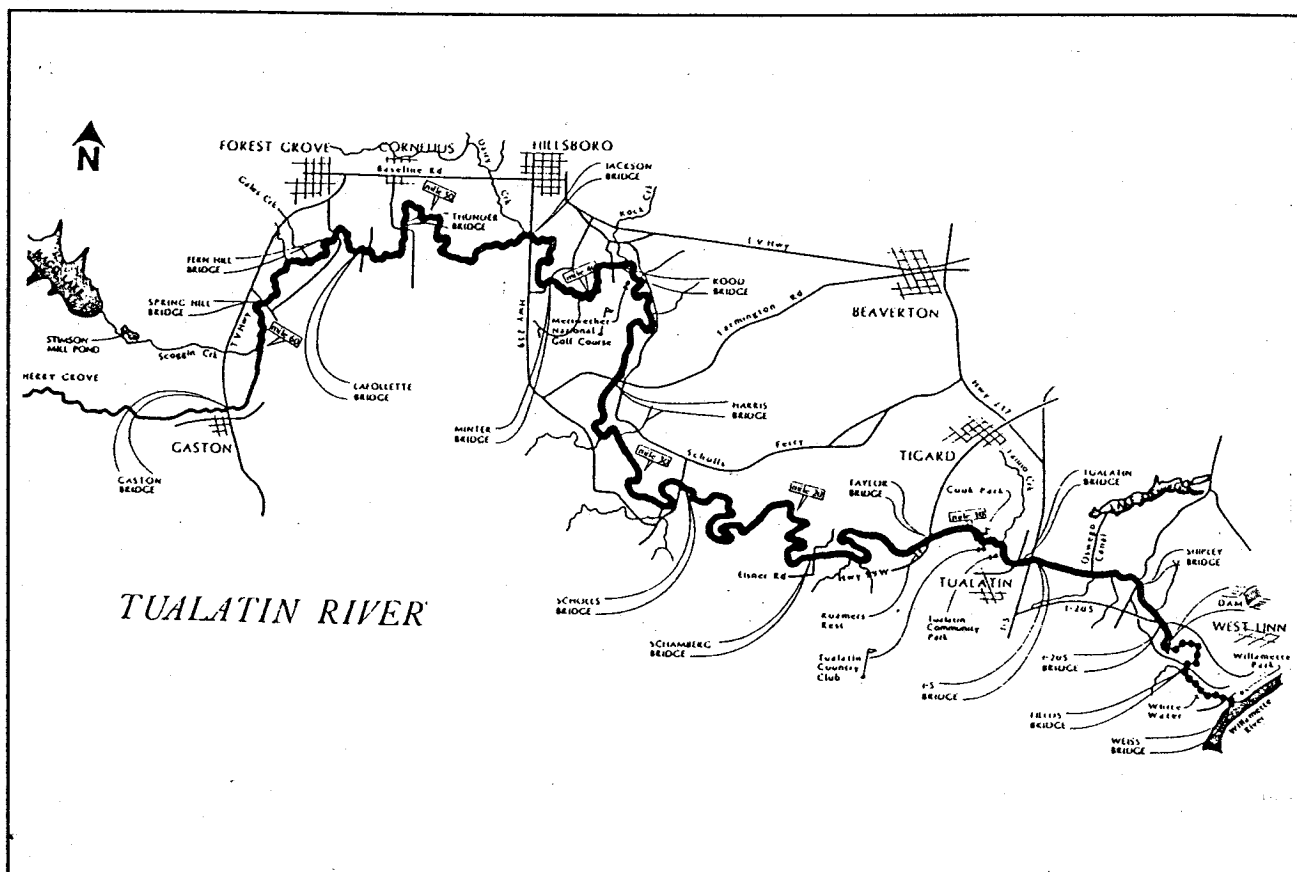


Issues Surrounding the Biota of the Tualatin River Basin



Oregon Water Resources Research Institute
Oregon State University

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TUALATIN RIVER BASIN SPECIAL REPORTS

The Tualatin River Basin in Washington County, Oregon, is a complex area with highly developed agricultural, forestry, industrial, commercial, and residential activities. Population has grown in the past thirty years from fifty to over 270 thousand. Accompanying this population growth have been the associated increases in transportation, construction, and recreational activities. Major improvements have occurred in treatment of wastewater discharges from communities and industries in the area. A surface water runoff management plan is in operation. Agricultural and forestry operations have adopted practices designed to reduce water quality impacts. In spite of efforts to-date, the standards required to protect appropriate beneficial uses of water have not been met in the slow-moving river.

The Oregon Department of Environmental Quality awarded a grant in 1992 to the Oregon Water Resources Research Institute (WRRI) at Oregon State University to review existing information on the Tualatin, organize that information so that it can be readily evaluated, develop a method to examine effectiveness, costs and benefits of alternative pollution abatement strategies, and allow for the evaluation of various scenarios proposed for water management in the Tualatin Basin. Faculty members from eight departments at Oregon State University and Portland State University are contributing to the project. Many local interests groups, industry, state and federal agencies are contributing to the understanding of water quality issues in the basin. This WRRI project is based on all these research, planning and management studies.

This publication is one in a series designed to make the results of this project available to interested persons and to promote useful discussions on issues and solutions. You are invited to share your insights and comments on these publications and on the process in which we are engaged. This will aid us in moving towards a better understanding of the complex relationships between people's needs, the natural environment in which they and their children will live, and the decisions that will be made on resource management.

Issues Surrounding the Biota of the Tualatin River Basin

by

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Table of Contents

1.	Geomorphic and Hydrologic Change	1
2.	Riparian Issues	3
3.	Nutrient Cycling	5
4.	Biota	5
	Phytoplankton and Periphyton	6
	Influences of Aquatic Organisms on Algal Communities	6
	Native and Introduced Fishes	9
	Invertebrates	10
	Vegetation	12
	Terrestrial Biota	12
5.	Social Values	14
6.	Recovery of the Tualatin River Basin	15
7.	Summary	16
8.	Bibliography	18
9.	Appendix 1: Biological Surveys of the Tualatin River Basin	32

List of Figures and Tables

1.	Figure 1: Tasslecap photograph of Tualatin Basin from Landsat satellite imagery, 1988	21
2.	Figure 2: Log rolling in Tualatin River as done in 1889 by Hillsboro loggers	22
3.	Figure 3: Stream Ecosystem Model simulation of grazer influence on algal biomass	23
4.	Figure 4: Stream Ecosystem Model simulation of maximum algal biomass at increasing nitrogen concentrations under the influence of stream grazers	24
5.	Figure 5: Stream Ecosystem Model simulation of grazer influence on gross primary production at increasing nitrogen concentrations	25
6.	Figure 6: Stream Ecosystem Model simulation comparing total annual production of algae, grazers, and vertebrate predators at increasing concentrations of nitrogen	26
7.	Table 1: Fish Communities of the Tualatin River Basin	27
8.	Table 2: Status of Amphibians and Reptiles, Tualatin Basin	28

Tributaries of the Tualatin River cascade down high gradient slopes for relatively short distances, then flow into the low gradient mainstem which meanders for much of its length. The gentle, east-facing slopes of Oregon's Coast Range provide the geomorphic and climatic template for the watershed's patterns of discharge, water quality, and biological distribution. Human activity has altered this stream for over 150 years. Navigation, agriculture, and dam diversion at Lake Oswego were early impacts on Tualatin tributaries and mainstem. Demands from increasing urban development, such as domestic water use and streamside development, are likely to further exacerbate alterations to flow regimes, in-stream structure, and channel morphology.

Biological communities within the stream as well as organisms inhabiting adjacent riparian vegetation and hillslopes are influenced strongly by physical processes across the entire watershed (Gregory et al 1991). From upslope headwaters through meandering mainstem, the biota comprise a continuum of organisms whose composition, quantity, and diversity reflect upstream and downstream phenomena (Vannote et al. 1980). In this report we will emphasize this landscape perspective by considering patterns of physical and biological processes across the entire basin. The purpose of this report is to review the available information on the Tualatin River basin biota, to suggest the kinds of biological data still needed, and to identify potential problems related to recovery of biological integrity in this watershed.

GEOMORPHIC AND HYDROLOGIC CHANGE

Agricultural activities began in the Tualatin River basin when the first pioneers off the Oregon Trail arrived (J. Smith, Oregon Historical Society). Today agriculture comprises 25% of the basin's land use (ODFW Tualatin subbasin plan, 1991). To make way for crops and grazing lands, channels have been straightened, wetlands removed, and flows diverted. Satellite imagery depicts the consequent impact on the Tualatin Basin (Fig. 1). River and stream channels are barely visible on the images of the basin. Drainage of Wapato Lake by railroad developers, then diking of Hill, Wapato and Ayres Creeks are historical examples of these practices (R. L. Benson, 1973); the old lake basin now is filled with agricultural lands (Fig. 2).

In the nineteenth century boating and logging activities changed the shape and composition of stream channels in the Tualatin basin. Ferries and steamboats plied the river from 1851 to approximately 1897 (Farnell, 1978). Logs were driven in enormous rafts from upstream logging sites to downstream mills from 1865 to about 1907 (Fig. 3). At the height of logging activities millions of board feet per year scoured streambeds as far up as Cherry Grove on the mainstem and high up into major tributaries such as Gales Creek and Dairy Creek (Farnell, 1978).

Today, lack of riparian vegetation and floodplain terraces throughout the basin indicate reduced floodplain function, with the exception of Jackson Bottom that is a wetland restored as part of a joint mitigation project near Hillsboro. Because of deliberate alterations to the channel, removal of natural structure such as large wood, streamside development, and flow regulation from Scoggins Dam, the Tualatin River no longer spreads into much of its natural floodplains and wetlands.

