**Macroinvertebrate Patterns in the Hinkle Creek Watershed**

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## Introduction

Abundance, diversity and production of stream invertebrates respond to riparian perturbation at multiple scales. The paired watershed study at Hinkle Creek provides an opportunity to examine these measures of benthic invertebrates in streams dominated by mature coniferous forests and subsequent responses to planned harvests.

The River Continuum Concept (Vannote et al., 1980) predicts that composition and function of invertebrate assemblages will change predictably downstream with increasing discharge and changes in riparian canopy associated with greater stream width. Current conditions at Hinkle Creek create the context for examining this continuum in two sub-watersheds with relatively little harvest activity.

The first stage of research will examine how benthic invertebrates, terrestrial invertebrates falling into the stream, fish and amphibian diets change along the Hinkle Creek continuum from its headwaters to the main stem. After harvest research will compare how these measures change downstream from headwater timber activities and contrast those responses to control conditions in the uncut subbasin.

## Methods

In Fall 2002 and 2003, researchers collected benthic invertebrate and organic matter samples to get more than one year's data on pre-harvest conditions (n=15, 6 samples/site). There were seven paired sites, upstream and downstream of the end of fish occurrence, plus one unpaired site upstream of fish occurrence (Fig. 1). These sites were all in headwater tributaries only. The paired sites should provide not only pretreatment invertebrate information, but also allow examination of potential differences associated with fish predation.

In 2004, in collaboration with other team members collecting fish, amphibian and hydrologic data, the research built on the previous sampling design and added downstream study sites to assess changes along the stream continuum (Fig. 2). Added sites included a fish-bearing tributary site in the North Fork, two North Fork main stem sites, and four South Fork main stem sites. To capture the diversity and seasonal fluctuations of invertebrate assemblages sampling occurred in spring, summer and fall.

All invertebrate samples were collected at randomly located points within study sites to be representative of that site. Study sites were 30 meters and 100 meters long for tributaries and main stems respectively. Benthic invertebrate samples were collected using 500 micron mesh Surber sampler (6 samples per site, $0.09m^2$ sampling area each). In the fall, benthic organic matter was collected along with invertebrates. Emerging insects were collected using four traps each covering $0.18m^2$ of streambed. Invertebrates hitting the stream surface were collected with pantraps (6 traps per site, $0.1m^2$ each). In headwater tributaries, riparian invertebrates crawling on the substrate were collected by placing 10 pitfall traps ($0.006m^2$ each) with their opening level with the surface within 1 meter laterally from the wetted channel. Seasons and locations of the various types of sampling are listed in Table 1. This entire suite of invertebrate samples will be repeated in spring 2005, providing additional data prior to harvest. All invertebrates were preserved in 70% ethanol in small whirlpak bags. Drifting organisms, important prey for salmonids, are a combination of benthic and emerging insects, as well as terrestrial invertebrates that fall into or are blown into the stream. This component of invertebrates is likely a useful measure of cumulative effects in the downstream gradient. Feasible ways of sampling drift at Hinkle Creek are being explored because bedrock and cobble/boulder substrates make setting drift nets difficult.

Sampling sites were placed strategically to examine differences in potential prey where fish were dense compared to other sites where they were less common. The invertebrate sampling has been integrated with fish sampling that occurred previous to current funding. In 2004, the assessment of fish diet began (Table 1). This was accomplished by anaesthetizing cutthroat trout, then gently pumping their stomachs before returning the fish to the stream. Stomach contents were washed onto small coffee filters and preserved in 70% ethanol. Up to 20 fish per site were sampled, depending on availability of fish. Similarly, a small number of giant Pacific salamanders from headwater sites were collected and their stomachs were pumped to determine diet.

**Preliminary Results: Spring 2004 Benthic Invertebrates**

To date, examinations have been conducted of spring 2004 benthic samples from all main stem and seven tributary sites (3 fish/no fish pairs and a single fish-bearing site; Fig. 3). Benthic invertebrate samples were processed in the lab, by combining the six samples from each site and subsampling to get a minimum count of 500 organisms. Invertebrates were identified to the lowest practical taxonomic level. Insects were identified to genus except for chironomids and ceratopogonids, which were only identified to subfamily/tribe. Snails were also identified to genus. Other non-insects were identified to coarser taxonomic levels.

