FINAL REPORT

ASSESSMENT OF MACROINVERTEBRATE COMMUNITIES OF THE TUALATIN RIVER BASIN

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EXECUTIVE SUMMARY

- Aquatic life in the Tualatin River Basin has likely undergone substantial change as human influence has altered water quality, physical habitat, and hydrology for more than 100 years. The objective of this study was to determine the condition of macroinvertebrate communities in tributaries to the Tualatin River. Macroinvertebrate communities were sampled from 44 sites on 22 tributaries of the Tualatin River. A modified multimetric index was used to determine the condition of the macroinvertebrate community at each study site.
- The condition of macroinvertebrate communities varied widely among stream reaches in the basin. A number of rural streams in forested areas (upper Chicken Creek, upper Dairy Creek, and Roaring Creek) had diverse communities well represented by mayflies, stoneflies, caddisflies, and other more sensitive species. These reaches were used as reference sites against which other sites were compared. Urban streams generally showed the highest levels of impairment relative to reference conditions. Mayflies, stoneflies, caddisflies, and other sensitive taxa generally were absent from the most impaired urban reaches.
- This study provides the first comprehensive set of data describing macroinvertebrate communities in the Tualatin River Basin. The data can help prioritize future restoration efforts and serve as baseline information to help assess further degradation or future improvement of stream reach conditions.

TABLE OF CONTENTS

EXECUTIVE SUMMARY i
LIST OF FIGURES iii
LIST OF TABLES iii
LIST OF APPENDICES iv
ACKNOWLEDGEMENTS iv
INTRODUCTION 1
STUDY AREA 1
METHODS 3
    FIELD DATA COLLECTION 3
    SAMPLE SORTING AND MACRO-INVERTEBRATE IDENTIFICATION 4
    QUALITY ASSURANCE 4
    DATA ANALYSIS 4
RESULTS 6
DISCUSSION 13
LITERATURE CITED 15

LIST OF FIGURES

Figure 1. Mean overall condition ranks (OCRs) of macroinvertebrate communities sampled from 44 sites in tributaries to the Tualatin River, Oregon, during fall 2000. 6

Figure 2. Mean metric scores (+ 1 SD) of macroinvertebrate communities sampled from reference sites, rural sites, and urban stream sites in the Tualatin River Basin, Oregon, during fall 2000. 9

Figure 3. Relationship between individual positive metrics and overall condition rank of macroinvertebrate communities at each of 44 sites in the Tualatin River Basin, Oregon, sampled during fall 2000. 10

Figure 4. Relationship between individual negative metrics and overall condition rank of macroinvertebrate communities at each of 44 sites in the Tualatin River Basin, Oregon, sampled during fall 2000. 11

Figure 5. Relationship between number of sensitive and sediment sensitive taxa to overall condition rank of macroinvertebrate communities at each of 44 sites in the Tualatin River Basin, Oregon, sampled during fall 2000. 12

LIST OF TABLES

Table 1. Macroinvertebrate sampling locations in the Tualatin Basin, Oregon fall 2000. 2

Table 2. Metric set used to assess condition of macroinvertebrate communities in the Tualatin River Basin, Oregon, sampled during fall, 2000. 5

Table 3. Overall condition ranks of macroinvertebrate communities sampled from forty-four sites in the Tualatin River Basin, Oregon, during fall 2000. 7

LIST OF APPENDICES

Appendix 1. Study sites for the Tualatin Basin Tributary Macroinvertebrate Study, 2000.....16

Appendix 2. Metric scores of macroinvertebrate communities at each of 44 sites sampled in the Tualatin River Basin, Oregon, during fall 2000. 23

Appendix 3. Metric score ranks of macroinvertebrate communities at each of 44 sites sampled in the Tualatin River Basin, Oregon, during fall 2000. 26

Appendix 4. Water chemistry data collected during fall 2000 macroinvertebrate surveys of the Tualatin River Basin, Oregon. 29

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INTRODUCTION

The Tualatin River Basin has undergone steady agricultural, forestry, industrial, and urban development for more than 100 years. This steadily increasing human influence on the basin has degraded the water quality and physical habitat of surface waters, and has altered the hydrology of the basin. As a result, substantial changes have likely occurred to aquatic communities. Despite the likely effects that development has had on fish and macroinvertebrate communities in the basin, little was known of the status or species composition of aquatic communities until recently because monitoring in the basin has largely been limited to water quality testing. Intensified concerns over clean water and imperiled salmonid populations in northwest Oregon have spurred efforts to better understand how well surface waters of the basin are supporting aquatic life. The Oregon Department of Fish and Wildlife (ODFW) initiated surveys of fish communities in tributaries of the Tualatin River within the Urban Growth Boundary (UGB) in 1995 (ODFW 1995). In 2000, the second year of basin-wide surveys, ODFW expanded coverage to a number of rural streams outside of the UGB.

Assessing macroinvertebrate communities has gained wide acceptance as a reliable and meaningful tool for measuring the condition of surface waters. Because these biological communities integrate the effects of multiple stressors—excess nutrients, toxic chemicals, increased temperature, excessive sediment loading, and others—they provide a reliable measure of the overall ability of a water body to support aquatic life.

Little information regarding the condition of macroinvertebrate communities exists for the Basin. In recent years, studies of macroinvertebrate communities have been limited in scope and coverage, and have likely been conducted using a number of different methods.

Recent studies in the upper Tualatin/ Scoggins Creek watershed (Cole et al. 1999), as well as sampling in upper Gales Creek, indicate that macroinvertebrate communities in less-developed forested areas of the upper basin remain diverse and relatively undisturbed. Conversely, macroinvertebrate communities in the middle reaches of Council Creek were low in diversity and not well represented by sensitive taxa (Cole 1999, unpublished data). These observations support the concern that macroinvertebrate communities have been substantially altered throughout much of the Basin, and that these changes are likely to be most pronounced in more developed areas.

The objective of this study was to determine the condition of macroinvertebrate communities in tributaries to the Tualatin River throughout the Basin. This study represents the first comprehensive assessment of macroinvertebrate communities in the Basin. The information will be used by water resource managers to help prioritize restoration efforts, and as baseline data to help determine the effects of restoration projects in years to come. The continued monitoring of macroinvertebrate communities will assist measuring long-term trends in the biological condition of surface waters in the Tualatin River Basin.

STUDY AREA

The Tualatin River Basin is located primarily in Washington County, Oregon, with small areas extending into Multnomah, Yamhill, and Clackamas Counties. The Basin generally drains in a southeasterly direction, with headwaters occurring as far west as the eastern slopes of the Oregon Coast Range. The Tualatin River empties into the Willamette River at river kilometer 46.1, just west of Oregon City. Along its course from the Coast Range to the Willamette River, the Tualatin River and its tributaries exhibit a number of physical and hydrologic changes. These changes are due, in part, to the naturally-occurring physiographic variation that occurs in the area, but have been exacerbated by human settlement in the Basin.

Streams occurring farther east of the Coast Range, in the Willamette Valley, are generally characterized by low gradient, heavy sediment loading, seasonal flooding, temperature extremes, and low habitat heterogeneity (ODFW 1995). Streams on the east slopes of the Coast Range and in areas of more topographic relief elsewhere in the western portion of the Basin are characterized by higher gradients, larger and more heterogeneous substrate, and more heterogeneous habitat. Streams representing a wide range of physical conditions and levels of human influence were included for sampling in this study. We sampled from a total of 44 sites: two on each of 22 tributaries of the Tualatin River, ranging from the east slopes of the Coast Range, to the lower portions of the Basin near the River's confluence with the Willamette River (Table 1).

Table 1. Macroinvertebrate sampling locations in the Tualatin Basin, Oregon fall 2000.

Stream	Reach	Macroinvertebrate Sampling Location
Hedges Creek	Lower	In Tualatin Hills park along Boones Ferry Road
	Upper	105th Street to 489 meters upstream
Fanno Creek	Lower	In Durham City Park
	Upper	39th Street to 404 meters downstream
South Rock Creek	Middle	Highway 99W to 300 meters upstream
	Upper	Tualatin-Sherwood Road to Oregon Street
Chicken Creek	Lower	Mouth to 585 Meters upstream
	Upper	Kruger Road to 285 meters upstream
Butternut Creek	Lower	Mouth to River Road
	Upper	Farmington Road to Oak Street
Rock Creek	Lower	Mouth to River Road
	Upper	Tributary crossing at Rock Creek Road to 400 meters upstream
Dairy Creek	Middle	Roy Road to railroad bridge
	Upper	Greener Road to Little Bend Park
Cedar Creek	Middle	Meineke Road to 599 meters upstream
	Upper	Rein Road to 400 meters downstream
Summer Creek	Lower	Mouth to Fowler Junior High School
	Upper	135th Street to Old Scholls Ferry Road
Ash Creek	Lower	Mouth to Highway 217
	Upper	Taylors Ferry Road to 765 meters upstream
Dawson Creek	Lower	Mouth to Baseline Road
	Upper	Airport Road to Shute Road
Beaverton Creek	Lower	Mouth to 216th Street
	Middle	185th Street to 170th Street
Bronson Creek	Middle	Cornell Road to Bronson Road
	Upper	Laidlaw Road to 445 meters downstream

Table 1. (Continued).

