reservoirs, Oregon Department of Fish and Wildlife monitoring has indicated that a number of these juvenile chinook move out of the reservoirs and reside in downstream waters. Therefore, the unmarked juvenile chinook salmon we encountered are probably a mix of fish with wild and hatchery genes. Naturally-reared fish include both true wild fish (if they still exist) and fish with hatchery parentage. Overall, about one-third of the juvenile chinook we caught in March had a clipped adipose fin. Only one juvenile chinook caught in the McKenzie River had a clipped adipose fin while over 40% of chinook in the Willamette River upstream of the confluence had a clipped adipose fin. None of the juvenile chinook we caught in September and none of those seined by Oregon Department of Fish and Wildlife in August (Willamette River between the McKenzie River confluence and Harrisburg) had a clipped adipose fin. This suggests that hatchery-reared juvenile chinook salmon move downstream of Corvallis (probably to the Columbia River) sometime between late spring and late summer. Radio tagging of hatchery chinook salmon in the McKenzie River and Willamette River by Schreck et al. (1994) supports this theory.

Catches of large salmonids were dominated by mountain whitefish in March at main channel sites with natural banks and at one McKenzie River site with riprap (Figure 15). Unlike most riprapped segments of the river, the flow at this site does not have a high velocity. Mountain whitefish did not use sites with barbs or any of the off-channel features. Strangely, most mountain whitefish were gone in September. This was probably not due to the water temperature since maximum temperatures rarely exceed 64 deg F. Cutthroat trout were more numerous than rainbow trout, except at McKenzie River sites with barbs in March. There, the two species of trout where were co-dominate.

Large cutthroat and rainbow trout caught at Willamette River main channel sites during September were considerably less numerous upstream of the McKenzie River confluence than downstream. Immediately downstream of the McKenzie River, Willamette River sites with natural banks had densities of large trout similar to the McKenzie River. Large trout were mostly absent between Harrisburg and Corvallis in September.

Large salmonids were found in off-channel features at low densities. When caught within alcoves, they usually occupied the downstream ends of alcoves. Here, they probably have good opportunities to feed at the interface between the still alcove water and the swift main channel.

A few large cutthroat trout were found in gravel pits during March but they were absent in September. In contrast, natural ponds supported large cutthroat trout throughout the summer.

As with large salmonids, small salmonids were dominated by mountain whitefish at main channel sites with natural banks during March (Figure 16). Values were highest for the McKenzie River and sites upstream (above Springfield) and downstream (Harrisburg to Corvallis) of the confluence area. Small mountain whitefish were rarely found at riprap sites, sites with barbs, or within off-channel features. In September, the small mountain whitefish were mostly absent at all sites.

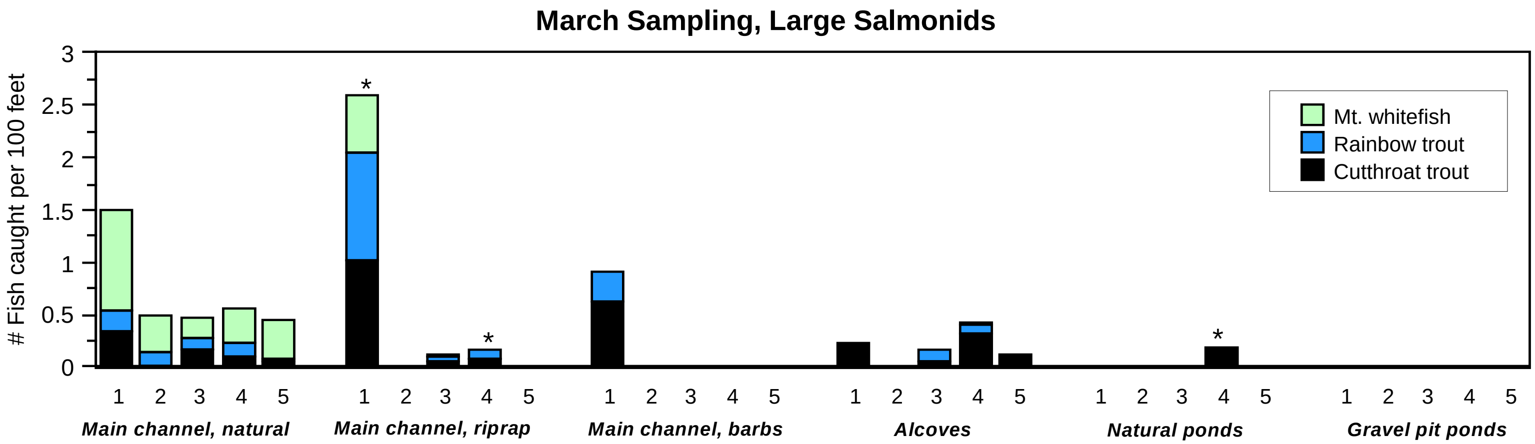
Small cutthroat trout and rainbow trout were uncommon at all sites and particularly in September. Pool seining in the lower Willamette River by the Oregon Department of Fish and Wildlife in August (1993 to the present) also indicated that small trout were scarce. This coincides with findings by Moring et al. (1988) who demonstrated that cutthroat trout in the Willamette River basin usually spend the first two years of their lives in tributaries before moving downstream to larger rivers.

Juvenile chinook salmon (>2.4 inches long) were caught at high densities only for McKenzie River sites with barbs. There, they were found in the slackwater immediately downstream of the barbs. Higher numbers of juvenile chinook salmon were also found at a riprap site downstream of the confluence and within several alcoves upstream of the confluence. Juvenile chinook salmon were uncommon in September at all sites, with alcoves having the highest densities.