Agricultural and urban demands for water have resulted in extensive alterations to stream discharge. Lake Oswego, which has a water right of 57.5 cfs diverts most of the river's natural flow during summer months (State Engineer of Oregon, 1959). This water right, one of the oldest on the river, derived from the Oregon Iron and Steel Company in 1906 (Oregon Department of Water Resources, certificate number 29248). This dam was built in 1888 and inundated lowlands from its present location at river mile 3.5 to the town of Tualatin (Farnell, 1978; Benson 1978). Since installation of Scoggins Dam in 1975 reservoir releases maintain flow to reaches below the Lake Oswego diversion and provides an additional 1,000 acre feet per year to Lake Oswego. A smaller reservoir that is a water supply for Forest Grove occurs at Clear Creek on Gales Creek. In addition ODFW reports an illegal dam at Balm Grove on Gales Creek (ODFW 1991).

Reservoir releases, along with irrigation and domestic diversions, presently determine discharge patterns and fluctuations that are temporally and seasonally likely to be different from conditions under which the native fauna and flora evolved. The dams restrict fish passage as well as reduce available streamflow. Effectiveness of the fishway at the Lake Oswego diversion is variable in allowing fish passage, and the unscreened diversion channels some ill-fated juvenile salmonids into the dam's turbines (ODFW 1991). There is no fish passage at Scoggins Dam. In 1985 a total of 18,345 acre-feet were withdrawn from the Tualatin River through a combination of municipal, industrial and agricultural uses (as reported in ODFW 1991). Water rights on the river total 1,146 cubic feet per second that potentially can be withdrawn during a given year. These reductions from natural flow reduce fish migration and are likely to reduce

available habitat. Flow regulation can reduce the effects of storm events, change periodicity of peak flows, minimize subsequent substrate scour, and reduce flushing of nutrients (Ward and Stanford 1979, Ward 1984). The cumulative effects of these physical and temporal changes probably have been to simplify benthic communities to include those which tolerate altered regimes.

Interaction with natural floodplains is also limited because lowered flows and channelized stream banks are less able to redistribute sediments onto the original floodplain. Future plans for the basin must evaluate the impact on stream biota imposed by the physical barriers created, the changes in water volumes, and temporal fluctuations imposed by these structures.

RIPARIAN ISSUES

Riparian zones serve as nutrient filters, provide shade, structure, and food sources to streams (Gregory et al 1991). Healthy riparian zones can create diverse aquatic habitats, reduce light levels, modulate temperatures, serve as barriers to erosion into the stream, and provide travel corridors for wildlife species. The extent and continuity of the riparian vegetation are critical to both aquatic and terrestrial communities.

In the Tualatin River basin, much of the riparian habitat has been fragmented or eliminated in both agricultural and urban reaches. As illustrated in satellite photographs of the basin (Fig. 1), only the uppermost reaches are forested; most of these forested areas are in private ownership. The aerial photos indicate very little mature forest in high-gradient areas. A small tract of old growth forest belonging to the Bureau of Land Management remains near Lee Falls (Benson 1973; D. Beam personal communication).

In contrast to upland forests, where riparian zones are regulated by the Forestry Practices Act, riparian zones in agricultural lands (which comprise one-quarter of the Tualatin landbase) are unregulated, with the exception of wetland areas (ODFW Draft Tualatin Sub-basin Fish Management Plan, 1991). Where riparian forests have been harvested up to the stream margins, streams are exposed to high solar radiation, increased temperatures, increased erosion, and reduced filtration of terrestrial runoff. Between 1986-1989, average stream temperatures ranged between 7^o-21^o C in the mainstem below Rock Creek, and showed a generally warming trend as it flowed from headwaters to the confluence with the Willamette (USA Appendix E.3). Data from 1990 and 1991 indicate that tributaries enter the mainstem warmed by solar insolation,

and contribute to higher mainstem temperatures. For example, Gales Creek, that enters the Tualatin at river mile, reached morning temperatures of 21.9°C in June, 1992. Daily maxima would be higher. Dramatic temperature fluctuations and absolute high temperature maxima both will limit growth and survival of fish and other biota (Bisson and Davis 1975). Moreover, temperature more than 15°C will tend to increase phosphorous desorption with likely increases in algal production (Karr and Schlosser).

Regulations of riparian zones within the urban boundary are maintained by the United Sewage Agency (L. Kelly, personal communication). Riparian setbacks of only 25 feet are enforced on present management proposals in urban areas, though 100-foot setbacks have been recommended by agencies in the Tualatin River basin, including United Sewage Agency (USA), the Department of Environmental Quality (DEQ), and the Oregon Department of Fish and Wildlife (ODFW). Unfortunately, even 25-foot standards apply only to new projects, and have no effect on prior installations. Consequently complete riparian removal has occurred in some residential patches, and extremely reduced corridors with adjacent parking lots and other developments are common along the mainstem Tualatin River.

The patchwork of jurisdictions and lack of regulatory power are reflected in the discontinuity of the current riparian corridor. In a watershed where urban populations are growing and streamside residences are becoming more valuable, attention must be paid to the effects of riparian fragmentation on riverine processes. In 1989 approximately 200 dwellings were identified within a 200 foot margin on each side of the mainstem Tualatin between the river mouth to Forest Grove (USA Wastewater Facilities Plan, Appendix E.4). Bank stability, shading, habitat diversity, and wildlife corridors are some of the values potentially at risk when riverine forests are converted to other land uses. A comprehensive survey of riparian health is needed on the tributaries and mainstem of the Tualatin.

Woody debris from the riparian zone shape stream channels and creates complex habitat. Both fish and invertebrates use habitat formed by fallen trees, roots and other woody material (Swanson et al. 1982, Gregory et al. 1991). As late as the 1950's stream surveys counted high numbers of woody snags that accumulated easily in the Tualatin River, but many of these log jams were removed in the 1960's (ODFW 1991 Tualatin Sub-basin Fish Management Plan). For navigational, storm runoff, and aesthetic reasons, large wood in streams often is removed. As riparian zones have been degraded along the Tualatin, amounts of large wood available for future natural stream structure has decreased. Because these structures are valuable in forming stream channels and habitat, care must be exercised before additional large wood is removed

from the stream.

NUTRIENT CYCLING

Nutrient dynamics are intimately tied to both aquatic and terrestrial biota. Before entering streams particulate and soluble phosphorous and nitrogen can be retained by riparian vegetation. Riparian width and condition determine the effectiveness of this interception. Likewise wetlands, particularly macrophytes, retain sediments and nutrients. Loss of these biological filters will increase nutrient input to streams. Areas with potentially high terrestrial inputs would benefit most from intact riparian forests and wetland areas; Dairy Creek, where 60% of agricultural lands erode at three times rates acceptable by Soil Conservation Service, is a good example (Soil Conservation Service 1990). Another target for restoration could be the Tualatin River mainstem reach between river mile 27.1 and 16.5 that is subject to both agricultural and urban influences; in this part of the mainstem land use practices account for increases in phosphorous, ammonia and total Kjeldahl nitrogen (USA Appendix E.3).

Sediment deposition and residence times have been dramatically altered by reservoir flow regulation and channel modifications. Flow alteration reduces high, flushing discharges and results in added nutrient-rich sediments. Because of longer residence times more nutrients are likely to be released from deposits. If the Tualatin River were flowing freely through its natural floodplain sediments and nutrients would be deposited onto the floodplain and removed from the main channel in periods of high flow, but agricultural and urban development now restrict this river function. Consequently added loads of nutrient and sediments accrue in the river channel. Given these changes in deposition rates and sediment interception, restoration of largescale river processes such as floodplain dynamics and discharge periodicity could play important roles in improving Tualatin River water quality.

BIOTA

Despite great public concern over the status of the Tualatin River basin, little is known about the biota of the system as a whole. Emphasis has been placed on lower mainstem problems, and very little has been documented for upper reaches of the watersheds, particularly upper tributaries. Most information is localized or anecdotal, and basin-wide surveys are non-existent at almost every level of biological organization, from algae to terrestrial vertebrates. Historical data generally were restricted to single day, non-replicated samples. Nevertheless, trends in biological resources can be inferred from the little information available. This report highlights

potential problems, but more thorough descriptions are essential for understanding the role of the biota within the river ecosystem.

Phytoplankton and Periphyton

Because algae are closely linked to water quality there has been great interest in algal abundance in the Tualatin. Nevertheless, the algal data is generally confined to phytoplankton in the mainstem water column and reviewed in Appendix E.3 of the USA Wastewater facilities plan (Water resources, 1990). Little is known about algae in the tributaries or periphyton on bottom surfaces in the mainstem. In recent years diatoms have dominated the Tualatin River mainstem. At Cherry Grove, benthic diatoms were prevalent in surveys conducted in both 1976 and 1987. Planktonic algae have been suggested as part of the outfall from Scoggins Reservoir, but collections to date have not confirmed that possibility. Downstream, below river mile 58, benthic pennate diatoms are common. In 1976 noxious blue-green Aphanizomenon alga were dominant below river mile 33, but in 1987 centric filamentous diatoms such as Melosira were most abundant (Carter et al 1976; Sweet 1987). Reasons for the downstream shift in alga taxa are unclear, but may be related to improved water quality. If this trend away from blue-greens toward filamentous diatoms continues, the lower mainstem may not be subject to continued blue-green algal blooms, but turbidity and public perception of undesirable algal production may persist.

In a recent Willamette River basin study of periphyton, measures of standing crops of chlorophyll *a* and periphyton biomass were higher in the Tualatin than in the Willamette mainstem (Gregory 1993). Whereas these measures of algal abundance generally lower in tributaries, the Tualatin was a notable exception. These high values, taken from only one Tualatin River site, at river mile 1.6, suggest the need for more extensive survey of periphyton in this highly productive system.