Benthic invertebrates were abundant and diverse in spring samples from Hinkle Creek sites (Table 2). The types and relative abundances of sensitive and tolerant invertebrates were determined and used to calculate a benthic invertebrate index of biotic integrity (B-IBI) (Oregon Department of Environmental Quality (DEQ), 1999; see Appendices for criteria and calculations). By DEQ guidelines, sites where the B-IBI score is greater than 39 have little or no indication of degradation. The Hinkle Creek samples enumerated to date had B-IBI scores ranging from 42-50 (Table 2), indicating healthy invertebrate assemblages prior to upcoming forestry treatments.

In examining similarity in taxa composition between these samples using (Nonmetric Multidimensional Scaling (NMS); PC-ORD ordination, main stem sites clearly separated from headwater sites (Figure 4a). Taxa that distinguished the headwater sites included stoneflies (*Kathoperla, Moselia*), true flies (*Prosimulium, Chelifera*), snails (*Pristimicola, Juga*) and freshwater clams (Pisidiidae). Insects that distinguished the main stem sites were true flies (Chironomini, Orthocladinae, *Antocha, Clinocera*), mayflies (*Drunella, Ephemerella*), a stonefly (*Hesperoperla*), and a caddisfly (*Gumaga*). These preliminary results suggest that invertebrates will provide useful indicators of the stream continuum prior to harvest.

In contrast, NMS ordination reveals that the North and South Fork sites share some similarities; that is, their invertebrate assemblages are not distinctive from each other (Figure 4B). Thus, treatment and control sites were similar in spring 2004, prior to harvest in the headwaters. Potentially the similarity between sites in the two sub-watersheds pretreatment will provide a good context for comparison of future harvest effects in the South Fork.

Stream invertebrates are expected to be most diverse in spring and emerging insects may be most abundant then. Other seasons are likely to have other dominant or representative taxa. Terrestrial invertebrates are likely to be more abundant in the summer. As seasons change, fish diet may reflect changes in prey available in the drift and in the benthos. Recent work in the Coastal Range of Oregon determined cutthroat trout consume more aquatic prey in the winter and spring, but depend on terrestrial prey in equal proportions to aquatic in the summer. Cutthroats rely more heavily on terrestrial prey in the fall when aquatic prey are less available (Romero et al., in review). An examination of this dynamic in the changing scenario following harvest will be useful in estimating the importance of headwater riparian resources to fish diet and growth.

**Literature Cited**

Oregon Department of Environmental Quality, 1999. *Oregon Plan for Salmon and Watersheds: Water Quality Monitoring Guidebook.* http://www.oweb.state.or.us/publications/mon_guide99.shtml .

Romero, N, R. Gresswell and J. Li. In review. Changing patterns of coastal cutthroat diet and prey in deciduous canopies. Canadian Journal of Fisheries and Aquatic Sciences.

Vannote, R.L, G.W. Minshall, K. W. Cummins, J. R. Sedell, & C. E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