The seining of deep pools by Oregon Department of Fish and Wildlife located directly downstream of riffles (1993 to the present) indicated that juvenile chinook salmon were not particularly abundant in August. The average catch was only five fish per set. These sites were located between the McKenzie confluence and Harrisburg. These results, along with the scarcity of juvenile chinook caught in a trap at the mouth of the McKenzie River in 2000, suggests that densities of these fish are not high in the confluence area. Nevertheless, there is a small chance that the night boat electrofishing we conducted, the pool seining by Oregon Department of Fish and Wildlife, and the fish trap all undercounted juvenile chinook. Seining of juvenile chinook in the Deschutes River during the summer proved to be superior to boat electrofishing in a study conducted by Oregon Department of Fish and Wildlife (personal communication, Jeff Ziller, ODFW, Springfield).

Overall, the salmonid community in the study area varied widely with season and according to the age class of the fish. The dominance of main channel sites by mountain whitefish in March was unexpected, as was the high seasonal use of barbs by both large trout and juvenile chinook salmon. However, juvenile salmon did not use the barbs in September, possibly because of the large densities of large trout that then used these areas (Healey and Reinhardt, 1995). Trout use of the Willamette River upstream of the confluence is low in September yet the reasons for this are not clear. The upper Willamette River is quite cold with maximum values only several degrees higher than the McKenzie River.

Ambient water quality measurements upstream and downstream of Eugene indicate no obvious decline in parameters that would influence fish. Furthermore, fish and macroinvertebrate monitoring upstream and downstream of the sewage treatment plant outfall and at a major stormwater outfall did not lead to a conclusion of habitat degradation. Nevertheless, the food supply of fish may be influenced by stormwater and other discharges throughout the Willamette River reach from Springfield through Eugene, but this needs further evaluation.



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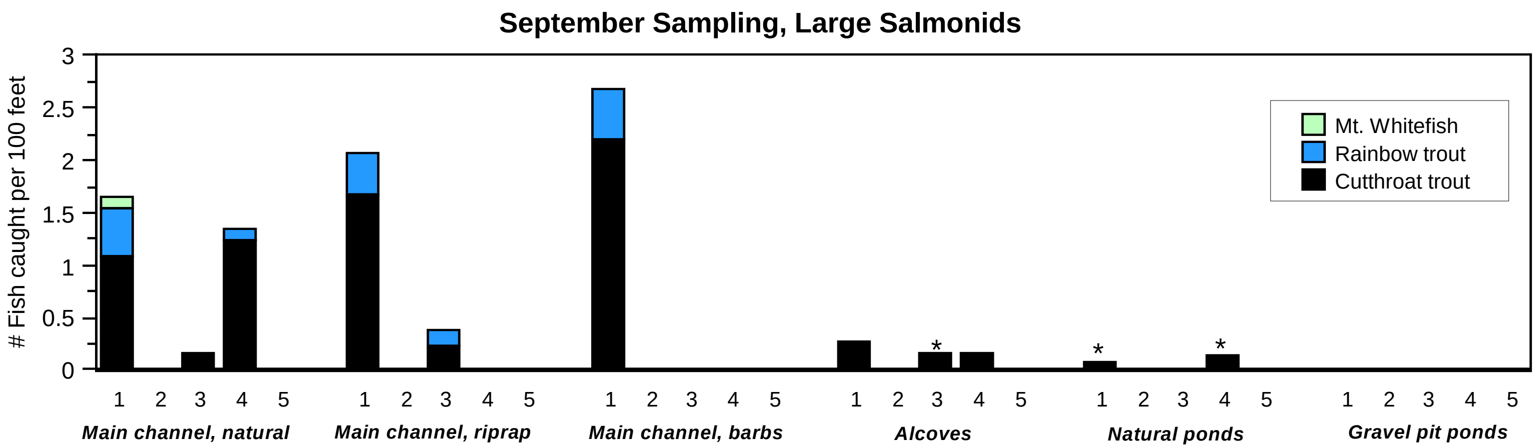

Figure 15. Large salmonid community structure for March and September sampling. Includes electrofishing results from this study, City of Eugene study, and EPA study. Bars with an asterisk indicates that only one site was sampled and therefore, results are less reliable than the other bars which have replication.