Stream	Reach	Macroinvertebrate Sampling Location
Cedar Mill Creek	Middle	Jenkins Road to 800 meters upstream
	Upper	113th Street to 500 meters upstream
Johnson Creek	Lower	Mouth to Division Street and 149th Street
	Upper	170th Street to 175th and Riegert Road
Christensen Creek	Lower	At Route 219 Bridge
	Upper	Above pond upstream of Dixon Mill Road
Burris Creek	Middle	Along SW Laurel Road below Laurel Community Church
	Upper	Above falls upstream of SW Stickney Road
Roaring Creek	Lower	Just above confluence with Tualatin River
	Middle	1st road crossing along Roaring Ck. Rd. abv. confluence w/ Tualatin River
Ayers Creek	Middle	Upstream of 1st road crossing along Dopp Road
	Upper	Immediately upstream of NE Albertson Road
Council Creek	Upper	Upstream side of Route 47 road crossing
	Middle	Downstream of pond on Oregon Roses, Inc. property

METHODS

FIELD DATA COLLECTION

Between 8 September and 5 October, 2000, we sampled macroinvertebrate communities and water chemistry at 44 sites in the Tualatin River Basin (site photos in Appendix 1). We conducted this study using the Level 3 sampling protocols, as described in the Stream Macroinvertebrate Protocol, Chapter 12, Water Quality Monitoring Guide Book, Oregon Plan for Salmon and Watersheds (WQIW 1999). At each of the 44 sampling sites, we first selected two areas of the same habitat type from which samples would be collected. We collected samples only from glide habitat (i.e. habitat characterized by an even, laminar flow with little or no turbulence) because this is the most common stream habitat type in the basin. We also wanted to avoid comparing samples from different habitat types because an additional and potentially large source of variation would be introduced into the data set, making comparisons of macroinvertebrate communities among streams less certain.

From each of two glides at each site, we randomly selected two instream sampling points using a random numbers table. Two four-digit numbers were selected: the first two digits represented the percent distance upstream through the glide and the second two digits represented the percent of stream width across the channel. In reaches where only one continuous glide was present, we randomly selected four instream sampling points from within this single habitat unit. A D-frame kick net (12-in wide, 500-µm mesh opening) was then used to collect macroinvertebrates from a 30 x 60 cm (1 x 2 ft) area at each of these sampling points. Larger substrates, when present, were first hand washed inside the net, then placed outside of the sampled area. The area was then thoroughly disturbed by hand (or by foot in deeper water) to a depth of 5-10 cm.

In areas with little or no discernible streamflow, the kick net was pulled back and forth through the water column over the disturbed area to collect suspended materials.

The four samples were placed into a 500-µm sieve and carefully washed to remove larger substrate and leaves after inspection for clinging macroinvertebrates. The composite sample was then placed into one or more 1-L polyethylene wide-mouth jars, labeled, and preserved with 70% isopropyl alcohol for later sorting and identification at the laboratory.

Following macroinvertebrate sample collection at each site, we collected the following water chemistry data: pH, temperature, dissolved oxygen, and conductivity. Temperature, dissolved oxygen, and conductivity were measured in the field using a YSI Model 85 water chemistry meter. We measured pH in the field with an Oakton pHTestr 3. No physical habitat data were collected.

SAMPLE SORTING AND MACRO-INVERTEBRATE IDENTIFICATION

Samples were first sorted to remove a 500-organism subsample from each original, preserved sample, following the procedures described in the Level 3 protocols (WQIW 1999) and using a Caton gridded tray, as described by Caton (1991). We first emptied the contents of the sample onto the gridded tray, then floated the sample to evenly distribute the sample matrix across the tray. We then randomly selected squares from the 30-square gridded tray, placed the contents of each square onto a petri dish, and sorted aquatic macroinvertebrates from the sample matrix under a dissecting microscope at 7-10X magnification. Macroinvertebrates were removed from each sample until at least 500 organisms were counted, or until the entire sample had been sorted. Following sample sorting, I identified all macroinvertebrates to the level of taxonomic resolution recommended for Level 3 macroinvertebrate assessments (WQIW 1999). Aquatic insects were keyed using Merritt and Cummins (1996). Other invertebrates were keyed using Pennak (1989).

QUALITY ASSURANCE

Following Level 3 protocols (WQIW 1999), we collected duplicate composite samples at 10% (four samples) of the sampled sites in the field. These samples were compared to ascertain within-site sample variability, and to determine what effect this variability might have on the results. We also resampled from 10% (four samples) of the 44 composite samples to determine how variability might be introduced by the laboratory sample processing protocols.

DATA ANALYSIS

We analyzed the data using a modified multimetric analysis. This approach employs a set of metrics, each of which describes an attribute of the macroinvertebrate community that is known to be responsive to one or more types of pollution or habitat degradation. Because metrics generally vary in their scale and because they can be integers, percentages, or ratios, scoring criteria are normally used to transform metric scores into a set of unitless scores on a standardized scale (EPA 1997). However, the scoring criteria described in the macroinvertebrate sampling protocols (WQIW 1999) were developed for use with riffle (erosional) samples; scoring criteria have not yet been developed for sampling from glide (depositional) habitats in western Oregon streams, which were sampled for this study (Daria Mochan and Rick Hafele, DEQ, personal communication). Accordingly, we did not employ scoring criteria to avoid producing biased multimetric scores. As an alternative approach for scoring the sites, we selected a set of 10 metrics that: 1) included attributes identical or similar to those listed in the macroinvertebrate sampling protocols; 2) have been previously used by DEQ in depositional habitats (Hubler 2000); and 3) provided a range of values that allowed sites to be ranked with few ties (e.g. scored on a percentage scale, rather than integers with only a few possible values; Table 2). The only metrics likely requiring some explanation of their names or relevance are the Modified Hilsenhoff Biotic Index (HBI) and Percent EPT. The Modified HBI, originally developed by Hilsenhoff (1982), is a measure of a taxon's sensitivity to organic enrichment. Index scores range from 1 to 10; lower scores indicate higher sensitivity. Percent EPT is the combined abundance of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) in a sample, expressed as the percent of total individuals in the sample.

Table 2. Metric set used to assess condition of macroinvertebrate communities in the Tualatin River Basin, Oregon, sampled during fall, 2000.

Metric	Response to Disturbance
Taxa Richness	Decreases
Percent Ephemeroptera (mayflies)	Decreases
Percent Plecoptera (stoneflies)	Decreases
Percent Trichoptera (caddisflies)	Decreases
Percent EPT[1] (all three orders)	Decreases
% Dominance (by 1 taxon)	Increases
% Dominance (by 3 taxa)	Increases
Percent Tolerant Taxa	Increases
Percent Sediment Tolerant Taxa	Increases
Modified HBI[2]	Increases

[1] Percent EPT = combined abundance of Ephemeroptera, Plecoptera, and Trichoptera
[2] Modified HBI = Modified Hilsenhoff Biotic Index

We first calculated each metric for each site (e.g. the number of mayflies or sediment-tolerant individuals in each sample). We then ranked the 44 sites based on scores they received for each of the 10 metrics. Five of these metrics are termed "positive metrics", indicating that communities in better condition receive higher scores for these metrics. Five of the selected metrics are "negative metrics," meaning that communities in worse condition receive higher scores. To maintain consistency, the ranking system was designed so that larger ranks were assigned to both high positive metric scores and to low negative metric scores. We then calculated the mean rank for each site, which hereafter is referred to as the overall condition rank (OCR).

Using these OCRs, we selected the four sites (~10% of the sample) receiving the highest ranks to serve as reference sites against which the other sites in the basin could be compared. In cases where the highest scoring sites either were, or had, duplicate samples, the mean OCR of the two samples was used to determine the site's rank. The mean and standard deviation of each metric was calculated for these reference sites, for all rural sites, and for all urban sites, to determine, at a coarse scale, how specific community attributes respond to increasing levels of human influence in the basin.