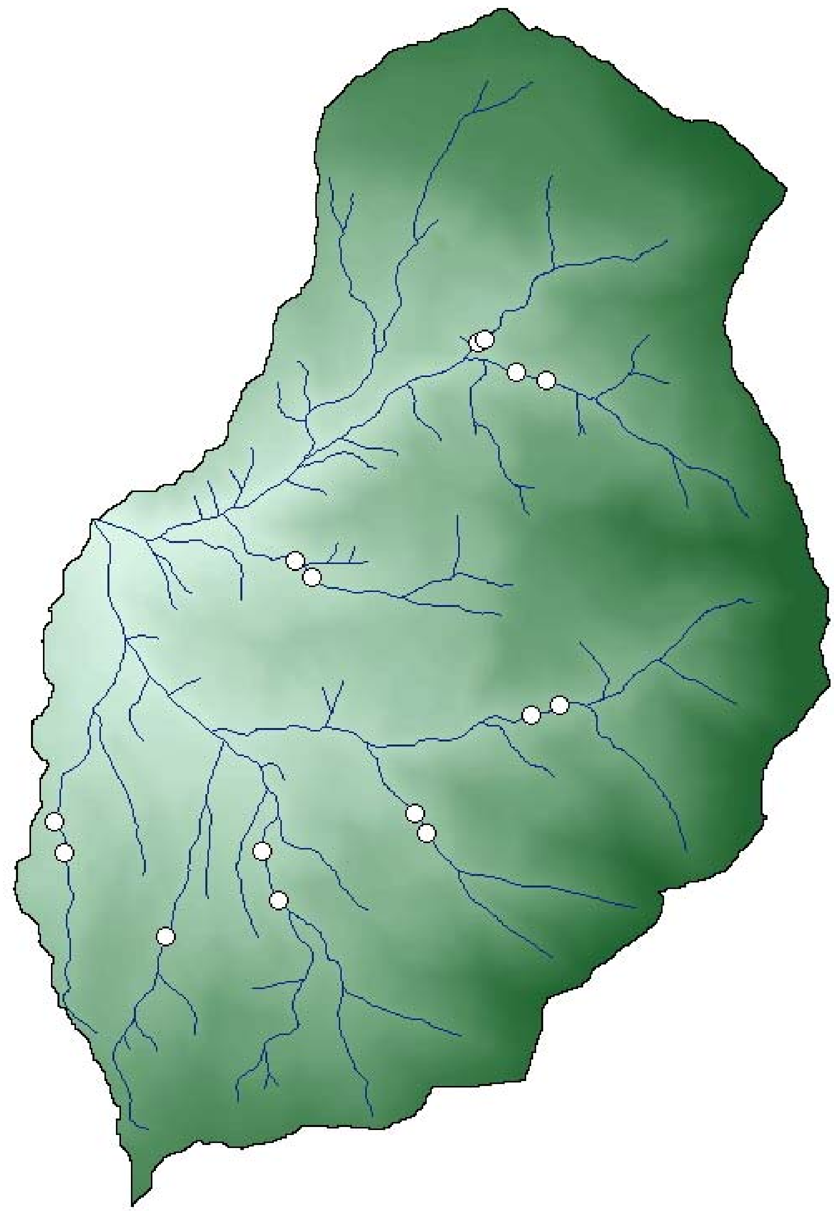


Fig. 1. Hinkle Creek invertebrate sampling sites for 2002 and 2003. With one exception, sites in each tributary were paired upstream and downstream of the end of fish distribution.