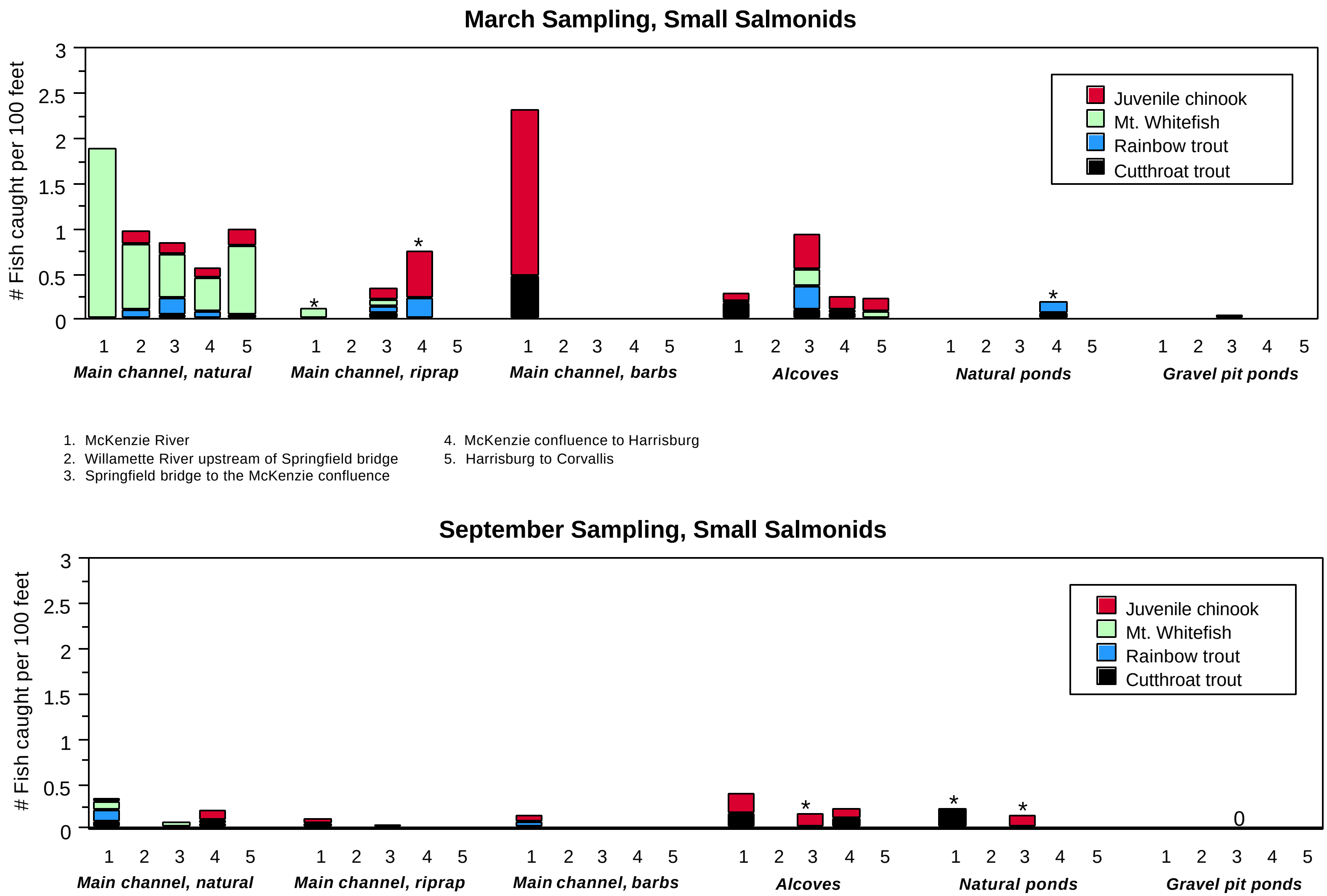

Figure 16. Small salmonid community structure for March and September sampling. Includes electrofishing results from this study, City of Eugene study, and EPA study. Bars with an asterisk indicates that only one site was sampled and therefore, results are less certain than the other bars which have replication.

Relative fish abundance and specific habitat features

We measured water depth and velocity and categorized vegetation and bank type at each main channel site that was fished. At alcove sites, we measured water depth, nighttime dissolved oxygen, and nighttime water temperature, as well as estimating the area of alcove with floating or submerged large wood and the length of bank with overhanging vegetation.

Correlations between groups of fish and habitat features were examined. We found no combinations that were correlated except that small native fish in September were inversely correlated to water depth at main channel sites that had natural banks. Nevertheless, the relative abundance of small native fish in the main channel during September was quite low so the relationship has no practical consequence.

We were surprised about the lack of correlation between fish and basic parameters such as water depth and velocity. At a micro-site scale, these factors often lead to segregation of fish species and size class. The variability of fish among even similar sites can be quite high. Consequently, a greater sample size with better precision measuring the habitat variables may be needed to isolate correlations between fish abundance and habitat features. Considering this, we believe that by presenting the results by river segments (1 to 5, Figures 13-16) and site type, we have extracted as much useful information as possible.

Other studies provide additional insight into the specific habitat needs of certain fish. It has been shown that juvenile chinook salmon prefer moderate flows with a gravel or cobble substrate. They also prefer sites with deep water (for protection) adjacent to shallow water (for feeding). Rivers with braided main channels and many side channels readily provide these features.

Large wood accumulations in deep pools are also preferred by juvenile chinook salmon because of the many crevasses and the sharp boundary between slow and fast water (Swales et al., 1986). The habitat needs of these fish during winter have been less studied because of difficulties locating fish when flows are high. Yet, they seem to prefer the river edge and side channels and ponds where they can get out of the high flow, especially during periods of cold water (Richards et al., 1992; Taylor, 1988; Swales and Levings 1989).

Outer anomalies

During the studies we kept track of outer anomalies, including disease, infection, parasites, injuries, missing body parts, and other deformities. Most outer anomalies occurred among largescale sucker greater than 11.8 inches (300 mm) long. Less than 1% of smaller-sized fish had outer anomalies. Fish greater than 11.8 inches long, excluding largescale sucker, had an outer anomaly rate of about 5%. Salmonids were relatively free of outer anomalies with cutthroat trout having no anomalies.

Outer anomaly rates of largescale sucker greater than 11.8 inches long varied widely by season and reach. Furthermore, rates were different between alcoves and main channel sites. Outer anomaly rates were about 50% in September for largescale sucker caught at main channel and alcove sites within the McKenzie River and Willamette River upstream of the confluence. Rates were considerably lower (< 10%) for the Whitely side channel and Willamette River downstream of the confluence.

In contrast, outer anomaly rates among largescale sucker greater than 11.8 inches long were low in March, except within Willamette River alcoves between Beltline Road bridge and the confluence where they averaged nearly 50%. Anomaly rates were low within alcoves of the McKenzie River and the Willamette River downstream of the confluence.

Largescale sucker anomaly rates for Willamette River in March decreased from the confluence of the Coast Fork and Middle Fork, through Eugene, and down to the McKenzie River confluence. Rates were higher in the McKenzie River (average about 30%) and intermediate in the Whitely side channel and downstream of the confluence. Outer anomaly rates in March averaged less than 10% for McKenzie River alcoves in March, while they were about 50% the previous September.