Further analysis of the sites in the study was conducted using a second set of two metrics that is also known to be responsive to degree of human influence. These two additional metrics were the number of sensitive taxa and the number of sediment-sensitive taxa. We conducted this additional analysis with these metrics because both metrics are commonly used in multimetric evaluations of macroinvertebrate communities in Oregon, and we wanted to further evaluate how human influence has changed macroinvertebrate communities in the Tualatin River Basin.

RESULTS

The 44 sites exhibited a wide range of overall condition ranks (Figure 1). OCRs ranged from 34.6 (best score) to 2.9 (worst score), indicating that the condition of macroinvertebrate communities varies widely among stream reaches in tributaries to the Tualatin River (Table 3). Upper Dairy, Upper Chicken, and Middle and Upper Roaring Creek sites received the highest four OCR scores and were used as reference sites for subsequent analyses.

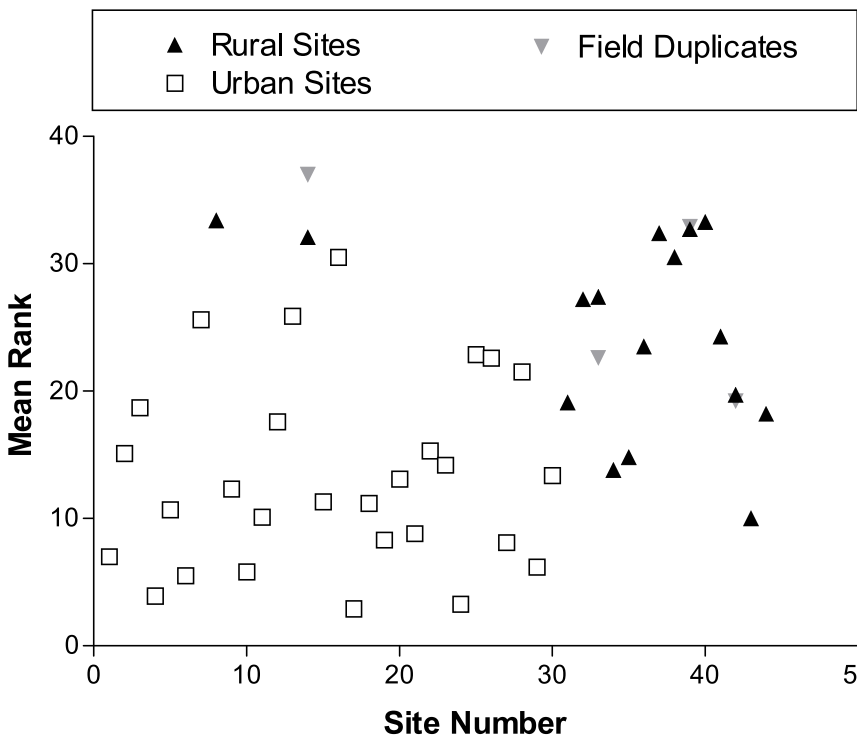

Figure 1. Mean overall condition ranks (OCRs) of macroinvertebrate communities sampled from 44 sites in tributaries to the Tualatin River, Oregon, during fall 2000.

Table 3. Overall condition ranks of macroinvertebrate communities sampled from forty-four sites in the Tualatin River Basin, Oregon, during fall 2000. Higher scores indicate sites with communities in better condition. (R = rural land use, U = urban land use).

Site	Land Use	Overall Condition Rank
Upper Dairy Creek	R	34.6
Upper Chicken Creek	R	33.4
Middle Roaring Creek	R	33.3
Lower Roaring Creek	R	32.8
Upper Burris	R	32.4
Upper Cedar Creek	U	30.5
Middle Burris Creek	R	30.5
Upper Baker	R	27.2
Middle Dairy Creek	U	25.9
Lower Chicken Creek	U	25.6
Lower Heaton Creek	R	25.0
Middle Ayers Creek	R	24.3
Upper Christensen Creek	R	23.5
Middle Bronson Creek	U	22.9
Upper Bronson Creek	U	22.6
Upper Cedar Mill Creek	U	21.5
Upper Ayers Creek	R	19.5
Lower Baker Creek	R	19.1
Lower Fanno Creek	U	18.7
Middle Council	R	18.2
Upper Rock Creek	U	17.6
Upper Dawson Creek	U	15.3
Upper Hedges Creek	U	15.1
Lower Christensen Creek	R	14.8
Lower Beaverton Creek	U	14.2
Upper Johnson Creek	U	13.4
Upper Ash Creek	U	13.1

Table 3. (Continued).

Site	Land Use	Overall Condition Rank
Lower Butternut Creek	U	12.3
Middle Cedar Creek	U	11.3
Upper Summer Creek	U	11.2
Middle South Rock Creek	U	10.7
Lower Rock Creek	U	10.1
Upper Council	R	10.0
Lower Dawson Creek	U	8.8
Lower Ash Creek	U	8.3
Middle Cedar Mill Creek	U	8.1
Lower Hedges Creek	U	7.0
Lower Johnson Creek	U	6.2
Upper Butternut Creek	U	5.8
Upper South Rock Creek	U	5.5
Upper Fanno	U	3.9
Middle Beaverton Creek	U	3.3
Lower Summer Creek	U	2.9

Comparison of mean individual metric scores among reference sites, rural sites, and urban sites showed a clear pattern of decreasing positive metric scores and increasing negative metric scores with increasing human influence (Figure 2). Mean percent dominant (one taxon), percent dominant (three taxa), modified HBI, percent sediment tolerant, and percent tolerant scores all increased from reference, to rural, to urban sampling sites. In a similar manner, mean percent Ephemeroptera, percent Plecoptera, percent Trichoptera, percent EPT, and taxa richness all decreased from reference, to rural, to urban sampling sites. Generally, most urban stream sites scored considerably lower than reference sites in each of the ten metrics.

Each of the five positive metrics exhibited a clear relationship with overall condition ranks (Figure 3). Mayflies, stoneflies, and caddisflies were generally absent from the most degraded sites in the basin, including Lower Summer Creek, Middle Beaverton Creek, Upper Fanno Creek, Upper Butternut Creek, Lower Johnson Creek, and Lower Hedges Creek (Appendix 2). Conversely, these three insect orders represented 38-72% of the sampled communities from reference sites. Taxa richness clearly declined with lower overall condition rank; at the most disturbed sites (i.e., lowest OCRs), taxa richness ranged from 9 to 22, while at reference sites, it ranged from 27 to 40.

