FISH AND AMPHIBIAN USE OF INTERMITTENT AGRICULTURAL WATERWAYS IN THE SOUTH WILLAMETTE VALLEY

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Background

In the Pacific Northwest, seasonal streams and wetlands in lowland areas provide habitat for fish and amphibians during the wet-period of the year (fall through spring). In the south Willamette Valley, agriculture is a predominant land-use and most of such lowland seasonal waterways flow through grass seed producing fields. Concerns about water quality and native aquatic species in the Valley encourage agricultural practices and other conservation efforts that contribute to the protection of these seasonal habitats. At the beginning of this study, little was known about water quality and habitat conditions in drainages across the agricultural landscape where grass seed crops predominate. Furthermore, there was no information to help identify conservation practices that could have positive effects on water and aquatic organisms while offering growers access to programs that could offer an additional income in payment for such efforts.

More than 20 growers in the Benton, Lane and Linn counties have allowed us to sample on their farms along ditches and natural channels within the Calapooia, Luckiamute, Mary's, Amazon, Muddy, Flat and Long Tom watersheds. These are waterways that are completely dry from late spring to early fall. We sampled 21 seasonal stream sites during the 2002-03 wet-season, and more intensively studied 12 sites in 4 seasonal drainages in the 2003-04 wet-season. Fish and amphibians were collected from November to May using minnow traps, hoop traps and backpack electrofishing. We also collected invertebrates from the benthos (channel bottom) and the drift (those suspended in the water column) at the same 21 sites where fish and amphibians were sampled.

During the 2003-04 field season, fish species, their distributions and the diets of four indicator species were examined in more detail in four different drainages: (1) Butte Creek, (2) Tributary to Butte, (3) Ridge Road Creek and (4) Tributary to Luckiamute River. Sites were selected so the first two of these systems had incised channels with little or no flooding of the riparian zones and adjacent floodplain areas during seasonal high flows. Whereas, channels in 3 and 4 were unconstrained and their high waters could easily access the adjacent floodplains. This was important because fish access to off-channel pond-like areas could potentially give them access to terrestrial invertebrates rather than just aquatic ones, and therefore expanding their food supply. We also examined seasonal differences in the contribution terrestrial and aquatic invertebrates made to fish diets.

We also collected water samples to determine its quality at the fish and amphibian sampling sites. In addition, invertebrates found in the water and in stomachs of the fish were sampled to assess the availability and possible sources of food in these seasonal waterways.

Findings

<u>Aquatic Vertebrates</u>

Fifteen species of fish and 5 species of amphibians were collected over the study period (Table 1), including three salmonid species (chinook salmon, rainbow/steelhead trout, and cutthroat trout). Most fish (11 species) and amphibians (4 species) were native to the Willamette Basin. The rest were exotic (introduced) species, which not only were relatively scarce in these seasonal waterways, but seem to enter these habitats as conditions got warmer in the spring. In contract, exotic species are very abundant in the Valley's permanent streams and wetlands (Colvin, 2005).

In the 2002-03 survey, sites dominated by amphibians were distinguished by slower water velocities than sites dominated by fish. In sites dominated by fish, more fish were caught in drainages to the west of the Willamette River than in systems on its eastern side. Additionally, western sites were distinguished from eastern sites by having higher abundances of sculpins and fewer sticklebacks. Regional differences in the proportion of the watershed that was covered by forests and in the gradient (steepness) of the channels may account for some of the observed west-east side differences in fish abundance and aquatic community composition (Colvin, 2005).