It is unclear why outer anomaly rates among largescale sucker are so high, even in the McKenzie River. There may be a migration of stricken largescale sucker from lower reaches of the Willamette River to cooler upstream waters in order to find an environment that is less conducive to the spread of disease and parasites. However, recent studies by the EPA Research Laboratory of tagged healthy largescale sucker indicate that they have very localized home ranges.

Restoration principles for fish and their habitat

The information summarized above provides input into how conditions for fish might be improved in the confluence area. One thing we know is that the concept of "high quality" fish habitat can be complicated when the fish community includes many species with specialized habitat preferences. What is good habitat for large trout may be a death trap to small fish that try to share the same area with these predatory trout. What is preferred habitat for a sand roller would probably cause a mountain whitefish to starve. Since society generally assigns a higher value to salmonids than to other native fish, it often assumed that what is good for salmonid is also good for fish in general. This concept, if pursued to the extreme, could actually lead to a recommendation of simplifying the river geometry, at least for some salmonids, since their abundance is not directly tied to the presence of off-channel features. An alternative concept that we have adopted is that of providing a wide range of habitat types, roughly in proportion to that which the fish evolved. Historical accounts indicate that the McKenzie River and Willamette River contained more off-channel areas, shallow areas, and site channels that would tend to segregate species and size classes of fish.

With this in mind, we present the following discussion of habitat restoration and protection principles that seem to apply to the confluence area based on our study and studies conducted in similar settings.

- *Look for opportunities to increase the width of the active channel.*

  The active channel width of both rivers in the confluence area has been reduced over the last century in order to minimize river meandering and to extract gravel from floodplain areas. As a result, only a remnant of the once-many side channels, alcoves, and natural ponds remain. Restoration that leads to a varied and complex channel would be particularly helpful for young-of-the year chinook salmon and the many other native fish that breed and rear in backwater areas.

  Increasing the width of the active channel could occur in several ways. One, would be to breach dikes at spots along the river and construct a side channel that winds through shallow mined areas. Of course, this would not work well where abandoned deep pits were present, since bedload carried by the side channel would be lost to the pit. Another way of increasing the width of the active channel would be to excavate the upstream end of old side channels that are now plugged, thereby allowing the river to occupy these reaches. Peak flows are now too diminished by reservoir operations for the river to accomplish this by itself. Since a number of side channels were intentionally plugged decades ago, it may take an equally intentional action to get them unplugged. There is a chance that opened side channels would plug again soon after they were cleared, but designing the side channel inlet in a way to concentrate flow in the winter may help it become self-cleaning.

  Opening the inlet of the old McKenzie channel would be one of the most comprehensive actions for expanding the active channel of the river. It would add over 3 miles of wetted channel to the confluence area. However, a gravel mine is currently located in the middle of the old channel and other adjacent landowners may be troubled by the prospect of the McKenzie River again taking over this route and preventing access to portions of their land.

- *Keep upper Willamette River water segregated from McKenzie River water.*

For reasons yet unknown, the Willamette River upstream of the confluence has few salmonids during the summer compared to the McKenzie River. Currently, flow from the McKenzie River does not mix with the Willamette River until a mile downstream of the current confluence. This segregation of McKenzie water along the east half of the channel extends the zone of good water conditions for salmonids into the Willamette River.

Actions intended to increase channel complexity should probably be designed to maintain or expand segregation of the two rivers. For example, if the inlet of the old McKenzie River channel were ever opened, it should be designed to receive only McKenzie River water rather than a combination of the two rivers.

- *Excavate new alcoves and side channels, where appropriate.*

  Peak flow dampening at reservoirs has left the Willamette and McKenzie Rivers with limited power to create new alcoves and side channels. Intentional construction of these features in appropriate locations could help benefit channel complexity and provide more habitat for fish that seek out these features.

  An alcove was constructed near Corvallis by a gravel company several years ago and the EPA Research Laboratory monitored water characteristics and fish communities in the alcove over the next year. The constructed alcove was immediately occupied by native fish and was particularly attractive to salmonids at various times during the following year. It had no water quality problems that would limit its use by fish. An important feature of this constructed alcove was that fine sediments were readily scoured away during high flows, thereby maintaining its depth and width for the next summer. Constructing the alcove at an acute angle to the river helped ensure that high flows would keep it scoured.

- *Provide year-round connection of low-lying gravel ponds to the main channel.*

  Our sampling indicated that two gravel ponds located in low-lying areas near the river trapped native fish when flows were high. The pits have no connection with the main channel at low flow so these native fish are trapped until the next high flow occurs. Gravel ponds invariably become stocked with largemouth bass and bluegill, whether or not the landowner chooses. Predation of native fish by large largemouth bass, combined with warmer water, is probably the reasons we found so few native fish in September.

Providing a year-round connection of gravel pits to the main channel may solve several problems. First, the opening allows native fish to leave the pit if predation pressure becomes high or water quality diminishes. Second, the opening may allow large northern pikeminnow to move into the pits and feed on small exotic fish. The scarcity of introduced fish in natural alcoves may be a result of northern pikeminnow predation.

Year-round connection of near-river gravel ponds has been recently tried at one site near Harrisburg and two sites near Corvallis. The connections have been at the downstream end of the pond. Initial results indicate that fish readily move out of gravel pits through these openings.