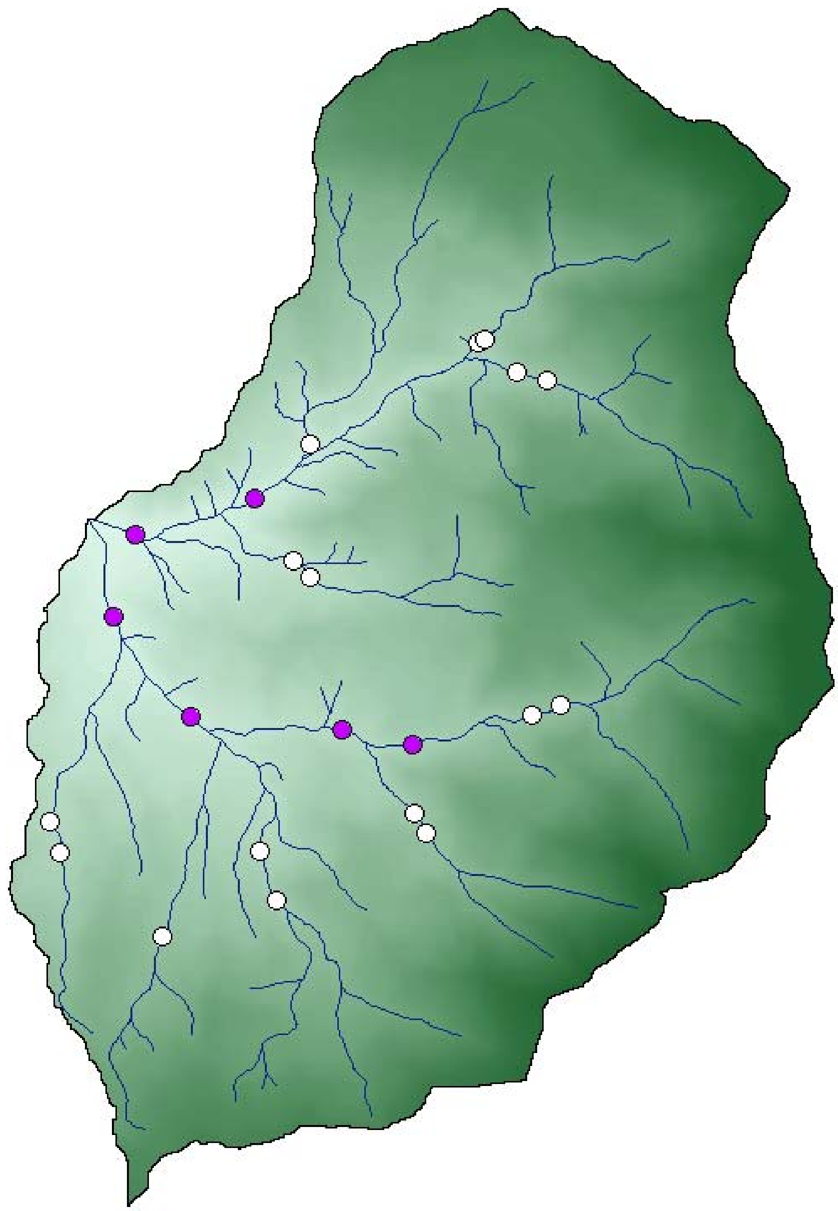


Fig. 2. Hinkle Creek invertebrate sampling sites for 2004. Purple circles indicate main stem sites; white circles indicate tributary sites.

Table 1. Samples collected for Hinkle Creek watershed study. Samples collected in 2002 and 2003 were collected prior to receiving funding for study of invertebrates. Single asterisk indicates samples partially processed. Double asterisk indicates samples completely analyzed.

**Fall 2002 (November)**
Tributary benthic invertebrate samples
Tributary benthic organic matter samples *

**Fall 2003 (November)**
Tributary benthic invertebrate samples
Tributary benthic organic matter samples *

**Spring 2004 (April-May)**
Tributary benthic invertebrate samples *
Main stem benthic invertebrate samples **
Main stem trout diet (hook and line sampling)

**Summer 2004 (August-September)**
Tributary benthic invertebrate samples
Tributary emerging invertebrate samples
Tributary invertebrate in-fall trap samples
Tributary Dicamptodon diet samples
Tributary trout diet samples (electrofishing)
Main stem benthic invertebrate samples
Main stem emerging invertebrate samples
Tributary riparian invertebrate pitfall trap samples
Main stem trout diet samples (electrofishing)

**Fall 2004 (October)**
Tributary benthic invertebrate samples
Tributary benthic organic matter samples *
Main stem benthic invertebrate samples
Main stem benthic organic matter samples *
Main stem trout diet (electrofishing)