Our results of the 2003-04 survey showed that the number of fish species found at our sampling sites decreased as distance to downstream perennial streams increased, independently of channel connectivity to the floodplain. For the diet component of this study we studied only four species: redside shiner, reticulate sculpin, speckled dace, and threespine stickleback. They were used because they were: (a) broadly distributed throughout our sampling sites, and (b) easy to sample for diet by washing out the content of their stomachs with a small jet of water. Out of the 230 individual stomach samples that we obtained, approximately 62% had invertebrates in them. In turn, of these invertebrates the vast majority (over 90%) were aquatic, which indicates that at least for these species and at the times we sampled the contribution of terrestrial invertebrates to their diets is extremely small (Colvin 2005). That does not mean that terrestrial invertebrates are not relevant to the food base of these aquatic habitats. They may benefit fish in an indirect way by being the prey of some aquatic invertebrates that in turn are eaten by fish. Differences in the diet composition between seasons and between drainage types were observed, but they were very small.

Table 1. Fish and amphibian species captured in intermittent streams during 2002/03 and 2003/04, ordered by decreasing relative abundance (from Colvin 2005).

Fish		**Amphibians**	
Threespine stickleback	*Gasterosteus aculeatus*	Roughskin newt	*Taricha granulose*
Redside shiner	*Richardsonius balteatus*	Long-toed salamander	*Ambystoma macrodactylum*
Reticulate sculpin	*Cottus perplexus*	Pacific treefrog	*Hyla regilla*
Speckled dace	*Rhinichthys osculus*	Redlegged frog	*Rana aurora*
Largescale sucker	*Catostomus macrocheilus*	Bullfrog*	*Rana catesbeiana*
Northern pikeminnow	*Ptychocheilus oregonensis*		
Chinook salmon (juv)	*Oncorhynchus tshawytscha*		
Rainbow trout	*Oncorhynchus mykiss*		
Cutthroat trout	*Oncorhynchus clarki*		
Riffle sculpin	*Cottus gulosus*		
Oregon chub	*Oregonichthys crameri*		
Mosquitofish*	*Gambusia affinis*		
Goldfish*	*Carassius auratus*		
Bluegill*	*Lepomis macrochirus*		
Yellow Bullhead*	*Ameiurus natalis*		

*denotes Exotic species

Evidence provided by tagged individuals from several different species, combined with changes in the size distribution of threespine sticklebacks showed that fish could grow in these seasonal habitats despite relatively low temperatures. Furthermore, the sudden appearance in spring of very small sticklebacks (approximately 10 mm in length) indicates that at least this species spawns and finds suitable nursery habitats in these seasonal waterways.

Although fish were able to travel relatively long distances (over 9 miles) to colonize these seasonal habitats, results from our fish tagging work did not allow us to determine movement patterns and/or differences in movement among species. Only 13 individuals were recaptured out of 496 fish that were tagged. Those 13 individuals were recaptured at the sites where they had been tagged. However, such a small recapture rate does not allow us to determine whether fish are highly mobile or they experience high mortality rates. This work is being repeated for the 2005-06 winter-spring season.

Aquatic Invertebrates

Aquatic invertebrates are important because they process organic matter derived from within the channel and near stream environment, provide food for aquatic vertebrates, and can indicate stream habitat and water quality conditions. Terrestrial invertebrates from riparian (river bank) zones or nearby farm fields could also be swept into seasonal waterways, and although they did not seem to be important components of the diet of the four species we selected, they may still play an important role in “feeding” the aquatic community.

At all sites, non-insects and chironomids made up more than 75% of benthic abundance. Non-insects collected at most sites included nematodes, flatworms, oligochaetes, lymnaeid snails, ostracods, isopods, amphipods and harpactacoid copepods. Although not abundant, species of caddisfly, were also collected at many sites. Greater invertebrate abundances were found at sites with slower water velocities and higher amounts of vegetation growing on the streambed. As with the vertebrates, the types of invertebrates differed between sites in drainages west and east of the Willamette River. Western sites had higher relative abundances of several aquatic insects (e.g., baetid mayflies, blackflies and midges), while eastern sites had more non-insects (e.g., ostracods, amphipods and flatworms). In contrast to benthic samples, drift samples contained organisms that were of both aquatic and terrestrial origin. Common invertebrates in drift samples included mites, collembola, midges and several types of microcrustaceans. Drift density was highest in sites with smaller watershed area, shallower waters and higher channel slopes. Again sites east and west of the Willamette River were distinctive. Drift from western sites contained more aquatic organisms including midges and microcrustaceans; eastern site drift contained more terrestrial organisms including collembola, spiders, barklice and thrips.