- *Find and protect the last remaining populations of three-spine stickleback.*

Our studies and those conducted by others suggest that three-spine stickleback are rapidly disappearing from the Willamette River valley. We found only one small population during our sampling in 1999 and 2000. These stickleback were in a natural pond on private land. Other small populations may exist in the confluence area and it may make sense to find them so that other river restoration activities do not end up destroying these sites. Stickleback we have found over the years were in alcoves or natural ponds, usually in water less than 3 feet deep, and where reeds grow in thick bunches.

- *Protect or establish large trees close to river channels or off-channel features.*

Large trout were often found in small pockets of slow water that adjoined faster water. These microsites provided the trout with a place to rest from the current but also good visibility of passing food. Large trees growing at the edge of the river often provided the small bank indentations that created these pockets of slow water. Our analysis of current vegetation along channels in the study area indicate a scarcity of large trees compared with conditions in 1944.

A long-term restoration strategy could include conversion of reed canarygrass and blackberries to trees along the edges of the river. Sites where the river is slowly meandering into the bank would be most appropriate for converting areas of introduced plants to native trees.

- *Where riprap is a must, add rock barbs.*

  Salmonids in the McKenzie River were particularly attracted to riprap banks that had barbs. Large trout inhabited the slow water immediately downstream of the barbs during September and juvenile chinook salmon occupied these same locations in March.

  Where riprap is a necessity in the confluence area, the addition of barbs can create some very useful habitat. During our sampling we noticed that the longer barbs (20 feet extending into the channel) attracted more fish than did shorter barbs.

Wildlife and their habitat

Purpose and methods

We conducted a 6-month survey of birds, amphibians, and reptiles in the confluence area in order to provide data for informing decision-makers about possible improvements to wildlife habitat. Project resources were limited so this effort is best characterized as a reconnaissance-level survey, rather than an intensive survey intended to identify every spot used by any or all species.

We used "area count" protocols to inventory birds during the months of January through May (the wintering and migration periods). We divided the accessible part of the project area into 24 survey units, and divided each unit into as many as 4 subunits depending on its general land cover (river, forest & slough, fields & residential). We visited most units 8 times during the January-May period; a few units were visited less often due to inundation of dirt access roads and delays in gaining permission for access. During each of the 8 periods it took about 4 days to survey all subunits; whenever possible these days were consecutive. Birds were identified and counted primarily by sight as the observer drove and walked through accessible parts of the unit, taking the same route and stopping at the same places each time. We noted the various habitat types observed in each of the wintering & migration survey subunits, photographed the subunits, and mapped the habitat types.

During the usual breeding season for most species (June), we made two visits to 121 points spread out somewhat evenly within the same units covered by the wintering-migration surveys, as well as in a few additional locations. Points were spaced at intervals of at least 200 meters (656 ft.), and geographic coordinates (accurate to within about 10 feet, using a GPS instrument) were determined for each point. At each point we identified birds by song (primarily) and sight during a standard 5-minute period. Also, while conducting the nesting bird surveys we estimated the percent of the surrounding 50-meter circle that was comprised of various habitat types, based on visual estimation. Our surveys covered all major habitat types in the confluence area, but did not include some habitats prevalent elsewhere in Lane County, e.g., extensive oak woodlands, conifer forest, large wetlands, reservoirs, small streams.

We scanned all water bodies with binoculars for evidence of western pond turtle during bird survey visits to each subunit and walked a substantial part of the shoreline of each slough and pond at least once during February-March to check for red-legged frog. To accommodate the bird surveys, most areas were visited during the cooler early morning hours. Unfortunately, this is the time of day when many reptiles and amphibians are hiding. We attempted to survey reptiles and amphibians (especially salamanders) by the use of cover boards. Two standard-sized, weathered boards were placed in each unit and were turned over during each visit to check for hiding reptiles and amphibians.

In addition to field surveys, we assessed habitat over the entire project area using satellite imagery that had been classified according to land cover type. The satellite imagery divides the project area into thousands of squares (pixels), each 30 x 30 meters (about 0.2 acre). Image analysts at the Forest Sciences Laboratory, Oregon State University, assigned each pixel to one of about 30 land cover classes based on its condition in spring and summer of 1992. The USEPA then used species models developed by Adamus and others (2000) to assign a score to each pixel, on a 0 (unsuitable habitat) to 10 (best habitat), for each species. After obtaining these species-pixel scores from the USEPA, we summed and mapped species richness (weighted by habitat suitability) for birds, mammals, and amphibians and reptiles. Determining the "weight" of species richness by habitat suitability involved summing the habitat suitability scores of all species predicted to occur within a pixel, based on its land cover, adjacency to other land cover types, and geography.

Results

Wintering and migrating birds

A total of 128 species of birds was detected among the 24 survey units during the 8 January-May visits. All the species we found are ones that have been found before in the Eugene-Springfield area, and most are found in many other parts of the Willamette Valley as well.

Nesting birds

A total of 75 species of birds was detected among the 121 survey points during the two June visits. This represents more than half of the species that may currently nest in the Eugene-Springfield area (Adamus and Larsen, in preparation). Of the 75 species we found, populations of 25 (one-third) are believed to have declined in western Oregon-Washington lowlands, based on national breeding bird survey data, 1968-1996. Nests we found were: bald eagle (1 nest), heron (2 rookeries with multiple nests), turkey vulture (2 nests), and multiple nests of osprey, great horned owl, and red-tailed hawk. None of the many species we found is restricted to the confluence area. All occur in other parts of Lane County, and most, commonly so. Although we surveyed weedy fields, during the nesting season we did not find rare grassland species (western meadowlark, grasshopper sparrow, vesper sparrow, northern harrier) that nest in drier weedy fields elsewhere in Lane County.