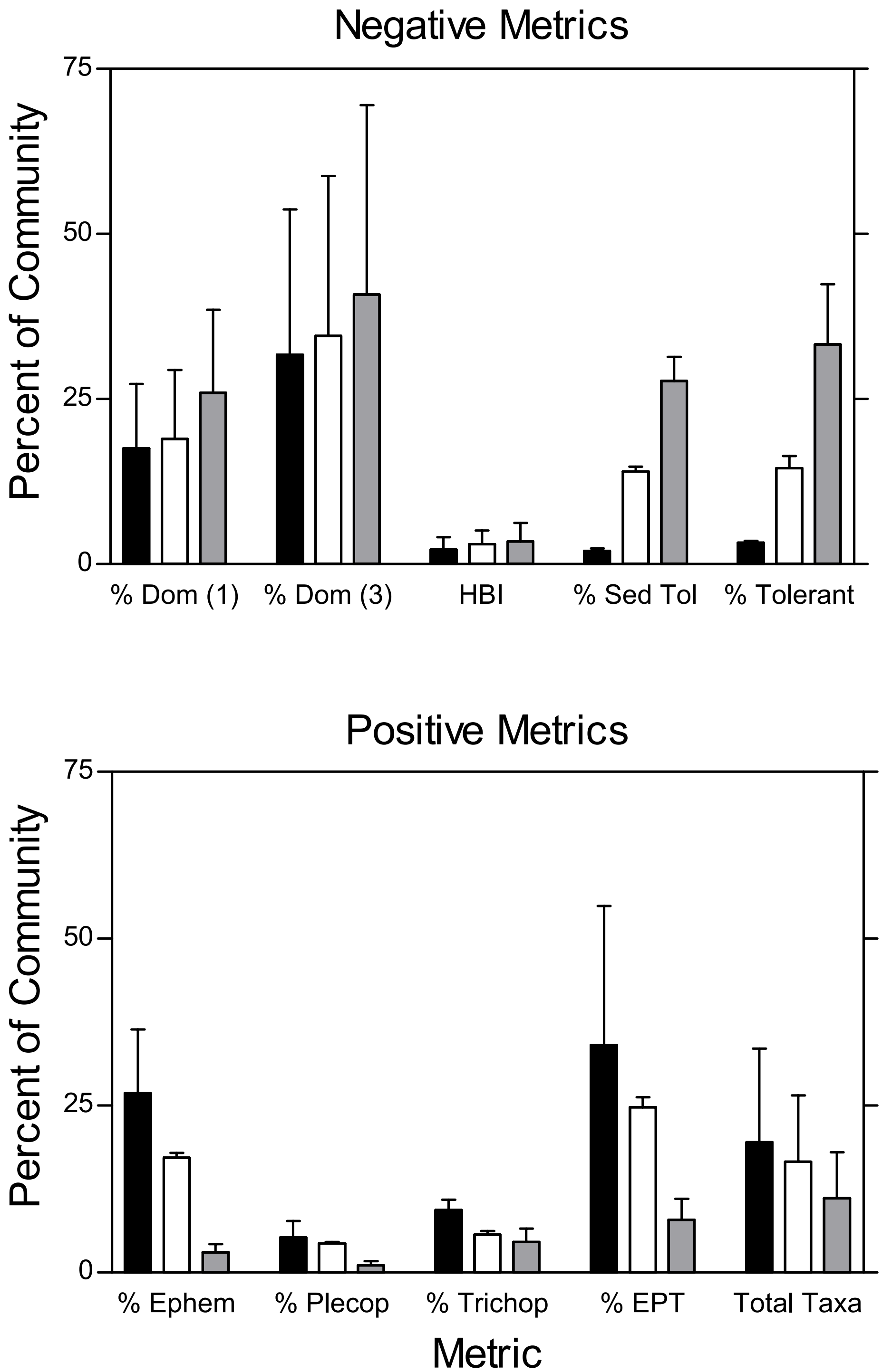

Figure 2. Mean metric scores (+ 1 SD) of macroinvertebrate communities sampled from reference sites, rural sites, and urban stream sites in the Tualatin River Basin, Oregon, during fall 2000.

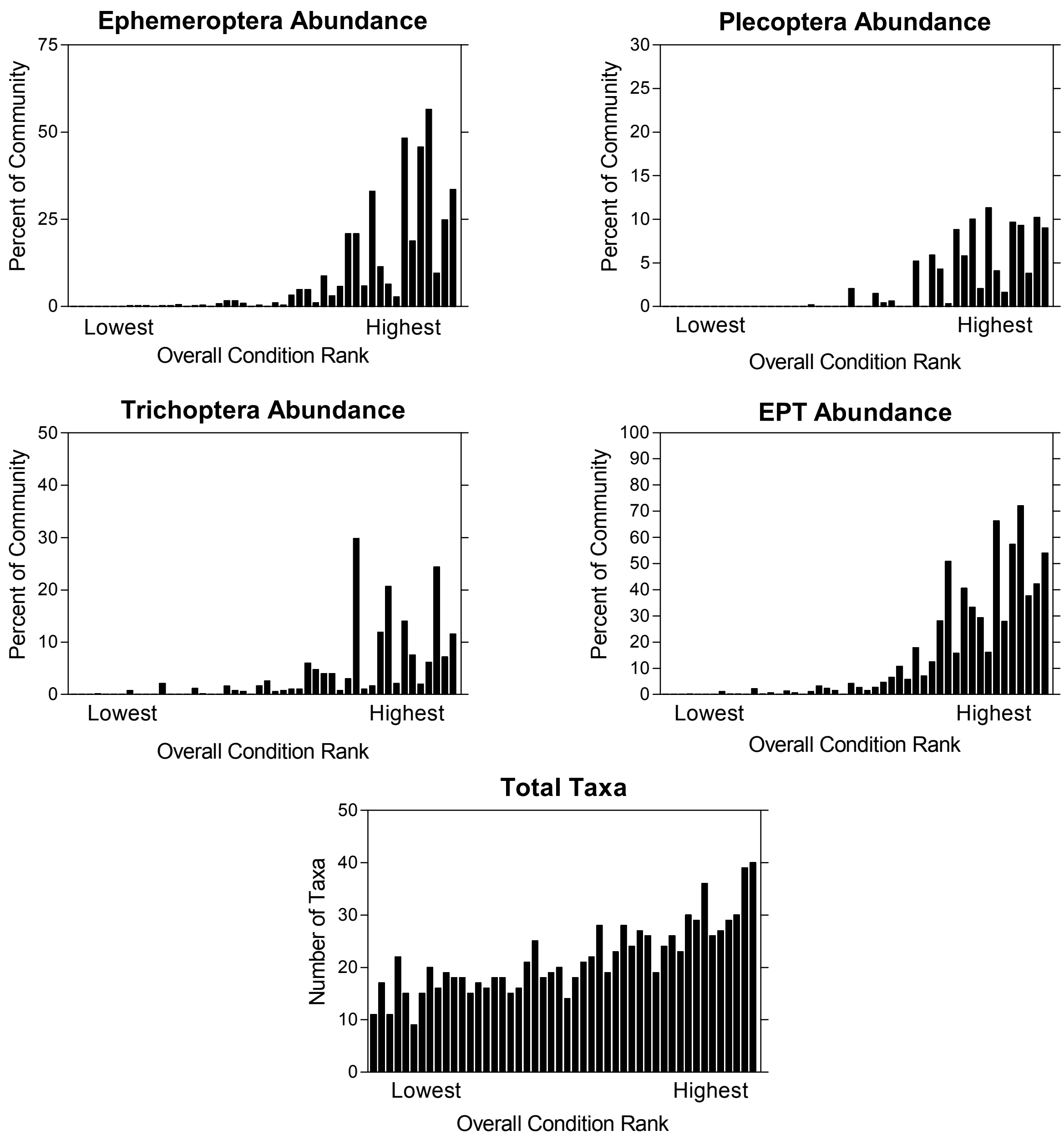

Figure 3. Relationship between individual positive metrics and overall condition rank of macroinvertebrate communities at each of 44 sites in the Tualatin River Basin, Oregon, sampled during fall 2000.

Negative metrics also showed a clear relationship with OCRs (Figure 4). Communities at more disturbed sites (based on OCR) were generally dominated by fewer taxa (as measured by both of the dominance metrics: that indicating percent composition by the single most-abundant taxon and that indicating percent composition by the three most-abundant taxa). Sediment tolerant macroinvertebrates at heavily disturbed sites represented as much as 82% of the community, whereas percent sediment tolerant individuals ranged from only 0.5 to 5.5 at reference sites. Likewise, tolerant macroinvertebrates were generally more abundant and modified HBI scores were higher at sites receiving lower OCRs.