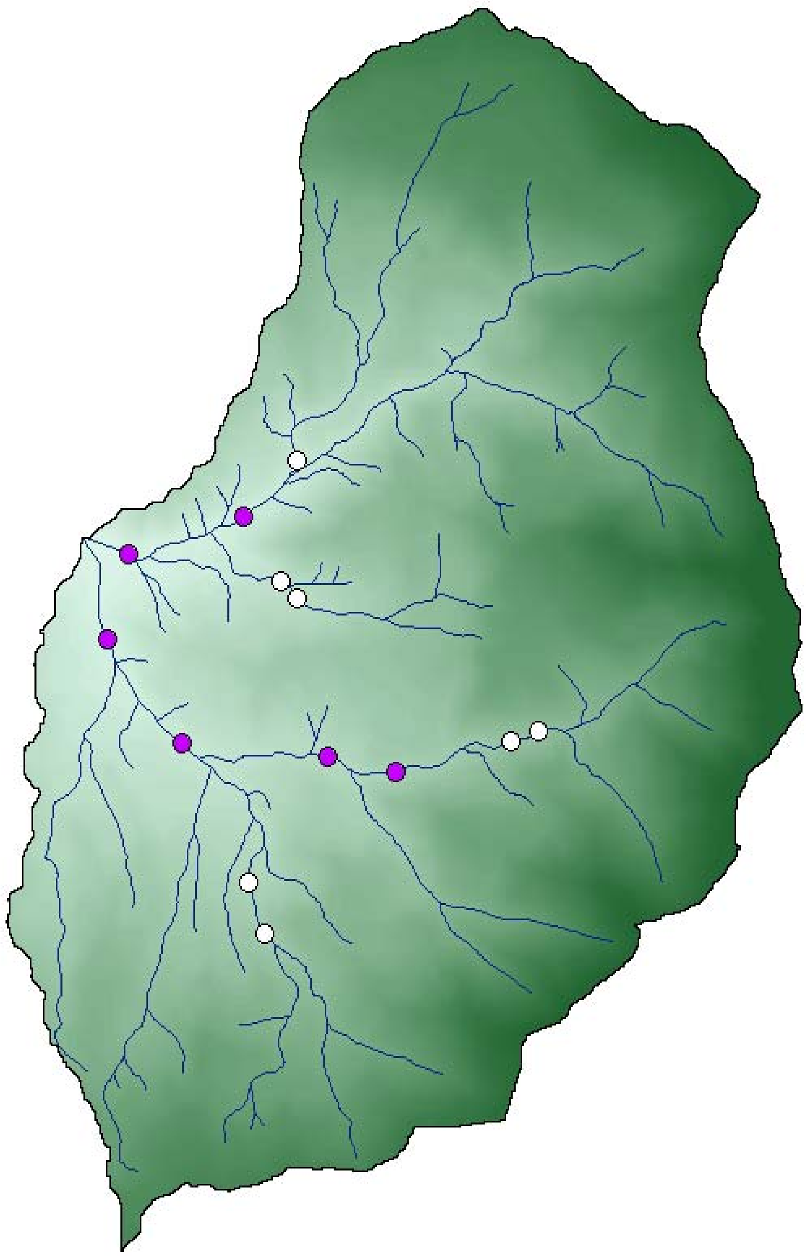
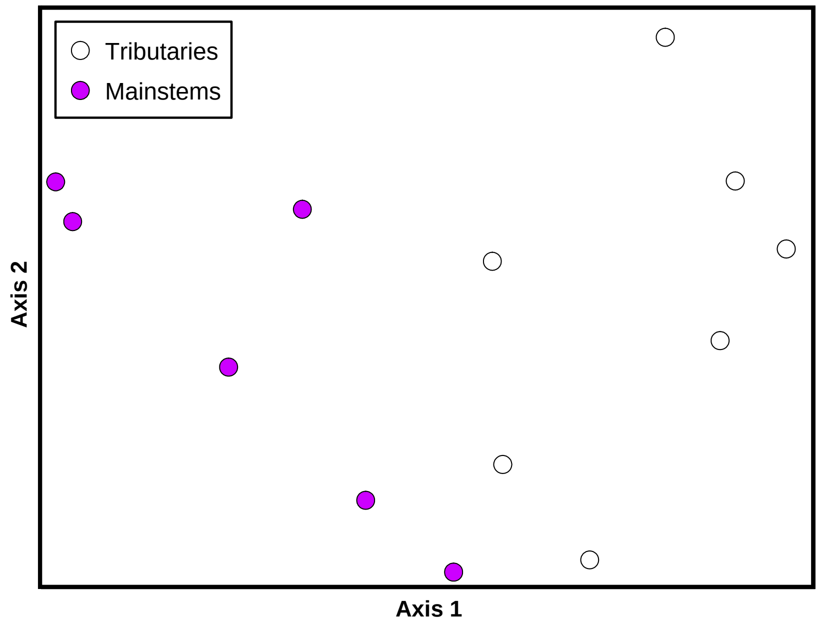


Fig. 3. Hinkle Creek sites where spring 2004 benthic invertebrate samples have been analyzed. Purple circles indicate main stem sites; white circles indicate tributary sites.