Reptiles and amphibians

Western pond turtle: Although not legally designated as endangered or threatened, this species is of interest to natural resource agencies because it apparently has declined throughout the Willamette Valley. Nevertheless, we discovered these turtles in 7 of our 24 survey units. Like others (Holland 1994, Cowie 1997, Holte 1998), we found basking turtles in sunny ponds (both natural and gravel pits) with partly submerged logs or boulders and year-round water. These ponds typically were surrounded by lands that had been partly cleared of trees for gravel mining or agriculture, but which contained moderately dense areas of grass or other short plants which provide cover to young turtles.

Red-legged frog: This is another species which, although not legally designated as endangered or threatened in Oregon, is of interest to natural resource agencies because it apparently is declining rapidly throughout the Willamette Valley. We found this frog in 2 of our 24 survey units, but it is likely that intensive surveys focused just on this species would discover it in additional units. Like the turtle, this species favors ponds, particularly ponds with extensive native herbaceous plants along the edge, and willow thickets or woodland nearby with substantial amounts of downed logs. Red-legged frog eggs and larvae are eaten by many species of fish, as well as the introduced bullfrog.

Others: Bullfrogs – noted predators of native amphibians – were heard at 2 of the 24 sites, and undoubtedly would have been found at more had the sampling protocol specifically targeted this species. Pacific tree frogs were heard at virtually all units. Long-toed salamanders were noted under our cover boards at one unit, and ensatina (another salamander) was found at 3 units. Somewhat surprising to us was a lack of any observations of snakes, and discovery of only one lizard (northern alligator lizard). This may partly reflect the time of day of our surveys. Finally, we note that we were particularly alert for foothill yellow-legged frog, a species more common in California but known currently to be at only one location in the Willamette River Basin. We found none.

Data from all the wildlife surveys and maps depicting the survey areas, bird monitoring points, locations of some of the less common species, and modeled wildlife habitat suitabilities are included in the detailed report.

Conclusions

Compared with much of the rest of the Willamette Valley, the confluence area provides an unusual abundance and variety of natural wildlife habitat. This is partly due to current and past land use practices, and partly to its position at the junction of two major rivers. The richness of habitat supports a corresponding richness of species: at least 133 bird species use the area, of which 76 (57%) probably nest there.

A potential exists for private landowners to enhance wildlife populations in the confluence area, by restoring some habitats on their land that were historically present, and by improving or enhancing other habitats that exist there now. Funds for doing so are available from a variety of sources (for example, see Oregon Wetlands Conservation Alliance 1999 and ODFW 2000). While some landowners voice a concern that improving wildlife habitat might attract legally-designated threatened or endangered (T & E) wildlife species and consequently bring on increased government restrictions, this concern is without technical merit. There are no T & E wildlife species in western Oregon -- other than Bald Eagle which already nests in the confluence area -- that would move into the confluence area if habitat were restored or enhanced. That is because none of the other listed species use a type of habitat that is even remotely similar to what exists now or would exist in the future in the confluence area.

In contrast, restoring and improving the habitats of species that already inhabit the confluence area should maintain or increase populations of the species currently present, thus helping *avoid* the necessity of a T & E listing in the future. Moreover, by choosing to aggressively restore and enhance wildlife habitats, especially on unused parts of their property, private landowners over the long term can help create a climate of public trust and good will toward the mining and farming activities that are important to the economy of the watershed and region.

Restoration principles for wildlife and their habitat

Analysis of the field data indicates that management and restoration of wildlife habitat in the confluence area should focus on four ecosystems: riparian woodlands, floodplain sloughs, inactive gravel-mined lands, and shrublands. These are discussed below.

Riparian woodlands

Riparian woodlands are forested areas along the rivers and sloughs. In the confluence area, they are primarily vegetated with black cottonwood, with intermixed willow, Oregon ash, big-leaf maple, and rarely, ponderosa (valley) pine. Of the various confluence habitats, riparian woodlands supported the widest variety of wildlife. They are the only habitat that supports nesting bald eagles and great blue herons. Riparian woodlands are one of four ecosystems highlighted as conservation priorities for land birds in western Oregon (the others are Grassland-Savanna, Oak Woodland, and Chaparral, none of which now occur extensively in the confluence area)(Altman 2000).

Landowners can help maintain and improve riparian woodlands on their property by considering the following:

- Avoid or minimize the conversion of riparian woodlands to other land uses. In particular, avoid or minimize loss of woodlands in any of the following situations:
  - woodlands covering the largest contiguous areas
  - woodlands with interspersed conifer trees
  - woodlands with large-diameter (>52 inch) trees and high, closed canopies, e.g., "gallery forest"
  - woodlands with native shrub understories (not Himalayan blackberry)
  - woodlands that host the following nesting bird species (none are endangered): band-tailed pigeon, MacGillivray's warbler, pileated woodpecker, hairy woodpecker, red-eyed vireo. These species may indicate higher riparian quality in the confluence area.

- Don't cut cottonwood trees for lumber or firewood, even if the trees or their limbs have fallen or are dying, or are washed up on the bank of a channel or pond. Over a dozen wildlife species depend on dead wood, and large amounts of standing and downed dead wood are needed for wildlife needs. Data we collected suggest the scarcity of dead wood in the confluence area is one factor that most limits wildlife. Standing or downed dead wood closest to rivers and sloughs is of particular importance (Steel and others 1999).

- Create conditions favorable for long term re-establishment of cottonwoods in some of the floodplain areas where they once occurred, especially in areas adjoining existing large tracts of older cottonwood. Restoring cottonwoods (and other woody vegetation) may not be desirable everywhere since other types, such as shallowly-flooded gravel pits, are needed by other wildlife.

- Minimize visits to areas in the vicinity of bald eagle nests and heron rookeries during the times in early spring when these species are nesting.