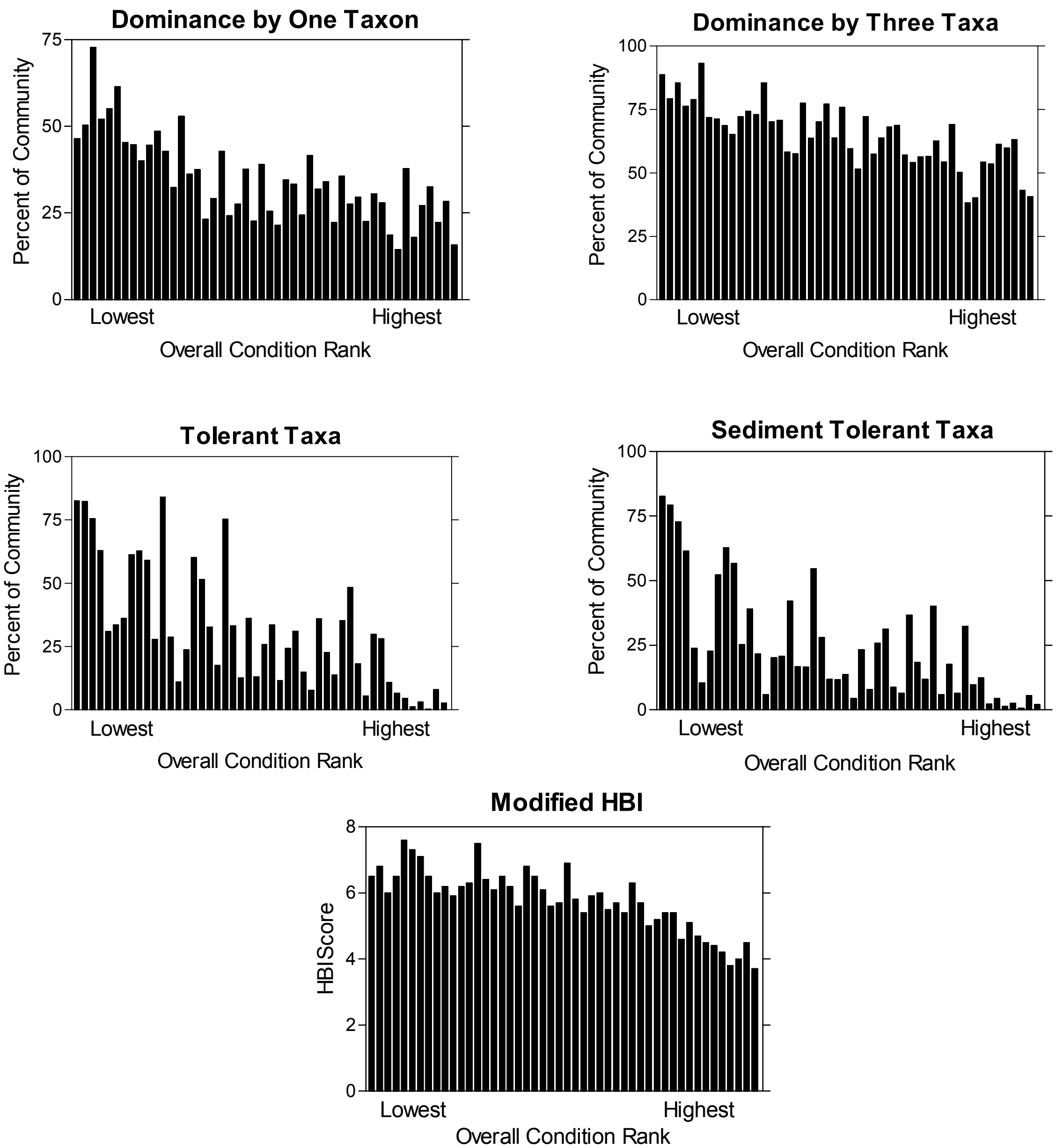

Figure 4. Relationship between individual negative metrics and overall condition rank of macroinvertebrate communities at each of 44 sites in the Tualatin River Basin, Oregon, sampled during fall 2000.

The two additional metrics, number of sediment-sensitive taxa and number of sensitive taxa, were also closely related to overall community condition. Except for reference sites, almost all sites lacked sensitive and sediment-sensitive taxa (Figure 5), whereas reference sites generally had one or more taxa of both sediment-sensitive and sensitive taxa.

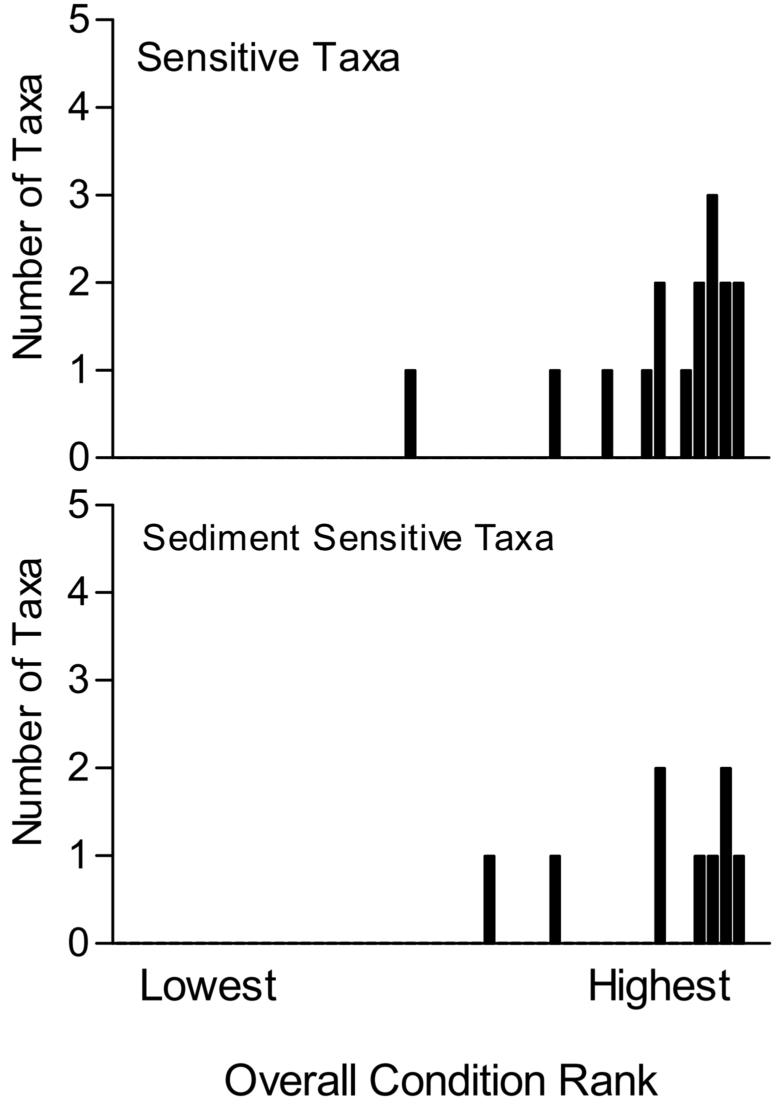

Figure 5. Relationship between number of sensitive and sediment sensitive taxa to overall condition rank of macroinvertebrate communities at each of 44 sites in the Tualatin River Basin, Oregon, sampled during fall 2000.

Field and laboratory duplicates produced results that were very similar to those produced from original samples. Two of the four field duplicates produced ranks that were adjacent to the ranks derived from the original samples (Lower Roaring Creek and Upper Ayers Creek). The other two field duplicates, from Upper Dairy and Lower Heaton Creeks, produced ranks similar to those derived from the original samples (32.1 vs. 37, and 22.6 vs. 27.4, respectively), indicating that field sampling procedures allowed accurate characterization of macroinvertebrate conditions at each site. Laboratory duplicate ranks differed from original samples by only 1.3 to 3.3 units.

Water chemistry data collected at each sampling site indicated that dissolved oxygen might be, in part, limiting macroinvertebrate communities (Appendix 4). At several sites, dissolved oxygen concentrations were as low as ~2.5 mg/L (Lower Johnson Creek, Lower Hedges Creek, and Upper Dawson Creek). No other variables appeared to be outside the tolerance range of most macroinvertebrates, but point samples of so few parameters cannot be used to determine whether water quality at these sites is affecting macroinvertebrate communities.

DISCUSSION

The condition of macroinvertebrate communities varies considerably among stream reaches of the Tualatin River Basin. The data indicate that a number of streams, including Summer Creek, Beaverton Creek, Fanno Creek, South Rock Creek, Butternut Creek, Johnson Creek, Hedges Creek, and Ash Creek, contain reaches that have macroinvertebrate communities that are heavily degraded by human influence. These streams are characterized by the absence of any sensitive or sediment-sensitive taxa; few, if any, mayflies, stoneflies, or caddisflies; greater dominance by only a few taxa; and larger numbers of macroinvertebrates that are tolerant to pollution and physical habitat degradation. These conditions typify macroinvertebrate communities that have been moderately to severely affected by human influence. In general, stream reaches classified as urban had the worst metric scores. These reaches in the more developed areas of the Basin have lost much of their capacity to support diverse benthic communities. Although we did not collect physical habitat information for this study, previous work in the Basin determined that aquatic habitat features, including channel morphology, riparian condition, streambank stability, instream cover, and substrate, have been degraded by human development (ODFW 1995). Clearly, these perturbations have affected macroinvertebrate communities. Macroinvertebrate communities in other stream reaches in the Basin, namely those receiving OCRs between the mid-teens and upper twenties, also have been degraded by human actions, but not to the extent as those receiving the lowest OCRs.

A number of stream reaches, including the upper reaches of Dairy and Chicken creeks and much of Roaring Creek, currently support diverse macroinvertebrate communities that are well represented by more sensitive taxa, including mayflies, stoneflies, and caddisflies. These reaches that we designated as reference sites are all located in well-forested areas with intact riparian zones and little land use other than forestry. One of the major challenges of biological monitoring lies in properly defining and selecting reference sites. A common pitfall in developing biomonitoring programs is using local sites that are somewhat degraded rather than looking further for those areas that are truly least affected by human actions (Karr and Chu 1999). Of the sites selected for this study, these four sites were least affected by human actions, and are among the least disturbed reaches in the Tualatin River Basin. However, to better characterize least disturbed macroinvertebrate communities in the Tualatin

Basin, such sites over a larger area should be identified and sampled. For example, upper Gales Creek perhaps harbors the greatest diversity of macroinvertebrates and may well best represent the least disturbed conditions in the basin (Cole, unpublished data).