Water Quality

During the 2004-05 water year, the average nitrate-N concentration was 0.98 ppm at approximately 90 sample sites along the entire length of the Calapooia River watershed (from the headwaters to the Willamette River); 98% of all samples contained less than 10 ppm nitrate-N. Unlike previous years (2001 to 2004), the greatest nitrate-N concentrations during the 2004-05 season were observed as two distinct peaks over time instead of just one; one was detected in December and the other in April and were associated with high winter and spring precipitation periods respectively. Relatively dry conditions predominated between the two peak periods. The average ammonium-N was 0.09 ppm, with 98% of all samples being less than 0.5 ppm and 99% less than 1.0 ppm. The pH of the water measured in these systems was 7.2. The average ortho-P concentration was 0.035 ppm and total P at 0.097 ppm. Average suspended sediment concentrations were 12.6 ppm, with no sample points greater than 522 ppm. The highest concentrations of soluble chemical constituents were found in the lower portion of the Calapooia River watershed between Brownville and the Willamette River (Table 2).

The concentrations of water quality constituents found in winter-seasonal agricultural drainages were generally low relative to concentrations believed to affect aquatic vertebrates. Nitrate- and ammonium-N and suspended sediment concentrations were generally below what are referred to as the lowest observed adverse concentrations (LOAC) when aquatic wildlife is present. A LOAC is typically far less than an acute concentration such as the LD_{50} (lethal dose at which 50% of the test sample dies). Published reports indicate Pacific Tree Frog embryos exposed for 10 days were affected by ammonium-nitrogen at 6.9 ppm, and tadpoles by 24.6 ppm (Schuytema and Nebeker, 1999; 2000). Previous research demonstrated that not all nitrogen forms found in drainages were derived from fertilizer applications. Naturally occurring nitrate-N moves with precipitation run-off from soils to streams and typically peaks in early winter when significant precipitation follows the dry summer season (Griffith et al., 1997; Wigington et al., 2003). The southern Willamette Valley soils are generally characterized as poorly drained and typically cause denitrification reactions to occur during the winter when soils are saturated. These and previous reported findings indicate that the quality of water in winter-seasonal agricultural drainages is generally good utilizing established recommendations for constituent concentrations that adversely affect aquatic wildlife. More detailed analyses will be conducted to determine the duration of exposure at the higher constituent concentration levels when wildlife are present.

Table 2. Water quality data of the Calapooia River watershed main-stem and associated tributaries from September 2004 through August 2005. The water quality constituents measured were pH, nitrate (NO_3-N), ammonium (NH_4-N), total phosphorous (TP), dissolved organic carbon (DOC), and suspended sediment.

Location		pH	NO_3-N	NH_4-N	TP	DOC	Sediment
		---------- (ppm) ----------					
Agriculture (lower portion)							
	Average	7.3	2.73	0.22	0.252	13.7	21.0
	Median	7.3	1.02	0.03	0.061	11.4	13.3
	Maximum	8.6	19.70	29.70	23.800	68.8	522.2
	Minimum	6.6	<0.01	<0.01	<0.005	1.7	0.8
Mixed Forested-Ag (middle portion)							
	Average	7.3	0.45	0.04	0.046	8.31	12.15
	Median	7.3	0.17	0.02	0.021	6.13	8.78
	Maximum	8.5	5.77	3.32	1.510	49.33	86.43
	Minimum	6.3	<0.01	<0.01	<0.005	2.35	0.67
Forested portion (upper portion)							
	Average	7.2	0.08	0.02	0.023	3.87	7.44
	Median	6.3	0.6	0.01	0.015	3.82	6.67
	Maximum	8.8	0.77	0.40	0.802	7.49	33.33
	Minimum	7.0	<0.01	<0.01	<0.005	1.68	0.00