Influences of Aquatic Organisms on Algal Communities

Though considerable thought and effort has been given to the connection between algal abundance and nutrient availability in the Tualatin River, very little data is available regarding other factors affecting algal biomass such as herbivory by aquatic organisms, hydrologic residence times, or terrestrial runoff of pesticides or herbicides. Equally important are the effects of predators that consume herbivorous animals. Modelling efforts and preliminary biological collections for the mainstem Tualatin are beginning to address these issues, but field data are scarce and manipulative experiment are not available. This area of investigation will be critical for understanding trends in phytoplankton and zooplankton in the Tualatin River.

Zooplankton herbivory can dramatically affect phytoplankton abundance and water quality (Edmondson and Litt 1982, Bergquist et al 1985); feeding rates and selection for particular alga can be species specific (DeMott 1982). Preliminary information from surveys conducted by USGS indicate that both *Daphnia* and *Bosmina* may dominate the water column at various times of the year (Ralph Vaga, personal communication). Other significant herbivores in the Tualatin River are suckers (members of the species *Catostomus*), which appear to be the most abundant fish in the lower mainstem. ODFW personnel have noted high numbers of suckers in collections of mainstem fishes, but actual counts were not made (K. Daily, personal communication). Both vertebrate and invertebrate herbivore distribution and abundance may affect dramatically the number and kinds of algae in the system.

In a study of benthic algae in the Willamette River (Gregory 1993), we used a model of a stream ecosystem developed by Dr. David McIntire at Oregon State University. The Stream Ecosystem Model includes the influences of light, temperature, current, limiting nutrients, and consumption by herbivores on algae. The model does not include a true phytoplankton component (algae scoured from the stream bottom is represented as transport). Invertebrate consumers are represented by grazing, shredding, collecting, and predaceous functional groups. Vertebrate predators capture half of their prey from the stream bottom and half from animals drifting in the water column. We set allochthonous inputs (i.e., leaves, needles, etc.) from the adjacent terrestrial ecosystem at one-tenth that of headwater streams to account for the larger area of stream bottom. Light intensities were held constant at 2000 foot-candles during summer. Nitrogen was considered to be the limiting element for photosynthesis based on the low N:P ratios in the Willamette River in late summer. The model was run first with the full complement of consumers and compared to a subsequent model simulation in which all animal consumers were eliminated from the ecosystem. The model simulation was designed to examine conditions in the Willamette River, but the overall dynamics are applicable to the Tualatin River.

Average annual biomass of benthic algae on the river bottom was reduced ten-fold by the presence of grazers up to nutrient concentrations of approximately $125 \mu\text{g N/l}$ (Figure 3). At nutrient concentrations higher than $125 \mu\text{g N/l}$, algal biomass was much closer to that observed without consumption by herbivores. Maximum algal biomasses over the year were in the range of $80 - 110 \text{ g/m}^2$ (Figure 4), similar to algal biomasses observed in the Tualatin River. Algal biomass simply measures the abundance of algal matter present at a point in time and is not a rigorous measure of plant production. The model suggests that primary production increases in a hyperbolic

manner with increasing nutrient availability, but consumption of algae by herbivores sharply reduces metabolic rates at nitrogen concentrations less than $125 \mu\text{g N/l}$ (Figure 5). Rates of primary production are constrained by consumption by higher trophic levels at lower levels of productivity, but increased photosynthesis at high nutrient levels allows algal communities to "escape" the detrimental effects of grazing and accumulate substantially higher biomass. Total annual production of algae (not instantaneous biomass) is much greater for algae than for either herbivores or fish predators and is strongly affected by the presence of consumers (Figure 6).

The Stream Ecosystem Model predicts levels of algal abundance and production that are within the ranges observed in a recent OSU and DEQ study of benthic algae in the Tualatin river, the Willamette River, and its tributaries. The model simulation was based on assumptions that nitrogen limited rates of primary production. In many situations primary production in the Tualatin River may be limited by the availability of phosphorus instead of nitrogen, but the switch in the type of nutrient that is limiting would not change the influences of herbivory on algal communities. This does not indicate that the model is correct, but the general trends have important implications for assessing the ecological status of the Tualatin River basin and for designing future monitoring or research efforts.

In a system where algal numbers can be reduced by herbivores, attention must be paid to influences of higher trophic levels, such as the effects of predators on the herbivores. Zooplankton size and abundance are reduced dramatically by fish predators (Brooks & Dodson 1965, Carpenter et al 1985). Planktivorous fish, particularly non-native centrarchids such as largemouth bass and bluegills, probably have strong impact on zooplankton abundances in the Tualatin River. With the exception of 1987 lake samples (S. Geiger in Scientific Resources, Inc. 1988), previous zooplankton collections are conspicuously lacking, and enumerations of non-game fishes has been recorded only recently (ODFW data)

Monitoring of the Tualatin River ecosystem to date has included only meager consideration or measurement of benthic biota. This less transient component of the Tualatin River reflects long-term changes in habitat, water quality, and discharge patterns. We strongly encourage the state of Oregon to evaluate the major components of the Tualatin River within an ecological framework that is consistent with physical, chemical, and biological processes that shape the ecosystem. Simply measuring the abundance of phytoplankton or benthic algae and responses to nutrient supplementation in microcosms will almost certainly lead to erroneous conclusions. Models based solely on algal responses to physical and chemical factors may indicate potential

changes, but such models have little chance of accurately reflecting algal dynamics in a complex aquatic ecosystem like the Tualatin River.

Native and Introduced Fishes

Current surveys of zooplankton, phytoplankton, and fish in the mainstem by the USGS, ODFW, and OGI are pivotal to our understanding of community-level processes. Salmonids once dominated tributaries of the Tualatin basin, and recent ODFW surveys will document current abundance (ODFW 1992). Apparently both resident and sea-run cutthroat trout occupy headwater streams; current ODFW policy provides for an exclusively wild population of cutthroat trout in Gales and Dairy Creeks. Though winter steelhead were originally native to this basin, hatchery stocking augments native fish at present. Coho salmon also are maintained by fry releases. Estimates of anadromous fish are measured as a percentage of returning fish over Willamette Falls.

Recent surveys by ODFW Research Division included 10 Tualatin tributaries (see Appendix I). Preliminary analysis indicates that cutthroat trout and steelhead trout are most abundant in upper reaches; sculpin and redbreast shiners are present further downstream in the tributaries (K. Moore, personal communication). Fanno Creek is one of the last major tributaries to enter the Tualatin before the confluence with the Willamette and is almost entirely urban. An electrofishing survey suggests movement of warmwater and exotic species into Fanno, which still supports small numbers of cutthroat trout. Plans for fish management in the tributaries also must include evaluation for habitat conditions, such as riparian vegetation and temperature regimes. For example, plans to enhance wild cutthroat stocks must take into consideration high temperature maxima that may occur in Gales Creek.

Recent ODFW/USGS surveys that include both game and non-game fish will provide improved information about the fish community of the lower mainstem. Preliminary information about largemouth bass from 1992, fish gut samples, and prey abundance measures, suggest heavy predation on small herbivorous zooplankton. Continued surveys inclusive of all major trophic levels will be critical to understanding potential food web interactions and possible biological influences on algal abundances.

We cannot emphasize too strongly the importance of documenting the abundance and distribution of all fish species, not only salmonids. Native aquatic and terrestrial biota did not evolve in the presence of voracious predators such as largemouth bass, pumpkinseed, bluegill, and warmouth, thus they are vulnerable to high rates of consumption. Young fish, reptiles and especially amphibians are highly

susceptible to predation by fish. Thirteen species of exotic warmwater fish have been introduced accidentally (i.e. none were intentionally introduced by fisheries agencies) into the Tualatin River basin (Table 1). Except for sturgeon, these warmwater fishes were introduced in the late 1800's and early 1900's (ODFW 1991). Ten of these exotic species are planktivorous at some stage of their life history. One of these exotic species, grass carp, is herbivorous on macrophytes.

Largemouth bass have been captured by electrofishing predominantly as fingerlings in the lower mainstem (K. Daily, unpublished ODFW data)(see Appendix 1). These young bass depend heavily on zooplankton, and preliminary gut analyses appear to confirm this dietary selection in the Tualatin River (N. Munn & R. Vaga, personal communication). Seasonal electrofishing data indicate that largemouth bass are numerous only as fingerlings, and herbivorous largescale suckers probably comprise the majority of biomass in the mainstem (K. Daily, personal communication). Reasons for high mortality among young largemouth bass are unknown, but may include predation by larger fish and birds, and limited supply of adequate prey. In addition to largemouth bass and abundant suckers, other fish common in the lower mainstem Tualatin include white crappie, bluegill, pumpkinseed, black crappie, and squawfish (see Appendix 1). In May 1993 steelhead were collected.

"Moderate" levels of fishing for warmwater fish were reported for the lower Tualatin in 1964 (ODFW 1964). Yellow perch, bluegill sunfish, crappies, bullhead catfish, and largemouth bass were the most commonly caught. Though Lake Oswego lacked public access at that time, it received considerable anlgng pressure from local landowners and residents (ODFW 1964). At present there are no harvest records for these fishes, and access to the river continues to limit angling (ODFW 1991). Considerations of potential effects on migratory and resident fish should be made before expanding warmwater fisheries in the lower Tualatin. Monitoring both native and exotic fish communities will provide a critical measure of ecological recovery and trophic interactions in the Tualatin River basin.

Invertebrates

Benthic invertebrate surveys conducted in 1975 and 1976 (Sutherland 1976) provide some reference sites for kick samples taken by DEQ in October 1987. Though both surveys were cursory and unreplicated, increases in diversity, measured simply as number of taxa present, indicate some biological recovery. Most dramatic were changes in Rock Creek at River Road, downstream from the confluence with Beaverton Creek and formerly the Hillsboro treatment plant discharge. In 1975 this site contained

only small numbers of tubificid worms that are highly tolerant of pollution; in 1987 nine macroinvertebrate taxa were found, including a pollution-tolerant caddisfly, midges, and a few mayflies. Another site on lower Dairy Creek also showed increased diversity (12 taxa in 1987). An upper tributary site on East Fork Dairy contained high diversity even in 1975 (14-15 genera), but seemed to be limited by available substrate (dominated by broken cement). Insects found in October 1987, including riffle beetles and net-building caddisflies, indicate less substrate limitations, though mayflies were uncommon. Less recovery was apparent in the lower river tributary sites; little change was indicated on Beaverton Creek at Highway 216, and Fanno Creek taxa were similar, though tubificid worms were no longer present and amphipods (scuds) were added. Benthic collections by USGS, made in 1992, though limited in scope, will provide current information on biological recovery at a few of these sites (R. Vaga, personal communication).