Based on field observation, the reference reaches were among those with the highest gradients in the study. Stream gradient affects stream morphology and habitat characteristics, which in turn, influence the structure of biological communities (Rosgen 1996). To minimize these differences in physical habitat among streams with different gradients, we sampled only from depositional areas at all sites rather than sampling from the dominant habitat type at each site. Because least disturbed conditions in the Basin only occur in these areas with higher gradient streams, we were limited to characterizing least disturbed conditions in these areas where macroinvertebrate communities have likely always differed to some degree from those in the low-gradient, valley-floor stream reaches. It is important to note, however, that land use type clearly appears to be exerting the greatest influence on macroinvertebrate community conditions in the basin. These relationships between land use type/intensity and macroinvertebrates community conditions should be further examined to more precisely determine the causes of the large variation in macroinvertebrate community conditions in the Basin.

As previously stated, we did not use DEQ scoring criteria to analyze the data because these were developed for different habitats. Similar standardized scoring criteria have not been developed for use on samples collected from depositional habitats, which were the dominant stream habitat type in most of the sampled reaches. Typically, when multimetric scores are calculated, streams are grouped into four categories based on scores: no impairment, slight impairment, moderate impairment, and severe impairment (WQIW 1999). Because standardized metric scores cannot be calculated, there is no way to confirm that the reference sites are directly comparable to sites deemed free of impairment on the basis of multimetric scoring. To measure the ability of the ranking system used for this study to determine site condition relative to other sites in the study, we calculated multimetric scores for each site using riffle scoring criteria for western Oregon, and compared those scores to the ranks. The two methods produced the same highest scoring four sites. Although these multimetric scores (calculated with riffle scoring criteria) cannot be used to compare these sites to sites outside this study, nor can they be used to assign level of impairment categories to sites, they do demonstrate the ability of the ranking system to determine the least impaired sites within the data set.

The lack of appropriate scoring criteria for a study of this type illustrates the need to develop a standard set of scoring criteria for use in low-gradient streams in the Tualatin Basin and elsewhere in the Willamette Valley, where sampling from depositional habitats is necessary. This study is a first step towards developing such an analytical tool, but more information regarding reference conditions and further study to examine relationships between macroinvertebrate community conditions and degree of human influence is needed before such a set of criteria can be developed, tested, and applied. This study did not collect physical habitat information at any sites. Future macroinvertebrate monitoring activities in the Basin should include the collection of physical habitat data (e.g., canopy cover, general riparian and streambank conditions, stream channel dimensions, and substrate composition) to better understand physical site conditions and level of disturbance. The only measure of site conditions that could be used for this study was rural or urban classification of sites by USA. We reclassified a few of these sites after field visits, but much more reliable and precise measures of site condition or level of human influence should be considered in the future.

This study provides the first comprehensive set of data describing macroinvertebrate communities in the Tualatin River Basin. We have identified stream reaches that support healthy, diverse macroinvertebrate communities, and we have characterized other streams in the basin relative to these reaches. As a result, we have identified stream reaches in the Basin with impaired macroinvertebrate communities. The data provide a means to help prioritize restoration efforts based on severity of current impairment of biological condition and serve as baseline information to assess further degradation or future improvement of stream reach conditions. We suggest that efforts to monitor biological conditions in the Basin include regular sampling of macroinvertebrate communities at least once per year. Regular sampling provides more certainty in community characterizations by capturing the temporal and spatial variability that occurs at each site and provides for a more precise and accurate evaluation of the response of macroinvertebrate communities to restoration efforts.

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Appendix 1. Study sites for the Tualatin Basin Tributary Macroinvertebrate Study, 2000.

Site 1. Lower Hedges Creek in Tualatin Hills Park – 9/11/2000.

No Photo

Site 4. Upper Fanno Creek below 39th Street – 9/8/2000.

Site 2. Upper Hedges Creek upstream of 105th Street – 9/11/2000.

Site 5. Middle South Rock Creek at Highway 99 – 9/11/2000.

Site 3. Lower Fanno Creek in Durham City Park – 9/11/2000.

Site 6. Upper South Rock Creek above Tualatin-Sherwood Road – 9/11/2000.

Appendix 1. (Continued).

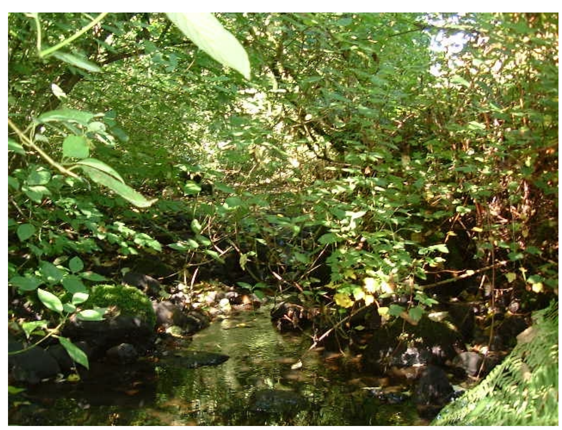
Site 7. Lower Chicken Creek above mouth – 9/11/2000.

Site 8. Upper Chicken Creek above Kruger Road – 9/11/2000.

Site 9. Lower Butternut Creek below River Road – 9/13/2000.

Site 10. Upper Butternut Creek at Farmington Road – 9/8/2000.

Site 11. Lower Rock Creek below River Road – 9/13/2000.



Site 12. Upper Rock Creek along Rock Creek Road – 9/12/2000

Appendix 1. (Continued).

Site 13. Middle Dairy Creek below Roy Road – 9/13/2000.

Site 14. Upper Dairy Creek at Little Bend Park – 9/13/2000.

Site 15. Middle Cedar Creek above Meineke Road – 9/11/2000.

Site 16. Upper Cedar Creek below Rein Road – 9/11/2000.

Site 17. Lower Summer Creek above mouth – 9/8/2000.

Site 18. Upper Summer Creek above 135th Avenue - 9/8/2000.

Appendix 1. (Continued).

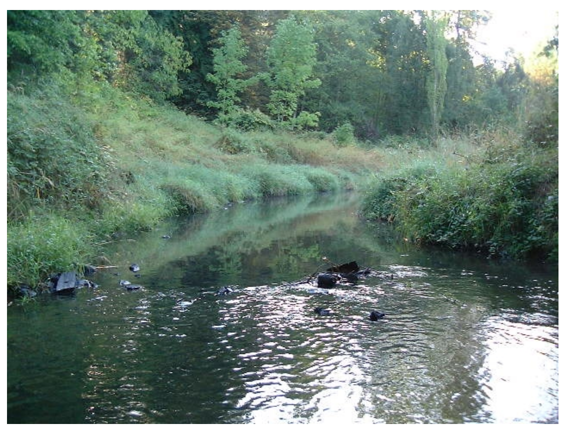
Site 19. Lower Ash Creek just above mouth – 9/8/2000.

Site 22. Upper Dawson Creek upstream of Airport Road – 9/12/2000.

Site 20. Upper Ash Creek above Taylor's Ferry Rd. – 9/8/2000.

Site 23. Lower Beaverton Creek below 216th Street - 9/12/2000.

Site 21. Lower Dawson Creek below Baseline Road – 9/12/2000.



Site 24. Middle Beaverton Creek below 185th Street– 9/12/2000.

Appendix 1. (Continued).

Site 25. Middle Bronson Creek above Cornell Road – 9/12/2000.

Site 28. Upper Cedar Mill Creek above 113th Ave. – 9/12/2000.

Site 26. Upper Bronson Creek above Laidlaw Road – 9/12/2000.

Site 29. Lower Johnson Creek upstream of Route 8 – 9/8/2000.

Site 27. Middle Cedar Mill Creek – 9/12/2000.

Site 30. Upper Johnson Creek above 170th Street - 9/8/2000.

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Appendix 1. (Continued).

Site 31. Lower Baker Creek below Mountain Creek Rd. – 9/18/2000.

Site 32. Upper Baker Creek above Taylor's Ferry Rd. – 9/27/2000.

Site 33. Lower Heaton Creek above Siefert Road – 9/18/2000.

Site 34. Middle Heaton Ck. above NE Mountain Home Road – 9/18/2000.

Site 35. Lower Christensen Creek at Route 219 - 9/13/2000.

Site 36. Upper Christensen Creek above Dixon Mill Rd. – 9/13/2000.

Appendix 1. (Continued).

Site 37. Middle Burris Creek along SW Laurel Road – 9/13/2000.

No Photo

Site 40. Middle Roaring Creek along Roaring Ck. Rd. – 10/5/2000.

No Photo

Site 38. Upper Burris Ck. above falls on SW Stickney Rd. – 10/5/2000.

Site 41. Middle Ayers Creek along Dopp Road – 9/18/2000.

No Photo

Site 39. Lower Roaring Creek above mouth – 10/5/2000.

Site 42. Upper Ayers Creek above Albertson Raod - 9/18/2000.