Floodplain sloughs

These water bodies are flooded annually by the river and provide crucial habitat to two of the rarest wildlife species – western pond turtle and red-legged frog, as well as to one-third of the birds we observed. The presence of one or more of the following species in a floodplain slough over many weeks (especially if in relatively large numbers), is often an indicator of good habitat quality in the confluence area: american bittern, american wigeon, green-winged teal, hooded merganser, wood duck, green heron, belted kingfisher, and marsh wren.

Development-related alterations to floodplain sloughs are reviewed by several government agencies, but the habitat quality of floodplain sloughs can nonetheless be degraded indirectly and severely by excessive sediment runoff (turbidity), spent lead shot, and excessive growths of some highly invasive plant species. Landowners can help maintain and improve floodplain sloughs on their property by considering the following:

- Keep sediment and chemicals from reaching sloughs.

- Don't automatically assume it is best to connect every isolated slough to a river, or disconnect every connected slough from its river. From a wildlife perspective there are advantages to having each, and an appropriate goal at a landscape scale may be to maintain a variety of sloughs, both connected and isolated, and ones that hold water year-round as well as ones that hold water only seasonally. Isolated sloughs (those with no year-round connection to a river) potentially have water quality problems due to poor water exchange rates, and provide little or no habitat for most native fishes. However, they may provide the best habitat for rare turtles and frogs, and support large and diverse aquatic plant and invertebrate populations. Among the best habitats are isolated sloughs that mostly or completely dry out in late summer but which are flooded annually by a river and hold water until at least mid-June.

- Place piles of untreated waste lumber, tree trunks, or boulders in sloughs so they protrude above the water surface during late spring and summer, providing resting habitat for turtles and frogs.

- Attempt to minimize the spread of reed canarygrass. This invasive plant chokes out native sedges and rushes that provide better conditions for most wildlife species. Although difficult, controlling reed canarygrass can sometimes be accomplished by mechanically breaking up existing stands and maintaining water depths of at least 2 feet above the tops of existing plants during at least 2 consecutive growing seasons. However, this frequently is impractical and long-term control remains elusive.

- When possible, minimize public access to sloughs, especially during the winter when disturbance-sensitive waterfowl populations are present. Post signs around sloughs and water-filled gravel pits requesting that no fish be introduced, because fish (especially warm water species) can eliminate populations of sensitive frogs and aquatic salamanders, as well as reducing numbers of aquatic invertebrates that feed young waterfowl.

- If possible, lay out any future roads so they stay at least 100 feet away from floodplain sloughs, or otherwise do not contribute sediment to sloughs via dust or runoff during highest flows.

Inactive gravel-mined land management

Inactive gravel-mined lands typically contain either stagnant water (seasonal or permanent) or extensive weedy and shrubby vegetation. At a landscape scale, inactive gravel-mined lands contribute importantly to the region's wildlife diversity. Landowners can help maintain and improve inactive gravel lands that contain gravel pits (excavations) by considering the following:

- In order to maximize waterbird habitat, maintain water levels at a depth of less than 4 feet in a pit. Where legal and feasible, pump or otherwise completely drain flooded pits for at least 3 consecutive days annually in order to maintain their habitat productivity and kill non-native fish. Draining should occur in late summer or early fall to minimize damage to native amphibians and to provide habitat for shorebirds that are migrating then.

- When the property contains multiple abandoned pits, if possible manage their hydrology such that a variety of water depths are present, e.g., one pit with many scattered seasonal puddles (necessary for shorebirds), another with a few acres of 3-4 foot depths (for western grebe), another with intermediate depths.

- If possible, avoid or minimize the frequency of sudden changes in water levels, e.g., more than one vertical foot per day.

- Reshape side slopes of pits to a more natural contour (see guidelines from Oregon Division of State Lands).

- Create flat sand or gravel bars that extend into the water. These provide good resting habitat for gulls and shorebirds, especially in larger flooded pits,

- On steep cliffs within active pits containing cliff swallow colonies, kingfisher burrows, or Killdeer nests, time the excavations near the colony or nests to avoid the May-nesting July period.

- When it is necessary to return inactive gravel-mined lands to active status, consider transplanting to other inactive sites some of the native wetland plant communities and amphibians that had colonized the site being activated.

When gravel lands contain extensive weedy and shrubby areas, landowners can maintain and improve these by considering suggestions in the following section on shrublands.

Shrubland and weed field management

Inactive gravel-mined lands contain some of the largest areas of shrubland and weed field in the confluence area. Extensive shrublands valuable to wildlife are also present along farm roads, within riparian corridors, where pastures have been abandoned, and as plantations of cottonwood, hybrid poplar, or Christmas trees. The highest quality shrublands in the confluence area are those that are contain native shrub species instead of just Himalayan blackberry or Scotch broom. Native shrublands with interspersed patches of weeds consistently support large numbers of sparrows during the winter and the following species during the nesting season: ring-necked pheasant, yellow-breasted chat, willow flycatcher, orange-crowned warbler, Lazuli bunting.

Landowners can help maintain and improve shrubland and weed field habitats by considering the following:

- Minimize removal or disturbance of naturally-established, sapling-sized cottonwood stands. These are increasingly rare in the region and hold the key to maintaining the future richness of wildlife.

- In appropriate settings on bare soil, encourage the planting and growth of willow, cottonwood, ash, and other native tree and shrub species, rather than letting Himalayan blackberry or Scotch broom take hold. When planting native shrubs or trees, plant them in a naturally irregular, staggered, open manner rather than in straight rows, and leave occasional gaps and small openings where herbaceous weeds (important to wintering sparrows and other species; ODFW 2000) can grow.