Opportunities for basin-wide monitoring are emerging. Habitat surveys conducted along with fish surveys by ODFW will provide badly needed tributary information. Beginning in fall 1992, benthic invertebrate, periphyton, and basin water chemistry surveys of 20 Tualatin River tributaries, were initiated by the Saturday Academy in conjunction with OGI, and conducted by local high schools; these studies have the potential of updating benthic community information at the watershed level. The USGS is establishing fixed stations on Fanno and at West Linn on the mainstem, where macroinvertebrates, fish and water quality tests will be collected regularly (I. Waite, personal communication). These kinds of programs should be integrated into an overall scheme to monitor basin restoration.

Biological effects of anthropogenic chemicals in the Tualatin mainstem or tributaries are poorly known. Past investigations have examined effects of toxics generated by electronic companies, but potential problems related to homeowner, agricultural, or municipality runoff have not been considered. For example, copper sulfate is routinely administered to Lake Oswego, but downstream effects on biota that are potentially affected by this chemical (*sensu* Winner and Farrell 1976) have not been measured. Cumulative effects of herbicide or pesticide treatments from a variety of sources also may influence algal and/or zooplankton numbers. Recent benthic surveys of the lower mainstem revealed severely depauperate invertebrate populations, primarily midges (R. Vaga personal communication); causation is unknown at this preliminary stage, but cumulative effects are possible. To maximize biological reduction of algae via natural populations of herbivores, management agencies must carefully consider ecological effects of chemical application on non-target organisms.

Ecological recovery of the Tualatin River will be realized when the communities and biological processes return to patterns within the historical range of ecological performance. This will require the reestablishment of native species in portions of the drainage where they occurred before human intervention altered discharge patterns, chemical composition, stream temperature, riparian forests, floodplain function, and introductions of exotic organisms. Biotic interactions profoundly shape all of these aspects of the Tualatin River ecosystem and must be integrated into our study and long-term assessment of this river basin.

Vegetation

Macrophytic and riparian vegetation distribution and abundance are known for only very localized areas within the Tualatin River basin (see USA Wastewater Facilities Plan, Appendix E.3). Though riparian species lists have been developed riparian conditions for most of the mainstem and tributaries are unknown. Examining the extent, connectedness, and composition of riparian and wetland vegetation will provide baseline information on rare and endangered species, influences of introduced species, and potential for riparian processes such as temperature control and nutrient retention. Available surveys by Lake Oswego, Friends of Jackson Bottom, and Hillsboro Landfill establish a good beginning. For example, exotic English ivy has escaped domestic gardens in Lake Oswego and is invading much of the urban riparian forest (City of Lake Oswego, 1992); reed canary grass is also a concern. Plants seeded for wetland mitigation in Hillsboro are no longer mown after management recognized the importance of grasses and herbaceous plants in wetland/floodplain function (Northwest Ecological Research Institute, 1991). Oregon statute mandates regular review of natural resources, and provides opportunity for assessment within urban areas. A pending GIS study by Metro may be able to delineate patterns of riparian and other vegetation within the urban growth boundaries. Coordinated GIS mapping for forested and agricultural areas with the Metro study could result in a basin-wide view of vegetation patterns. Examining landscape fragmentation, riparian forest continuity, floodplain features, erosion and other watershed-level characteristics with the use of aerial images will be invaluable for assessing potential Tualatin River basin restoration.

Terrestrial Biota

Global and state-wide declines of amphibians and reptiles create an urgency for discovering distribution and abundances of these animals within the Tualatin River basin. Declining numbers of riparian-dependent amphibians and reptiles probably have

resulted from a combination of factors: habitat loss, predation by exotic predators, and possibly climatic change (M. Hays, personal communication). As with the aquatic biota, thorough surveys of terrestrial plant and animal communities across the Tualatin River basin are needed. Detailed species lists have been established for Jackson Bottom and Hillsboro landfills; other records are derived from a small set of historical samples (Gordon 1939; St. John 1987), re-examination of old collections by Mark Hays, and current surveys by Dan Holland (Table 2).

The most sensitive amphibians still occurring in the Tualatin River basin are the long-toed salamander (*Ambystoma macrodactylum*) and northern red-legged frog (*Rana aurora*) (M. Hays, personal communication). Drought conditions have compressed early life stages of the northern red-legged frog, making them very susceptible to predation by non-native predators. Young frogs are non-feeding and quiescent; consequently they are vulnerable to even the small mosquitofish, *Gambusia*. Long-toed salamanders are not only vulnerable to predators early in life, they are also highly sensitive to metal ions and ammonium and to warm temperatures.

Though there are previous anecdotal records of Western pond turtles (*Clemmys marmorata*) in the Tualatin River basin these turtles may no longer occur (D. Holland, 1991). These turtles, which live more than 40 years, have suffered from loss of habitat around oxbow lakes where they formerly laid eggs on dry nesting sites. Habitat may have been marginal in the Tualatin River basin. Rechannelizing the meandering stream and other agricultural practices have severely reduced possible nesting areas. Surveys in 1991 revealed very few young and drastically diminished numbers of adult western pond turtles for the entire Willamette basin (Holland 1991).

Some organisms thrive in habitats altered by humans, whereas more sensitive species often decline. Examples of more plastic species in the Tualatin River basin are the roughskin newt (*Taricha granulosa*), Pacific treefrog (*Hyla regilla*), and ensantina (*Ensatina eschscholtzi*). Roughskin newts possess unpalatable toxins in their skin that protect them from predators; other species are invariably eaten in preference over this newt. The Pacific tree frog and ensantina are very plastic in their habitat tolerances, and both are common in this basin. In contrast seven more vulnerable amphibian species probably occurring in the upper Tualatin basin require moist, cool forested areas (Table 2), including Cope's salamander *Dicamptodon copei* listed as an Oregon sensitive species. Because very little sampling for terrestrial vertebrates has occurred in the Tualatin River basin, several species are likely to be more common than suspected, including the northern and southern alligator lizards, and sharp-tailed snake that live in grassy habitats.

Bird counts for this basin were initiated following the installation of Scoggins Dam. Seasonally regular bird surveys by volunteers at Jackson Bottom, Audubon Society and consultants at Northwest Ecological Research Institute provide good information. The most dramatic change has been a steady increase in starlings that now comprise more than half the birds counted (G. Herb, personal communication). Loss of woodlots, fence rows, and riparian corridor associated with agricultural and urban development probably contributed to declines in other bird populations. The result of wetland mitigation and enhancement, such as the active interest at Jackson Bottom, has been an increase in waterfowl nesting. The present wetland policy for the Corps of Engineers and Oregon State Lands is to manage for no net loss of waterfowl associated with wetlands. Yearly raptor counts reveal active ospreys at Scoggins Reservoir and at the confluence of the Tualatin River with the Willamette River.

Basin-wide survey information for mammals does not exist, but abundances for species of economic or recreational value can be inferred. Permits for beaver trapping are occasionally granted, presumably because there are numbers of beaver in the watershed. Raccoons, that are generally compatible with human populations, are also common (G. Herb, personal communication). Deer census are conducted in association with hunting seasons. An ecosystem perspective would not be complete without a survey for all mammals, including those that are closely associated with streams such as mink or otter, or those using riparian areas as corridors.

Though biologists from various agencies and jurisdictions on the Tualatin River have estimates of wildlife species based on scattered observations or habitat information, quantitative data for these taxa at the basin-wide scale are lacking. These larger animals and birds, as well as anadromous salmonids, must migrate through several habitats during their life histories, and will be good indicators of landscape integrity and recovery.

SOCIAL VALUES

The relationship between humans and the environment is one of constant exchange. Inevitably humans leave a strong imprint on the landscape. These modifications occur as societies find ways to produce food, find shelter, and move about their natural environment. In addition, natural ecosystems can provide an indelible aesthetic impression on humans. Records of crayfish and beaver trapping, salmonid and bass fishing, irrigation removals, and water removals for Lake Oswego demonstrate the river's potential for production. Establishing goals for what other values citizens expect from the river may be more difficult.

High quality water resources are a high priority in this urban basin. Swimmable, drinkable waters imply water free from toxic substances and reasonably low in nutrients. If these levels are achieved, will the public also want high clarity water that supports low algal growth? In this naturally low-gradient, slow-flowing stream, the standard of high clarity may be difficult to achieve. If we consider the entire Tualatin basin, reduction of upstream soil erosion, changes in seasonal discharge patterns, and improved riparian canopy may affect downstream water quality. Matching achievable goals to expectations should be an integral part of setting directions for management of the Tualatin.

An aesthetic appreciation of the river can be a sensory experience, a combination of visual, auditory, and tactile sensations. These values often extend beyond the water's edge and necessarily incorporate a landscape perspective. For example, people with access to the river, as urban landowners or recreational boaters or fishermen, may expect a cooling, shading effect from the riparian zone. Others may expect to hear the vocal chorus of birds, or chirping of frogs. These require healthy, intact corridors of riparian forest.

Plant and animal communities can be very much a part of societal values attributed to the river system. The public's perception of these resources may be the most powerful measure of desired resource conditions. Changes associated with urban growth and demand for agricultural lands, as well as unchecked introduction of exotic animals, could very easily conflict with values held for this urban river system.