Table 2. Benthic invertebrate summary measurement for Hinkle Creek sites, April 2004. Index of biotic integrity scores greater than 39 indicate minimal negative anthropogenic impacts.

| | **Mean** | **Range** |
|---|---|---|
| **Density (# per square meter)** | 1960 | 1072 - 2867 |
| **Taxa richness** | 45 | 38 - 55 |
| **Index of biotic integrity** | 45 | 42 - 50 |

**a)**



**b)**

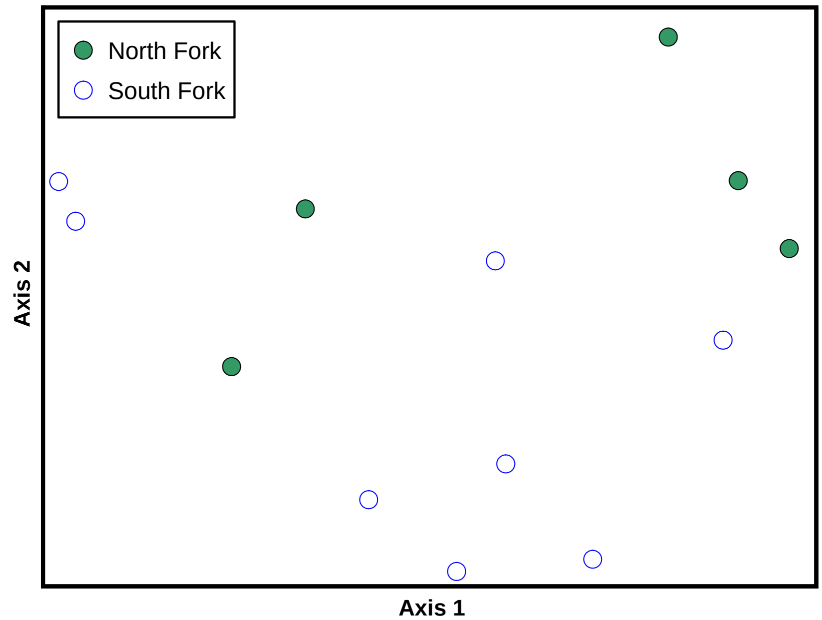



Fig. 4. NMS ordination of Spring 2004 benthic invertebrate data. Symbols indicate sites and proximities of symbols indicate similarities of invertebrate assemblages. Both graphs are the same ordination with sites coded by **a)** channel size and **b)** subbasin.

Appendix 1a. Invertebrate assemblage metrics used to calculate the ODEQ B-IBI and predicted response to human impact.

| Metric | Predicted Response to Increasing Human Impact |
|---|---|
| Total taxa richness | Decrease |
| Ephemeroptera richness | Decrease |
| Plecoptera richness | Decrease |
| Trichoptera richness | Decrease |
| # of taxa sensitive to organic pollution | Decrease |
| # of taxa intolerant to fine sediment | Decrease |
| Modified HBI | Increase |
| % individuals tolerant to organic pollution | Increase |

| | |
|---|---|
| % individuals tolerant to fine sediment | Increase |
| % dominance (single taxon) | Increase |

Appendix 1b. ODEQ B-IBI scoring criteria for invertebrate samples with midges identified to sub-family or tribe and other aquatic insects identified to genus.

| **Metric** | **Scoring Criteria** | | |
|---|---|---|---|
| | **1** | **3** | **5** |
| total taxa richness | < 19 | 19-35 | > 35 |
| Ephemeroptera richness | < 4 | 4-8 | > 8 |
| Plecoptera richness | < 3 | 3-5 | > 5 |
| Trichoptera richness | < 4 | 4-8 | > 8 |
| # of taxa sensitive to organic pollution | < 2 | 2-4 | > 4 |
| # of taxa intolerant to fine sediment | 0 | 1 | > 1 |
| Modified HBI | > 5.0 | 4.0-5.0 | < 4.0 |
| % individuals tolerant to organic pollution | > 45 % | 15-45 % | < 15 % |
| % individuals tolerant to fine sediment | > 25 % | 10-25 % | < 10 % |
| % dominance (single taxon) | > 40 % | 20-40 % | < 20 % |

Appendix 2. Component metric and total Benthic Index of Biotic Integrity (B-IBI) scores using methods of Oregon Department of Environmental Quality (1999). Total B-IBI scores greater than 39 indicate minimal negative anthropogenic impacts.