- When feasible, align new farm and mining roads along the edge of wooded tracts, rather than through them. Roads and clearings in woodlands speed the spread of Himalayan blackberry or Scotch broom, to the detriment of native shrubs that are more useful to wildlife.

- Allow patches or lines of shrubs (hedgerows) and weedy herbaceous plants to become established amid agricultural fields.

- Keep puddles in weed fields and cultivated fields nearly bare of vegetation and don't connect or drain them. Winter and springtime puddles, when not choked with plants, are very important to shorebirds (killdeer, dunlin, and others).

Fish, wildlife, and flood protection

Results from the flood study conducted by Northwest Hydraulics, Inc. indicate that the flood vulnerability of existing gravel mining sites is greatest along the Willamette River upstream of the confluence. Here, the projected 100-year flood elevation is expected to be greater than the height of existing dikes at several locations. Facilities in the McKenzie River have few locations where a 100-year flow would breach existing dikes. One exception, is the pond at the end of the peninsula separating the Willamette River from the McKenzie River (Figure 9). No gravel extraction operations exist downstream of the confluence except for a small operation in the old McKenzie River channel (right bank).

Gravel operations have been proposed for areas of Reach 1 (left bank) and Reaches 2 and 3 (right bank). Portions of these proposed sites were inundated with water during the 5-year event in 1996 (Figure 9). Much greater area of inundation would be expected during extreme flow events, such as occurred in 1965. Either setbacks from the flood plain or diking would be needed to exclude high water at these operations.

The inundated areas shown in Figure 9 help reveal where old channels of the confluence area still exist. Of most significance, are the braided channels of the old lower McKenzie River, which are also evident in the 1944 aerial photographs (Reaches 1 and 2, right side). Here, exist some of the best opportunities to protect and enhance fish and wildlife. The area between the old McKenzie River channel and the Willamette River (hereafter called the Green Island complex) provides some of the best existing channel diversity (alcoves, side channels, and ponds) and vegetation types to support fish and wildlife. In addition, this section of the confluence area is heavily influenced by the cool and productive McKenzie River. Consequently, there should be a high priority put on protecting and enhancing habitat in this area since this is where natural functions are least disturbed.

Nevertheless, because of the dampening of peak flows by upstream reservoirs, some of the natural functions have been eliminated. One, of considerable importance is the ability of the river to change course and create new off-channel features and maintain existing features. Talks with local residents indicated that many of the channels in the Green Island complex filled in gradually after dams were built. Without the flushing flows once provided by extreme flood flows, the old McKenzie channel and its appendages were abandoned, except during high flows. Direct intervention may be needed to restore flow to these channels by mechanically removing gravel plugs at their entrances. This is not without precedent; farmers remove collected gravel at the inlet of some Willamette River side channels each season to allow flow into channels from which they pump water for irrigation.

There are some trade-offs between fish and wildlife when opening up plugged side channels. In their plugged form, these channels often are a series of natural ponds during low flows. Some of these ponds are too warm or low in dissolved oxygen to support fish during the summer, thereby leaving any pond turtles or red-legged frogs isolated from predator fish from the river. However, this isolation from predation is often foiled by bullfrog or largemouth bass in the ponds. Efforts to connect plugged off-channel features to the river should be tempered with a need to also provide predator-free areas for red-legged frogs and pond turtles.

The upper Willamette River has less salmonid use due to possible water quality problems, has less complex habitat for wildlife, and banks are more affected by gravel extraction and other land uses. Because of this combination of factors, habitat protection and enhancement should be considered less of a priority here.

The large island west of the confluence (Figure 9) has intermediate potential for restoration and enhancement. Existing wildlife life habitat is quite good. The north and east tips of the island support older stands of hardwood trees that support a heron rookery and an eagle nest. The landowner has agreed to protect these portions of the island from disturbance. Gravel operations on the island have began but are not extensive. Only one section of river bank has been riprapped so far and the island is dissected by small channels during higher flows, resulting in complex fish habitat. Nevertheless, its potential for producing fish, especially salmonids, is not as high as it could be due to the influence of upper Willamette River water.

The two near-river gravel pit ponds we sampled trap some salmonids during the winter. These fish apparently do no survive the summer in the warm ponds or they are eaten by largemouth bass. Connecting these ponds to the river year-round is possible by simply constructing a trench at the downstream ends of the ponds. This would allow native fish to move out of the ponds when desired. Yet, these ponds contain large numbers of bluegill and largemouth bass. The dispersion of these aggressive introduced fish into the river during the summer may promote localized seeding of waters that are not yet stocked by these species. Fish poisoning or dewatering of ponds before connecting them to the river entails many technical and social obstacles. Connecting these ponds to the river might also reduce the pond's use by wildlife. Both ponds are off limits to the public and wildlife thrive, due in part, to the lack of disturbance. But if boat access became available through the connecting channel, the ponds may then be considered as public areas that are open to hunting and the wildlife disturbed more often. On the other hand, the connecting channel could be constructed to exclude boats.

Deep gravel pits next to the river (up to 100 feet deep) are probably the most difficult feature in the confluence area to deal with. Connection of these deep ponds to the river is problematic because of the need to keep them from being captured by the river and becoming a sink for the river's bedload. At some sites, the threat of river capture is already high due to weak or low dikes. Furthermore, the steep banks of these deep pits are not favorable habitat for either fish or wildlife since the food for these animals usually comes from areas with shallow water that support aquatic plants and a web of small organisms.

The next step

The next step in this process will be to evaluate site-specific opportunities for protecting or enhancing fish and wildlife habitat, while providing some degree of flood protection. The Confluence Area Steering Committee will be using the mapping and data products presented in this report, along with the recommended restoration principles, to accomplish this task.

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