RECOVERY OF THE TUALATIN RIVER BASIN

The first step for restoring the Tualatin River basin will be establishing a societal vision of the future Tualatin River. When ecological and developmental priorities are determined, then appropriate restoration measures can be identified. The river's future will depend on balancing needs of agriculture and urban growth, with ecological resources of water, soils, plant and animal life.

Our report has noted several ongoing studies that begin to fill the void of baseline information. However a coordinated effort to survey all biological groups with accompanying habitat data is needed for the basin. Stream and river access have set some traditional collection sites that could easily become monitoring locations. Regularly sampled transects also are needed for riparian and wildlife surveys. Economic and recreational values may tend to emphasize particular taxa for study, but assessing the total community will be more useful in understanding community and ecosystem processes.

Baseline biological data is needed across the basin, from headwaters to the confluence with the Willamette, and across seasons of the year. Samples should be made in sufficient replication, appropriate spatial intervals, and at adequate seasonal changes to capture the distribution and fluctuations of organisms.

Evaluation of the Tualatin River basin requires an expansive approach. Criteria for restoration must include values of longevity and stability. Because floodplains integrate long-term watershed changes rather than small fluctuations, changes in floodplain processes could provide good indicators of recovery. If floodplain restoration becomes an objective, expansive policy changes would affect stream structure, vegetation, flow regimes and ultimately biological processes.

Recovery of native biological communities also would serve as long-term indicators. As riverine functions improve organisms presently restricted to upper tributaries and uplands could be found further downstream. Changes in moisture levels, riparian forests, and wetland habitat, as well as extirpation of exotic organisms would facilitate expanded native distributions.

SUMMARY

The Tualatin Plain, one of few natural prairies of the northwest, was the original settlement site for early settlers traveling the Oregon Trail (Oregon Historical Society). For almost two centuries the Tualatin River basin has been central to colonization and productivity of the upper Willamette Valley. Aerial photos of the watershed today reveal the results of human habitation, forestry, and agriculture. At the Oregon River Council's Tualatin River Conference in May, 1992, Russell Sadler feared that "The Tualatin is a sacrifice for increased development, (a stage for) urban-rural conflict." Perhaps a more holistic, watershed-wide approach to solving problems in this basin could avert escalation of the ongoing struggle about how to manage the Tualatin River.

A landscape perspective must begin by recognizing and measuring the magnitude of landscape and riparian fragmentation across the basin. The view that this watershed is a continuum from its headwaters to the confluence with the Willamette naturally leads to a consideration of upstream physical and biological processes and downstream consequences. For example, soil erosion, nutrient releases, and increased temperatures can be initiated upstream or upslope and accumulated in downstream reaches. Many organisms that travel through different parts of the basin, such as migratory fish or raptors, depend on the integrity of the entire ecosystem for survival. Therefore basin-wide surveys of biological and physical parameters are needed to

accurately describe the current status of the basin.

Attention must be paid to geomorphic, chemical, and biological components of both aquatic and terrestrial domains. Introduction of non-native plants and animals, chemical treatments to the landscape and within the waterways, and discharge and channel alterations have had dramatic effects on biological communities within the basin. Seasonal monitoring of all trophic levels, from primary producers such as algae, to ultimate consumers in the food chain such as warmwater game fish and raptorial birds, will be needed to understand the potential effects of society's manipulations as well as fundamental biological processes operating in the Tualatin.

Keys to recovery must be measured on bases appropriate to landscape and watershed-level phenomena. A landscape perspective recognizes the stream and terrestrial environments as continua within the basin. We suggest that recovery of floodplain processes and return of native biota to more expanded ranges will be important criteria for restoration. Human residents of the Tualatin basin, holding possibly diverging values for the riverine ecosystem, must set goals that recognize how physical and biological processes operate across the landscape.

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Figure 1. Tasselecap photograph of Tualatin Basin from Landsat satellite imagery, 1988.
30 meter resolution. Dark blue = water; Light blue = Forest/trees; Red =
agricultural lands; Purple = asphalt.

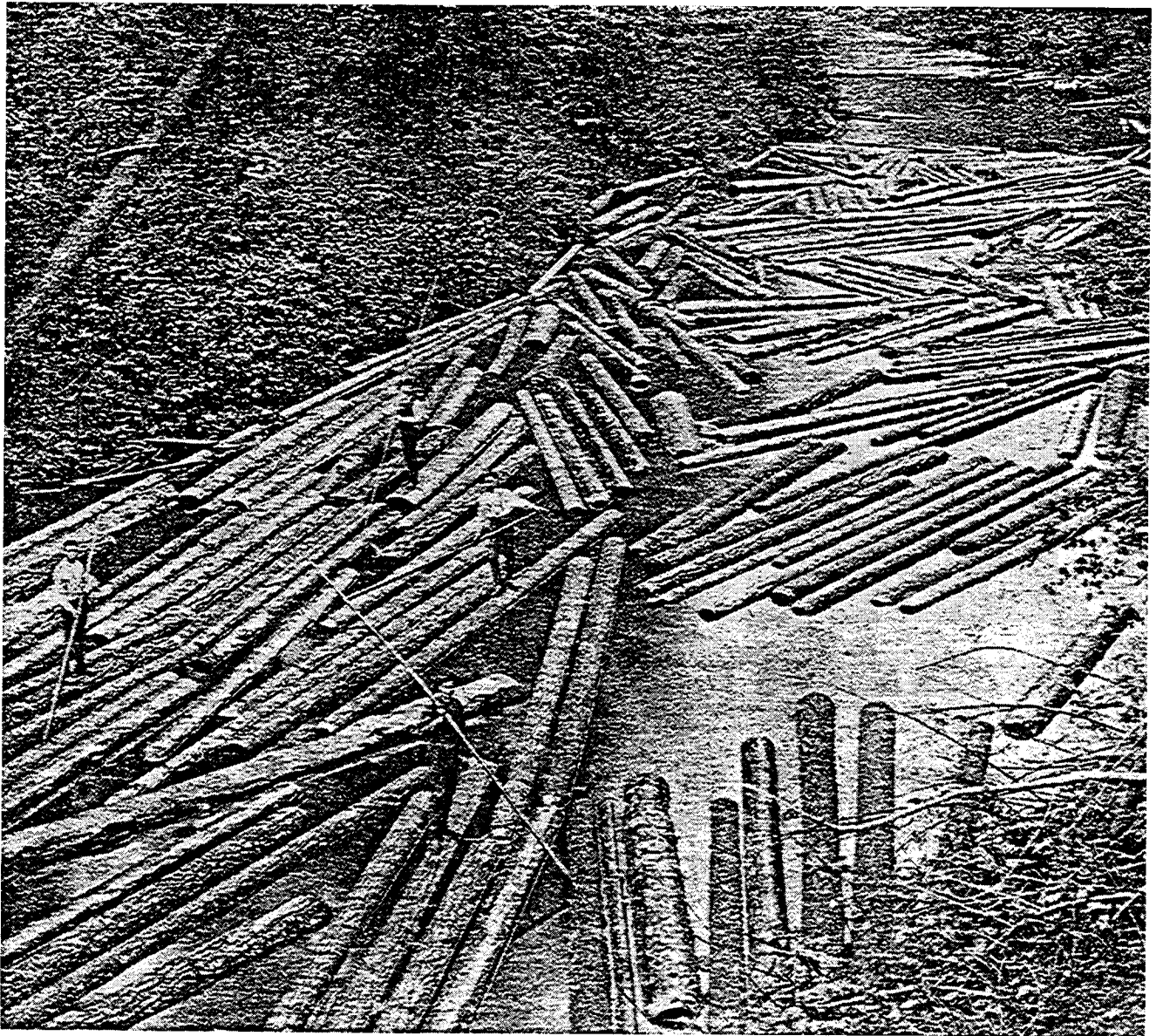


Figure 2. **Log rolling in Tualatin River as done in 1889 by Hillsboro loggers**
Photocopy from Farnell, 1978