Appendix 2. Metric scores of macroinvertebrate communities at each of 44 sites sampled in the Tualatin River Basin, Oregon, during fall 2000. Sites are listed in order of their overall condition rank from highest to lowest ranks.

		Raw Scores									
Site Name	R/U	%Eph	% Plec	% Trich	% EPT	Total Taxa	% Dom (1)	% Dom (3)	% Tol	% Sed Tol	HBI
Upper Dairy Cr. - Dup	R	33.5	9.0	11.6	54.0	40	15.7	40.6	2.6	2.0	3.7
Upper Chicken Creek	R	24.9	10.2	7.2	42.3	39	28.4	43.1	8.0	5.5	4.5
Middle Roaring Creek	R	9.5	3.8	24.4	37.6	30	22.3	63.0	0.2	0.6	4.0
Lower Roaring Cr. – Dup	R	56.5	9.3	6.2	72.0	29	32.5	59.9	3.1	2.5	3.8
Lower Roaring Creek	R	45.7	9.7	2.0	57.4	27	27.1	61.4	1.2	1.4	4.2
Upper Burris	R	18.8	1.6	7.6	27.9	26	18.0	53.5	4.6	4.4	4.4
Upper Dairy Creek	R	48.2	4.1	14.0	66.3	36	37.8	54.3	6.5	2.4	4.5
Upper Cedar Creek	U	6.4	2.1	20.7	29.3	30	18.6	38.2	28.1	9.7	5.1
Middle Burris Creek	R	2.7	11.3	2.1	16.1	29	14.4	40.2	10.9	12.4	4.7
Lower Heaton Creek	R	11.4	10.0	11.9	33.3	23	27.9	50.2	29.9	32.3	4.6
Upper Baker	R	33.0	5.8	1.7	40.5	26	30.5	69.1	5.5	6.4	5.4
Middle Dairy Creek	U	5.9	8.8	1.0	15.7	24	22.5	54.4	18.1	17.6	5.4
Lower Chicken Creek	U	20.8	0.3	29.8	50.9	19	29.6	62.6	48.3	5.9	5.2
Middle Ayers Creek	R	20.8	4.3	3.0	28.1	26	27.6	56.5	35.1	40.0	5.0
Upper Christenson Cr.	R	5.7	5.9	0.8	12.4	27	35.6	56.4	13.8	11.8	5.7
Middle Bronson Creek	U	3.1	0.0	4.0	7.1	24	22.3	54.2	22.6	18.4	6.3
Upper Bronson Creek	U	1.0	0.0	4.8	5.8	23	31.9	68.7	7.7	6.4	5.7

Appendix 2. (Continued).

		Raw Scores									
Site Name	R/U	%Eph	% Plec	% Trich	% EPT	Total Taxa	% Dom (1)	% Dom (3)	% Tol	% Sed Tol	HBI
Lower Heaton Cr. - Dup	R	8.7	5.2	4.0	17.9	28	34.0	57.1	36.0	36.5	5.4
Upper Cedar Mill Creek	U	4.8	0.0	6.0	10.8	19	41.5	68.2	14.8	8.8	5.5
Upper Ayers Creek	R	4.8	0.6	1.0	6.5	28	24.4	63.8	31.1	31.3	6.0
Upper Ayers Creek - Dup	R	3.2	0.4	1.0	4.6	22	33.3	57.4	24.3	25.9	5.9
Lower Baker Creek	R	0.4	1.5	0.8	2.7	21	34.6	72.1	11.5	7.9	5.4
Lower Fanno Creek	U	1.0	0.0	0.5	1.5	18	21.4	51.5	33.5	23.3	5.8
Middle Council	R	0.0	0.0	2.6	2.6	14	25.5	59.5	25.9	4.3	6.9
Upper Rock Creek	U	0.4	2.1	1.7	4.1	20	39.0	75.9	13.1	13.6	5.7
Upper Dawson Creek	U	0.0	0.0	0.0	0.0	19	22.6	63.8	36.2	11.7	5.6
Upper Hedges Creek	U	0.9	0.0	0.6	1.5	18	37.6	77.1	12.6	11.8	6.1
Lower Christenson Creek	R	1.6	0.0	0.8	2.4	25	27.6	70.2	33.3	28.0	6.5
Lower Beaverton Creek	U	1.6	0.0	1.6	3.2	21	24.2	63.7	75.4	54.5	6.8
Middle Heaton Creek	R	0.8	0.2	0.0	1.0	16	42.8	77.5	17.5	16.5	5.6
Upper Johnson Creek	U	0.0	0.0	0.0	0.0	15	29.1	57.5	32.8	16.6	6.2
Upper Ash Creek	U	0.4	0.0	0.2	0.6	18	23.2	58.2	51.5	42.0	6.5
Lower Butternut Creek	U	0.2	0.0	1.2	1.4	18	37.5	70.9	60.2	20.7	6.1
Middle Cedar Creek	U	0.0	0.0	0.0	0.0	16	36.2	70.1	23.7	20.1	6.4
Upper Summer Creek	U	0.6	0.0	0.0	0.6	17	52.9	85.6	11.0	5.9	7.5
Middle South Rock Creek	U	0.2	0.0	0.0	0.2	15	32.3	73.0	28.7	21.7	6.3

Appendix 2. (Continued).

		Raw Scores									
Site Name	R/U	%Eph	% Plec	% Trich	% EPT	Total Taxa	% Dom (1)	% Dom (3)	% Tol	% Sed Tol	HBI
Lower Rock Creek	U	0.2	0.0	2.1	2.3	18	42.8	74.3	84.1	39.0	6.2
Upper Council	R	0.0	0.0	0.0	0.0	18	48.5	72.1	27.9	25.3	5.9
Lower Dawson Creek	U	0.2	0.0	0.0	0.2	19	44.5	65.2	59.0	56.7	6.2
Lower Ash Creek	U	0.2	0.0	0.0	0.2	16	40.0	68.6	62.8	62.6	6.0
Middle Cedar Mill Creek	U	0.2	0.0	0.8	1.0	20	44.7	71.3	61.3	52.2	6.5
Lower Hedges Creek	U	0.0	0.0	0.0	0.0	15	45.3	71.9	36.2	22.7	7.1
Lower Johnson Creek	U	0.0	0.0	0.0	0.0	9	61.4	93.2	33.5	10.4	7.3
Upper Butternut Creek	U	0.0	0.0	0.0	0.0	15	55.0	78.9	30.9	23.9	7.6
Upper South Rock Creek	U	0.0	0.0	0.2	0.2	22	52.0	76.3	62.9	61.4	6.5
Upper Fanno	U	0.0	0.0	0.0	0.0	11	72.8	85.6	75.6	72.8	6.0
Middle Beaverton Creek	U	0.0	0.0	0.0	0.0	17	50.3	79.3	82.4	79.3	6.8
Lower Summer Creek	U	0.0	0.0	0.0	0.0	11	46.4	88.7	82.5	82.5	6.5

Appendix 3. Metric score ranks of macroinvertebrate communities at each of 44 sites sampled in the Tualatin River Basin, Oregon, during fall 2000. Sites are listed in order of their overall condition rank from highest to lowest ranks.

		Site Rankings									
Site Name	R/U	%Eph	% Plec	% Trich	% EPT	Total Taxa	% Dom (1)	% Dom (3)	% Tol	% Sed Tol	HBI
Upper Dairy Cr. - Dup	R	34	17	29	36	22	47	46	45	46	48
Upper Chicken Creek	R	32	21	27	34	21	31	45	40	40	43
Middle Roaring Creek	R	27	10	33	32	19	43	28	47	48	46
Lower Roaring Cr. – Dup	R	37	18	26	39	18	25	31	43	45	47
Lower Roaring Creek	R	35	19	17	37	16	35	30	46	47	45
Upper Burris	R	29	7	28	28	15	46	42	41	44	44
Upper Dairy Creek	R	36	11	31	38	20	17	40	44	42	42
Upper Cedar Creek	U	25	9	32	30	19	45	48	34	25	38
Middle Burris Creek	R	18	22	18	26	18	48	47	29	39	40
Lower Heaton Creek	R	28	20	30	31	12	32	44	13	23	41
Upper Baker	R	33	14	16	33	15	28	20	37	43	33
Middle Dairy Creek	U	24	16	10	25	13	41	39	25	31	35
Lower Chicken Creek	U	30	3	34	35	8	29	29	39	12	37
Middle Ayers Creek	R	31	12	21	29	15	33	37	10	16	39
Upper Christenson Cr.	R	23	15	7	24	16	21	38	30	34	27
Middle Bronson Creek	U	19	1	22	22	13	42	41	24	30	15
Upper Bronson Creek	U	14	1	24	20	12	27	21	38	41	28

Appendix 3. (Continued).