Conclusions

This research demonstrates that seasonal waterways (ditches as well as natural channels) that flow through grass seed producing fields in the Willamette Valley provide winter and spring habitats to many different species of native fish and amphibians. During the periods and at the locations where we sampled, water quality -in terms of nutrient concentrations- does not present a problem to aquatic vertebrates. These seasonal competition and/or predation shelters from exotic species may prove critical to the long-term presence of some of the native species that occur in the Valley.

Providing a species inventory and documenting the food resources in these seasonal waterways were the first steps towards describing the current situation for species that rely on habitats that are only a trace of what they used to be (see Hulse et al., 2002). The evaluation of the effects of agricultural conservation practices on these seasonal habitats and the aquatic vertebrate species that use them has not been completed yet. In fact, based on data from our first three years of work, we decided to examine the influence of vegetated (or grassed) ditch bottoms vs. bare clay on fish species composition, fish abundance, and their period of residence at a site. Additional conservation practices will be evaluated in future years.

This information can be used by farmers to determine the types of practices they can employ to protect water quality and wildlife habitats in the channels that drain their lands. Collaborators from the USDA-ARS are analyzing the economic tradeoffs between income forgone by not farming poorly drained portions grass seed fields, and Farm Program payments for establishing conservation practices in those areas. These programs have not been widely available to western Oregon grass seed farmers until the relatively recent inclusion of the Conservation Title in the 2002 USDA Farm Bill (Steiner et al., 2005).

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References

Colvin, R.W. 2005. Fish and amphibian use of intermittent streams within the Upper Willamette Basin, Oregon. M.Sc. Thesis. Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR.

Griffith, S.M., J.S. Owen, W.R. Horwath, P.J. Wigington Jr., J.E. Baham, and L.F. Elliott. 1997. Nitrogen movement and water quality at a poorly-drained agricultural and riparian site in the Pacific Northwest. Soil Science and Plant Nutrition 43: 1025-1030.

Hulse, D., Gregory S., and Baker, J. (editors). 2002. Willamette Basin Planning Atlas, Trajectories of Environmental and Ecological Change. Oregon State University Press, Corvallis, OR.

Schuytema, G.S. and A.V. Nebeker, 1999. Comparative Effects of Ammonium and Nitrate Compounds on Pacific Treefrog and African Clawed Frog Embryos. Archives Enivron. Contamination Toxicology 36: 200-206.

Schuytema, G.S. and A.V. Nebeker, 2000. Effects of Ammonium Sulfate on Growth of Larval Northwestern Salamanders, Red-Legged and Pacific Treefrog Tadpoles, and Juvenile Fathead Minnows. Bulletin Enivron. Contamination Toxicology 64: 271-278.

Steiner, J.J., G.R. Giannico, S.M. Griffith, M.E. Mellbye, J.L. Li, K.S. Boyer, S.H. Schoenholtz, G.W. Whittaker, G.W. Mueller-Warrant, and G.M. Banowetz. 2005. Grass seed fields, seasonal winter drainages, and native fish habitat in the south Willamette Valley. p. 79-81. *In* W.C. Young III (ed.) Seed Production Research at Oregon State University, USDA-ARS Cooperating. 2004. Dep. Crop and Soil Science Ext/CrS 124, March. Corvallis, OR. (technical bulletin)

Wigington, Jr., P.J., S.M. Griffith, J.A. Field, J.E. Baham, W.R. Horwath, J. Owen, J.H. Davis, S.C. Rain, and J.J. Steiner. 2003. Effectiveness of a riparian water quality buffer along a small agricultural stream in western Oregon. Journal of Environmental Quality 32: 162-170.