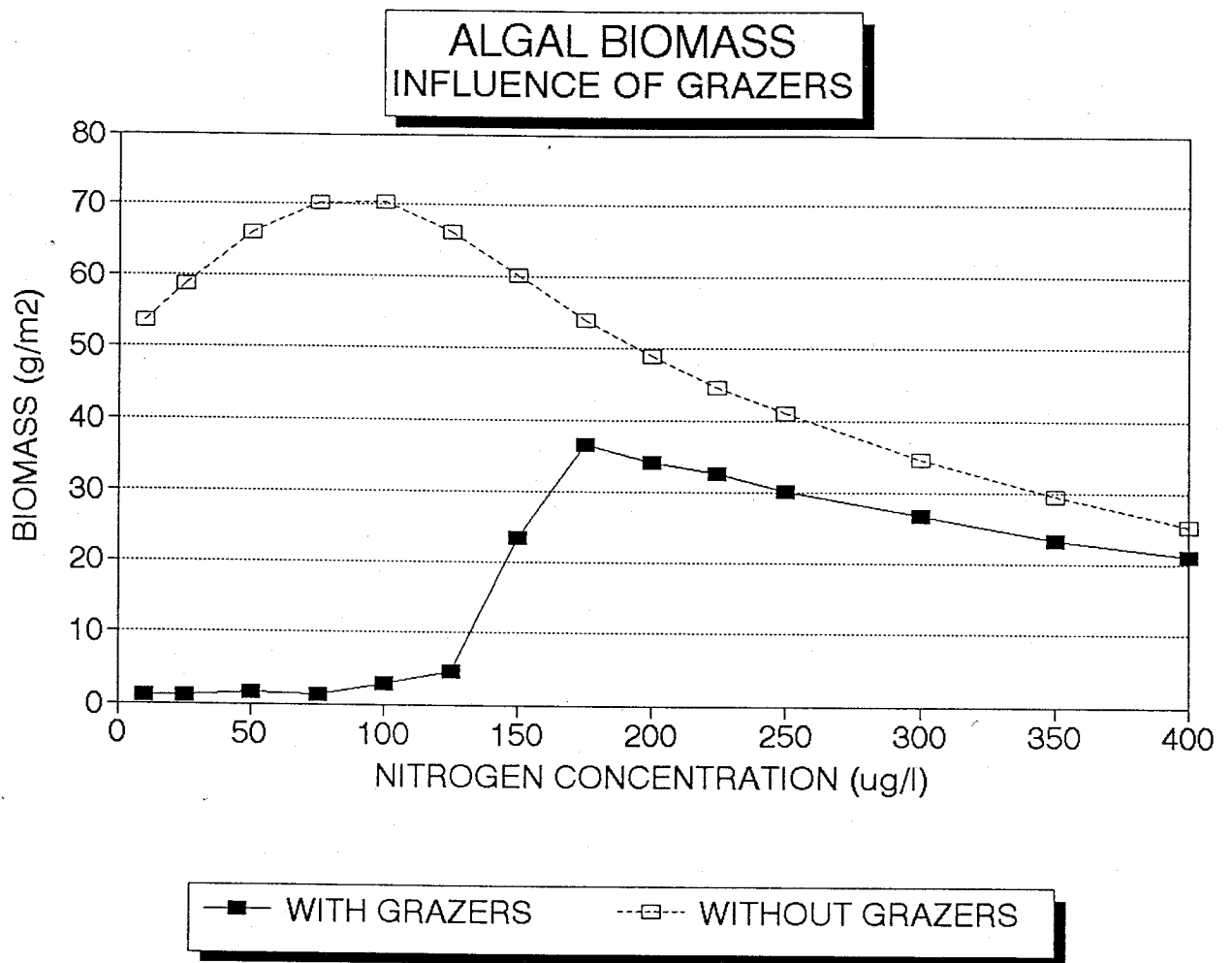


Figure 3. Stream Ecosystem Model simulation of grazer influence on algal biomass.

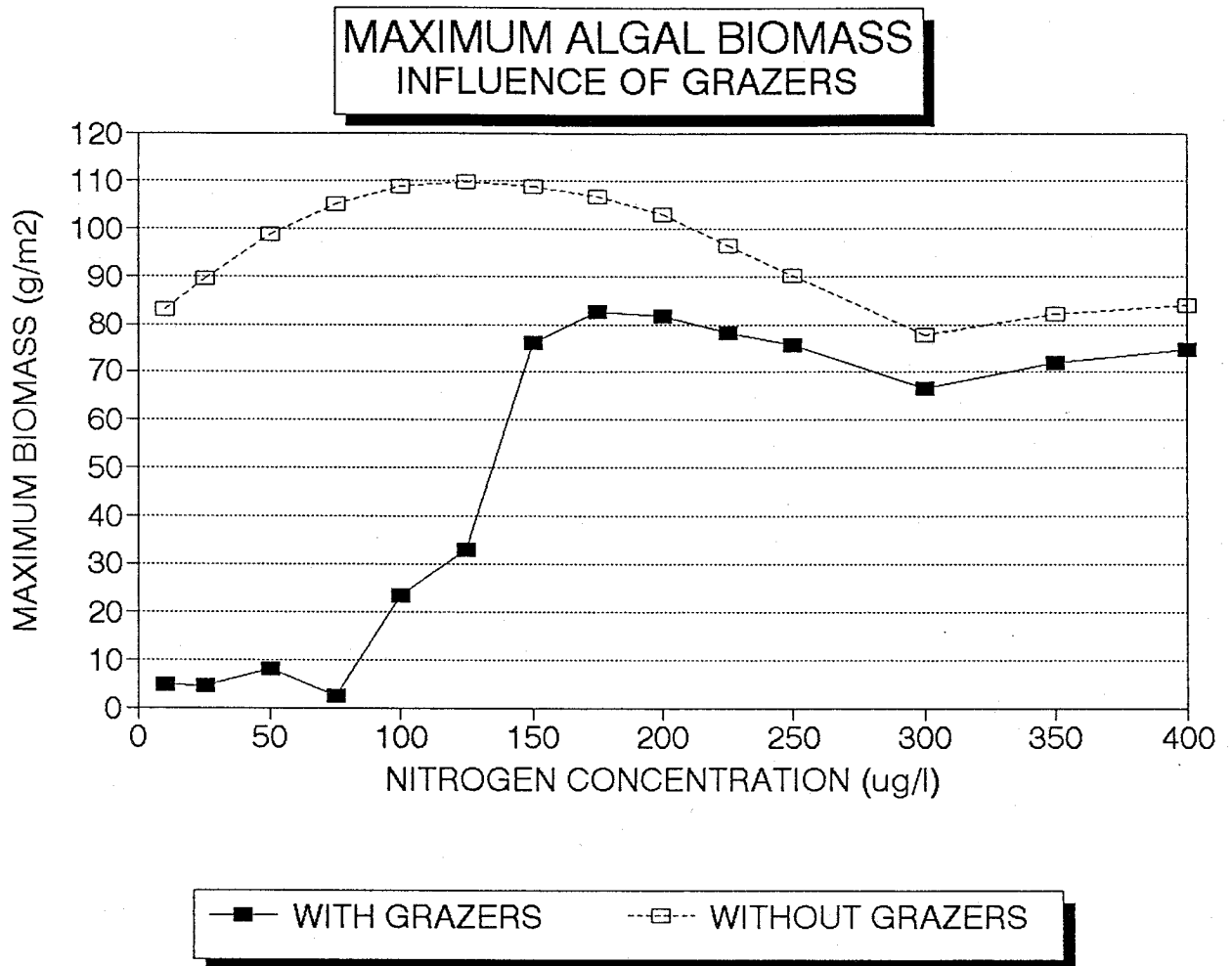


Figure 4. Stream Ecosystem Model simulation of maximum algal biomass at increasing nitrogen concentrations under the influence of stream grazers. Maximal algal biomasses are similar to Tualatin River concentrations.

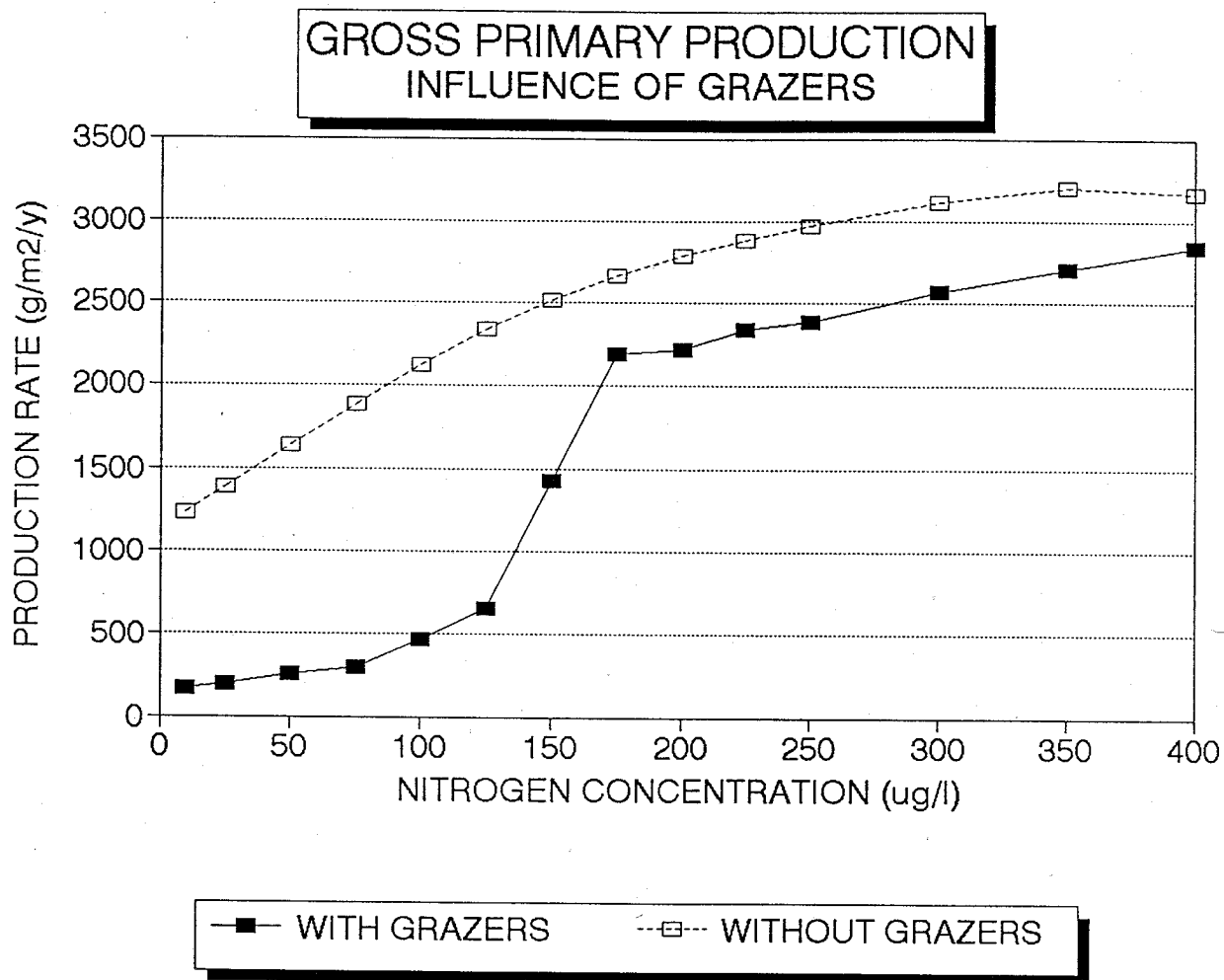


Figure 5. Stream Ecosystem Model simulation of grazer influence on gross primary production at increasing nitrogen concentrations.