		Site Rankings									
Site Name	R/U	%Eph	% Plec	% Trich	% EPT	Total Taxa	% Dom (1)	% Dom (3)	% Tol	% Sed Tol	HBI
Lower Heaton Cr. - Dup	R	26	13	23	27	17	23	36	12	15	34
Upper Cedar Mill Creek	U	21	1	25	23	8	14	23	35	33	32
Upper Ayers Creek	R	22	5	12	21	17	37	25	14	21	23
Upper Ayers Creek - Dup	R	20	4	11	19	11	24	35	16	28	24
Lower Baker Creek	R	9	6	6	16	10	22	13	36	37	36
Lower Fanno Creek	U	15	1	4	11	7	44	43	19	17	26
Middle Council	R	1	1	20	15	3	36	32	42	27	5
Upper Rock Creek	U	8	8	15	18	9	16	10	28	35	29
Upper Dawson Creek	U	1	1	1	1	8	40	26	32	13	30
Upper Hedges Creek	U	13	1	5	12	7	18	8	31	36	20
Lower Christenson Creek	R	16	1	9	14	14	34	18	15	19	8
Lower Beaverton Creek	U	17	1	14	17	10	38	27	7	5	6
Middle Heaton Creek	R	12	2	1	9	5	12	7	27	32	31
Upper Johnson Creek	U	1	1	1	1	4	30	34	26	20	16
Upper Ash Creek	U	10	1	3	7	7	39	33	9	11	11
Lower Butternut Creek	U	6	1	13	10	7	19	17	22	9	19
Middle Cedar Creek	U	1	1	1	1	5	20	19	23	29	13
Upper Summer Creek	U	11	1	1	6	6	4	4	39	38	2
Middle South Rock Creek	U	2	1	1	2	4	26	12	21	24	14

Appendix 3. (Continued).

		Site Rankings									
Site Name	R/U	%Eph	% Plec	% Trich	% EPT	Total Taxa	% Dom (1)	% Dom (3)	% Tol	% Sed Tol	HBI
Lower Rock Creek	U	7	1	19	13	7	13	11	11	1	18
Upper Council	R	1	1	1	1	7	7	14	17	26	25
Lower Dawson Creek	U	5	1	1	5	8	11	24	6	10	17
Lower Ash Creek	U	3	1	1	4	5	15	22	4	7	21
Middle Cedar Mill Creek	U	4	1	8	8	9	10	16	8	8	9
Lower Hedges Creek	U	1	1	1	1	4	9	15	20	14	4
Lower Johnson Creek	U	1	1	1	1	1	2	1	33	18	3
Upper Butternut Creek	U	1	1	1	1	4	3	6	18	22	1
Upper South Rock Creek	U	1	1	2	3	11	5	9	5	6	12
Upper Fanno	U	1	1	1	1	2	1	3	3	4	22
Middle Beaverton Creek	U	1	1	1	1	6	6	5	2	3	7
Lower Summer Creek	U	1	1	1	1	2	8	2	1	2	10

Appendix 4. Water chemistry data collected during fall 2000 macroinvertebrate surveys of the Tualatin River Basin, Oregon.

			Water Chemistry Variable					
Site	Date	Time	Temp (^{o}C)	DO (%)	DO (mg/L)	Conductivity (µS/cm)	Spec Con (µS/cm)	pH
Lower Hedges Creek	09/11/00	10:00	16.5	26.5	2.59	174.5	208.2	6.98
Upper Hedges Creek	09/11/00	10:25	15.5	78.8	7.60	71.7	81.2	6.97
Lower Fanno Creek	09/11/00	9:25	16.1	72.2	7.11	174.5	210.2	7.58
Upper Fanno Creek	09/08/00	13:40	15.1	83.5	8.37	76.2	94.2	7.41
Middle South Rock Creek	09/11/00	14:00	15.4	66.5	6.48	288.1	355.3	6.41
Upper South Rock Creek	09/11/00	13:30	20.4	55.1	6.20	281.2	300.9	6.32
Lower Chicken Creek	09/11/00	14:30	16.9	78.4	7.49	139.4	164.9	6.72
Upper Chicken Creek	09/11/00	12:15	15.2	92.2	9.23	55.2	67.7	6.68
Lower Butternut Creek	09/13/00	9:10	14.8	54.4	5.72	229.7	285.5	7.49
Upper Butternut Creek	09/08/00	15:15	17.5	74.8	7.00	78.7	91.6	7.24
Lower Rock Creek	09/13/00	9:35	16.9	60.7	5.88	275.2	325.7	7.58
Upper Rock Creek	09/12/00	11:55	13.8	95.8	9.68	72.2	92.6	7.58
Middle Dairy Creek	09/13/00	10:25	15.3	81.3	8.13	59.7	73.3	7.54
Upper Dairy Creek	09/13/00	11:20	12.3	97.7	10.14	50.0	61.0	7.58
Middle Cedar Creek	09/11/00	11:20	15.8	44.0	4.21	183.0	221.9	6.49
Upper Cedar Creek	09/11/00	11:45	15.4	61.6	6.05	55.7	68.0	6.48
Lower Summer Creek	09/08/00	11:25	17.3	64.5	5.93	146.4	171.5	7.31

Appendix 4. (Continued).

			Water Chemistry Variable					
Site	Date	Time	Temp (^{o}C)	DO (%)	DO (mg/L)	Conductivity (µS/cm)	Spec Con (µS/cm)	pH
Upper Summer Creek	09/08/00	10:30	16.4	64.4	6.23	128.3	153.3	7.26
Lower Ash Creek	09/08/00	11:45	15.6	74.4	7.40	85.4	104.0	6.86
Upper Ash Creek	09/08/00	12:55	15.4	74.6	7.48	90.5	99.1	7.31
Lower Dawson Creek	09/12/00	15:00	18.7	70.7	6.42	266.3	302.0	7.52
Upper Dawson Creek	09/12/00	10:15	16.5	29.7	2.83	227.7	272.0	7.21
Lower Beaverton Creek	09/12/00	15:45	18.3	71.3	6.61	226.8	260.1	7.56
Middle Beaverton Creek	09/12/00	8:45	17.1	58.8	5.74	244.5	287.7	7.51
Middle Bronson Creek	09/12/00	9:20	15.5	69.9	6.94	207.7	253.9	7.40
Upper Bronson Creek	09/12/00	12:40	14.3	59.5	6.11	161.4	202.1	7.62
Middle Cedar Mill Creek	09/12/00	14:10	19.2	100.5	9.06	420.9	473.1	7.49
Upper Cedar Mill Creek	09/12/00	13:45	16.6	103.8	9.86	149.9	178.2	7.89
Lower Johnson Creek	09/08/00	14:30	17.4	25.3	2.37	121.2	141.5	6.84
Upper Johnson Creek	09/08/00	9:40	14.9	61.8	6.22	89.7	115.0	6.77
Lower Baker Creek	09/18/00	13:30	17.3	81.3	7.67	49.4	57.8	7.23
Upper Baker	09/27/00	8:50	10.9	89.0	9.84	40.9	56.0	7.88
Lower Heaton Creek	09/18/00	12:35	16.6	66.8	6.38	88.2	105.1	7.19
Middle Heaton Creek	09/18/00	12:10	15.1	64.5	6.44	81.6	100.6	7.16
Lower Christenson Creek	09/13/00	13:15	14.9	42.5	4.13	218.5	271.0	7.46

Appendix 4. (Continued).

Site	Date	Time	Water Chemistry Variable					
			Temp (^oC)	DO (%)	DO (mg/L)	Conductivity (µS/cm)	Spec Con (µS/cm)	pH
Upper Christenson Creek	09/13/00	14:45	14.5	83.5	8.62	76.8	95.9	7.76
Upper Burris	10/05/00	13:55	10.9	93.3	10.50	57.5	78.5	7.91
Middle Burris Creek	09/13/00	13:50	14.9	78.5	7.60	65.7	84.1	7.41
Lower Roaring Creek	10/05/00	11:20	9.7	91.3	10.34	114.2	161.5	8.13
Middle Roaring Creek	10/05/00	12:30	11.3	87.6	9.30	95.4	129.2	8.00
Middle Ayers Creek	09/18/00	9:55	15.3	66.2	7.05	115.1	141.3	7.61
Upper Ayers Creek	09/18/00	10:45	15.9	78.3	7.83	54.7	66.6	8.00
Upper Council	09/26/00	14:20	19.5	101.1	9.42	73.9	74.1	7.75
Middle Council	09/26/00	16:10	13.6	19.7	1.95	255.6	326.1	7.26