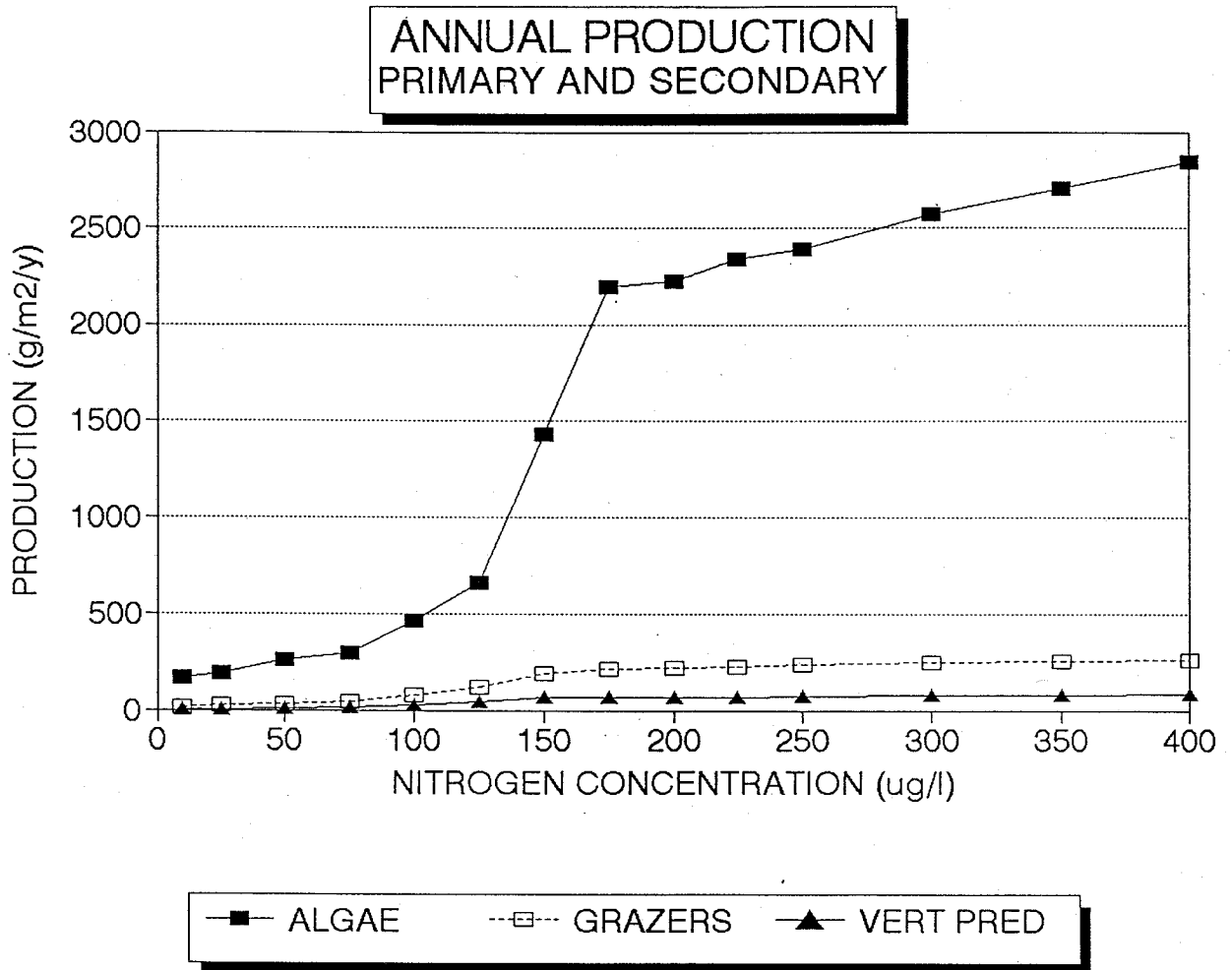


Figure 6. Stream Ecosystem Model simulation comparing total annual production of algae, grazers, and vertebrate predators at increasing concentrations of nitrogen.

Table 1. Fish Communities of the Tualatin River Basin. Based on Oregon Department of Fisheries and Wildlife surveys.

Upper River	Lower River	Upper & Lower River
Pacific lamprey	Pacific lamprey	Pacific lamprey
Western brook lamprey	Western brook lamprey	Western brook lamprey
Cutthroat trout	Cutthroat trout	Cutthroat trout
Rainbow trout	Rainbow trout	Rainbow trout
Steelhead	Steelhead	Steelhead
Coho salmon	Coho salmon	Coho salmon
Chinook salmon	Chinook salmon	Chinook salmon
	Chiselmouth	
	Peamouth	
	Northern squawfish	
	Goldfish ***	
	Common carp ***	
Redside shiner	Redside shiner	Redside shiner
Longnose dace	Longnose dace	Longnose dace
(Speckled dace)	(Speckled dace)	(Speckled dace)
Largescale sucker	Largescale sucker	Largescale sucker
Mountain sucker	Mountain sucker	Mountain sucker
	Pumpkinseed ***	
	Warmouth ***	
	Bluegill ***	
	Green sunfish ***	
	Smallmouth bass ***	
	Largemouth bass ***	
	White crappie ***	
	Black crappie ***	
	Yellow perch ***	
	Walleye ***	
	American shad ***	
Prickly sculpin	Prickly sculpin	Prickly sculpin
Reticulate sculpin	Reticulate sculpin	Reticulate sculpin
	Three-spine stickleback	
	Sand roller	
	Starry flounder	
	Banded killifish ***	
	Mosquitofish ***	
	Yellow bullhead ***	
	Brown bullhead ***	
	Channel catfish ***	
	White catfish ***	
	White sturgeon	

*** = Introduced fish; other fish are native.

Table 2. STATUS OF AMPHIBIANS AND REPTILES, TUALATIN BASIN
 AMPHIBIANS

STATUS	1984	PRIOR	HABITAT	SITE
Redlegged frog	R	X	Maple/Alder forest with lush undergrowth	Gales Glenwood
Spotted frog	R	X	Exterminated by bullfrog, maybe crop sprays	Gales
Tailed frog	R?			Upper river
Long-toed Salamander	C	X	Oak woodland; Mt coniferous forest & meadow	Lk Oswego
Western red-backed Salamander			Rocky tallus	Johnson Creek
Pacific giant Salamander			Mt, cold water	Upper Mainstem?
Roughskin Newt	C	X	Ponds, slow-moving streams	Gales
Ensatina	C	X	Rotting logs, conifers woodlands	Cherry Grv Gales

Pacific Tree Frog	C	X		Gales Cherry Grv Lk Oswego
Olympic Salamander	T	X	Mt: shady splash zone of streams; cold creeks; riparian cover	Gales
Dunn's Salamander	T	X	Mt: cool, damp places close to stream	Cherry Grv
Clouded Salamander		X	Bark of dead trees edges of fir & cedar forest	Gales
Western Toad	T?	X	Cornelius	
Bullfrog	<i>Exotic</i>	X	Sloughs, ponds, reservoirs backwaters	Hillsboro Gaston

REPTILES			HABITAT	SITE
STATUS	1984	PRIOR		
Western Pond Turtle	R	X	Quiet water: ponds, sloughs quiet rivers	Gaston Glenwood Henry Hagg Lk
Western Skink			Along streams, near Oaks, stream litter	
Western Fence Lizard	C	X	Open, sunny hillsides	Cherry Grv
Southern Alligator Lizard		X	Open, dry hillsides	Cherry Grv
Western Terrestrial Gartersnake	R	?	Upper reaches of small valleys, near streams Transition: Oak, Fir/Cedar forest	Gales Cherry Grv
Sharptailed snake	?			
Ringneck snake	?		Pocketed distribution	
Rubber Boa	C?	X	Meadow edge in conifer or oak forest	Gales
Racer	C	X	Sunny, Grass & brush	Gales Cornelius
Gopher Snake	C	X	Meadows, oak woodland & bottomlands	Cornelius Gaston

(Note: no juveniles, 1984)

Common Garter Snake	C	X	Grassy areas along streams and ponds	Cornelius Metzger Gales Glenwood Cherry Grv
Northwestern Garter Snake		X	Moist, grassy areas	Cornelius Gales Cherry Grv Gaston
Northern Alligator Lizard	T	X	Mt: forests, foothills	Cherry Grv Glenwood
Snapping Turtle	Exotic	?1992	Ponds; slow water?	Lk Oswego

Note: Information on distribution provided when locations identified; some taxa are listed based on professional judgement of herpetologists working in the region.

Key: R = Found rarely; C = Common; T = Transitional habitat; X = Probably occurring previously; ? = Occurrence questionable

Sources: M. Hays, personal communication; D. Holland, personal communication; Holland, D. 1991. A synopsis of the ecology and status of the Western Pond Turtle. Oregon Department of Fish and Wildlife
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APPENDIX I. BIOLOGICAL SURVEYS OF THE TUALATIN RIVER BASIN

A list of surveys used to develop our report. It is not exhaustive; algal surveys reported in USA Wastewater Facilities Plan are not included because they are thoroughly discussed in Appendix E. 3 of that report.

FISH

1. RANGE: Mainstem and all major tributary basins

DATE: Summer 1958 and 1959

SOURCE: Environmental survey report pertaining to salmon and steelhead in certain rivers of Eastern Oregon and the Willamette River and its tributaries. Part II: Survey reports of the Willamette River and its tributaries (June 1960)

DATA: Spawning ground survey counts of silver salmon 1952-1958
Temperatures, flow, stream conditions, obstructions.
Observations of salmonids in streams, no counts.

VALUE: Comprehensive historical stream conditions; especially valuable for tributaries. Anecdotal accounts of salmonid occurrence. No non-salmonid or warmwater fish information.

2. RANGE: Upper Tualatin mainstem, Dairy Gales and Scoggins Creeks

DATE: June 25-July 1963 (1 day samples)

SOURCE: Oregon Department of Fish and Wildlife Basin Investigations. The fish and wildlife resources of the lower Willamette basin, Oregon and their water use requirements.

DATA: Electroshocking; salmonid and non-game fish abundance

VALUE: Includes both salmonid and non-game fish counts for tributaries and upper Tualatin mainstem. Limited to one sample/year/site; all in early summer.

3. RANGE: Lower Tualatin mainstem, locations vague, possibly same as 1978 and 1980 surveys

DATE: August 24, 1976

SOURCE: Oregon Department of Fish and Wildlife Data

DATA: Gillnet counts; abundance, fork length.
Most abundant: coarsescale sucker, squawfish
Occasional: white crappie, warmouth

VALUE: Gear severely limited kinds of fish caught
River length sampled limited; restricted to 1 day/site/year.

4. RANGE: River mile 17.5 to river mile 23.4, 5 stations

DATE: August 15 1977

SOURCE: Oregon Department of Fish and Wildlife data

DATA: Electrofishing; fish abundance.

Most abundant: largemouth bass. Common: white crappie. Occasional: sculpin, bluegill, sucker, crayfish, redbreast sunfish

VALUE: Electrofishing collections emphasized warmwater fish. Report includes non-game fish counts. River length sampled limited; restricted to 1 day of sampling.

5. RANGE: Bridge at Highway 212 (about river mile 1.8) to approximately river mile 13

DATE: May 23, 1978; August 14,15, 1979; September 5, 1980.

SOURCE: Oregon Department of Fish and Wildlife data

DATA: Gillnet samples; fish abundance and lengths.

May sample: Common: steelhead, coarctate sucker. Occasional: crayfish, bluegill. August, September sample: Dominant: coarctate sucker. Common: white crappie, squawfish. Occasional: brown bullhead, rainbow trout, cutthroat trout, black crappie, carp.

VALUE: Gear selective; stream length restricted to lower mainstem; samples limited to 1 sample day/site/year.

6. RANGE: River mile 4 to river mile 20

DATE: September 22, 23 1987

SOURCE: Oregon Department of Fish and Wildlife. Draft copy, Tualatin subbasin management plan 1992

DATA: Electrofishing; game fish abundance and lengths; anecdotal information of non-game fish. Dominant: young-of-the-year largemouth bass; coarctate sucker and carp (based on approximate count). Common: bluegill, pumpkinseed, black crappie. Occasional: brown bullhead.

VALUE: Size distribution of largemouth bass indicates high mortality of young-of-the-year, then fairly constant mortality of later age classes (169 fish measured). Collections restricted to lower mainstem, only 1 sample date/year.

7. RANGE: Fanno Creek, 16 sites

DATE: August 11 and September 20, 1989

SOURCE: Oregon Department of Fish and Wildlife data

DATA: Electrofishing; most fish, also crayfish measured and counted. Speckled dace very abundant, carp common downstream; redbreast shiners common or abundant in mid-stream locations (e.g. Albertson's at Highway 10). Cutthroat trout found throughout Fanno Creek basin, especially upstream (e.g. between 39th and Albertson's at Highway 10); seem to be young-of-year and one-year old fish. Sculpin and crayfish also found in most locations.

VALUE: One of few collections made of a Tualatin River tributary. A few sites overlap between August and September. Measurements of areas sampled or temporal variations not quantified.

8. RANGE: River mile 0 to about river mile 28; spot check at river mile 26 and 28.5.

DATE: September 9 to October 4, 1991

SOURCE: Oregon Department of Fish and Wildlife data

DATA: Electrofishing; game and non-game fish counted. Length and weight of largemouth bass only. Most abundant: coarsescale sucker, young-of-the-year largemouth bass. Common: > 1 year-old largemouth bass, bluegill.

VALUE: Longer expanse of mainstem than previous samples. Emphasis on game fish. Comparable to samples taken following summer.

9. RANGE: River mile 5.5 to river mile 27 (11 stations); each site sampled once

DATE: June 9 and 30, 1992

SOURCE: Oregon Department of Fish and Wildlife data

DATA: Warmwater game fish and salmonids counted; anecdotal information on other fish. Stomachs of a few largemouth bass dissected for prey. Most abundant: coarsescale sucker, largemouth bass. Common: pumpkinseed, carp, bluegill. Occasional: cutthroat, coho, squawfish.

VALUE: Documents greater abundance of bass in lower reaches of mainstem (Kin Daily, personal communication). Consistent collecting technique over greater expanse of lower mainstem than in previous years. Early summer sample to compare with fall sample from previous year, similar sites.

10. RANGE: 10 tributaries of Middle and Lower Mainstem: Chicken, Murtagh, Hill, East Fork Dairy, Panther, Plenty, West Fork Dairy, East Fork McKay, McFee, Rock Creeks

DATE: Sept. 29-Oct 2, 1992

SOURCE: Oregon Department of Fish and Wildlife, Research Division

DATA: All fish enumerated at a few points in each tributary. Notes on riparian condition. Fish counted: cutthroat trout, steelhead trout, redbside shiner, sculpins. Data is not yet fully analyzed.

VALUE: First attempt at quantifying occurrence and abundance of fish in tributaries.

WILDLIFE

1. **RANGE:** Various point in Tualatin basin include: West Linn, Lake Oswego, Gales Creek, Cherry Grove, Cornelius, Gaston

DATE: May 1-28, 1984

SOURCE: Oregon Department of Fish and Wildlife. The herpetology of the Willamette Valley, Oregon. Alan St. John

DATA: Amphibians and reptiles; walking surveys. 1-day duration. Sitings from surveys, much of historical data anecdotal. Potential occurrence based on habitat included.

VALUE: Some identifications contested based on re-examination of museum collections; anecdotal reports of earlier observations not confirmed.

-
2. **RANGE:** Jackson Bottom

DATE: 1990-1991

SOURCE: The birds of Jackson Bottom checklist. Friends of Jackson Bottom

DATA: Weekly observations provide seasonal occurrence and abundance information. Birds and habitat described.

VALUE: Highly localized information, but very regularly scheduled observations include range of abundance; also notes occasional sightings.

-
3. **RANGE:** Hillsboro Landfill Wetlands

DATE: January, April, June, September 1991

SOURCE: Hillsboro landfill wetlands phase I monitoring annual report. Northwest Ecological Research Institute.

DATA: Quarterly wildlife census of 6 transects, 6 census points, also nest and

vegetation monitoring.

Enumerated 2 amphibian, 69 bird, 4 mammal and 2 fish species during regular census; 2 reptile, 10 bird and 3 mammal species added as casual observations.

VALUE: Regular, systematic and repeated surveys. Identifies limiting factors for low numbers of amphibians and reptiles. Discusses impact of management activities, especially mowing planted vegetation, on wetland recovery. Localized to landfill, but documents potential for floodplain restoration as mitigation effort. Accompanying water quality information for wetland and river will be necessary to understand mitigation success.

INVERTEBRATES

1. RANGE: 13 Tributaries: Scoggins, Gales, McKay, Dairy, Rock, Beaverton, Hall, Messenger, Cedar Mill, Willow, Chicken, Fanno

DATE: spring & summer 1975, 1976

SOURCE: Department of Environmental Quality. A biological assessment of the major tributaries of the Tualatin River using macroinvertebrates 1975-1976. Authorship uncertain: Sutherland or E. Quan.

DATA: Benthic samples, technique unknown. Qualitative data on benthic invertebrate occurrence (described as orders); substrate characterization.

Upper Tributaries: Upper Gales high diversity (14-17 genera); Scoggins and lower Gales dominated by bedrock, lower invertebrate diversity (8-10 genera). Taxa: Mayflies, stoneflies, caddisflies, midges, blackflies, and snails.

Middle Tualatin tributaries: Upper McKay, upper East Fork Dairy: moderately fast flowing streams with fair diversity (10-15 genera) including mayflies, caddisflies, true flies, stoneflies. Worms dominant at Upper McKay. Many downstream sites (e.g. lower Rock, Beaverton, and Cedar Mill Creeks) affected by siltation, chemical toxicity, sewage outfall. Silty sites contained clams, worms, scuds, and alderflies; chemically affected sites contained only Tubifex worms and midges.

Lower Tualatin tributaries: Upper Chicken Creek: good diversity (12 genera), but downstream more limited. Fanno: upstream fairly diverse, included midges, worms, snails, scuds and crayfish; downstream highly polluted, depauperate.

VALUE: Useful historical information, but not quantitative. Comparisons of upstream with downstream reaches reveal impact of high nutrient loads and chemical toxicities. Specific taxa and abundances would provide best indicators.

2. RANGE: Tualatin River mainstem: 7 locations.

DATE: September 2 through October 6 1987

SOURCE: Department of Environmental Quality data.

DATA: Artificial substrate baskets. Benthic invertebrate abundance (identified to

family or genus); substrate characterization.

Diversity: 4-11 taxa

Dominant: amphipod (*Gammarus*), midge (Chironominae, Orthocladinae).

Common: mayfly (*Paraleptophlebia*), oligochaetes

VALUE: Collection technique selective. Because sand was the dominant river substrate, baskets selected for invertebrates inhabiting larger substrates; some taxa were not obtained. Limited to autumn, low flow and precluded the collection of short-lived taxa that may have occurred in other seasons of the year.

3. RANGE: 8 tributary sites: Dairy, East Dairy, Rock, McKay, Fanno and Beaverton Creeks.

DATE: October 7th and 12th, 1987.

SOURCE: Department of Environmental Quality data.

DATA: Kick net samples; benthic macroinvertebrates abundance (family or genus identified).

Diversity: 8-15 taxa.

Dominant: oligochaetes, midges, net-spinning caddisfly (*Cheumatopsyche*).

Common: isopod (*Asellus*)

Below Tektronix: Low diversity: 3-4 taxa.

Dominant: amphipod (*Gammarus*), oligochaetes

VALUE: Limited number of streams; only 2 replicates per site inadequate for sampling organisms that are likely to be highly patchy in distribution. More efficient sampling than artificial baskets. Describes potential effects of Tektronix plant.