**Mainstem Sites**

| | **SFMS1** | | **SFMS2** | | **SFMS3** | | **SFMS4** | | **NFMS5** | | **NFMS6** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **value** | **score** | **value** | **score** | **value** | **score** | **value** | **score** | **value** | **score** | **value** | **score** |
| total taxa richness | 41 | 5 | 38 | 5 | 47 | 5 | 43 | 5 | 38 | 5 | 50 | 5 |
| Ephemeroptera richness | 11 | 5 | 11 | 5 | 9 | 5 | 8 | 3 | 10 | 5 | 10 | 5 |
| Plecoptera richness | 7 | 5 | 7 | 5 | 7 | 5 | 9 | 5 | 5 | 3 | 9 | 5 |
| Trichoptera richness | 6 | 3 | 6 | 3 | 8 | 3 | 6 | 3 | 6 | 3 | 10 | 5 |
| # of taxa sensitive to organic pollution | 3 | 3 | 3 | 3 | 3 | 3 | 8 | 5 | 3 | 3 | 6 | 5 |
| # of taxa intolerant to fine sediment | 0 | 1 | 1 | 3 | 0 | 1 | 1 | 3 | 2 | 5 | 4 | 5 |
| Modified HBI | 3.5 | 5 | 3.6 | 5 | 3.2 | 5 | 3.4 | 5 | 3.4 | 5 | 3.6 | 5 |
| % individuals tolerant to organic pollution | 6.7 | 5 | 2.5 | 5 | 6.7 | 5 | 14.3 | 5 | 4.2 | 5 | 8.5 | 5 |
| % individuals tolerant to fine sediment | 4.0 | 5 | 1.5 | 5 | 4.5 | 5 | 10.6 | 3 | 3.9 | 5 | 6.8 | 5 |
| % dominance (single taxon) | 19.2 | 5 | 27.2 | 3 | 12.1 | 5 | 13.4 | 5 | 14.2 | 5 | 12.5 | 5 |
| **B-IBI** | | **42** | | **42** | | **42** | | **42** | | **44** | | **50** |

Appendix 2 (cont'd). Component metric and total Benthic Index of Biotic Integrity (B-IBI) scores using methods of Oregon Department of Environmental Quality (1999). Total B-IBI scores greater than 39 indicate minimal negative anthropogenic impacts.

**Tributary Sites**

| | **2-Fish** | | **2-No fish** | | **3-Fish** | | **3-No Fish** | |
|---|---|---|---|---|---|---|---|---|
| | **value** | **score** | **value** | **score** | **value** | **score** | **value** | **score** |
| total taxa richness | 49 | 5 | 49 | 5 | 44 | 5 | 39 | 5 |
| Ephemeroptera richness | 8 | 3 | 9 | 5 | 8 | 3 | 9 | 5 |
| Plecoptera richness | 12 | 5 | 11 | 5 | 9 | 5 | 8 | 5 |
| Trichoptera richness | 8 | 3 | 7 | 3 | 7 | 3 | 5 | 3 |
| # of taxa sensitive to organic pollution | 11 | 5 | 10 | 5 | 7 | 5 | 6 | 5 |
| # of taxa intolerant to fine sediment | 1 | 3 | 1 | 3 | 2 | 5 | 1 | 3 |
| Modified HBI | 3.6 | 5 | 3.5 | 5 | 3.4 | 5 | 3 | 5 |
| % individuals tolerant to organic pollution | 8.6 | 5 | 11.9 | 5 | 5.3 | 5 | 6.4 | 5 |
| % individuals tolerant to fine sediment | 7.6 | 5 | 10.5 | 3 | 5.6 | 5 | 4.6 | 5 |
| % dominance (single taxon) | 16.9 | 5 | 12.4 | 5 | 15.6 | 5 | 10.3 | 5 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **B-IBI** | | **44** | | **44** | | **46** | | **46** |

Appendix 2 (cont'd). Component metric and total Benthic Index of Biotic Integrity (B-IBI) scores using methods of Oregon Department of Environmental Quality (1999). Total B-IBI scores greater than 39 indicate minimal negative anthropogenic impacts.

**Tributary Sites**

| | **5-Fish** | | **5-No fish** | | **NFT2-Fish** | |
|---|---|---|---|---|---|---|
| | **value** | **score** | **value** | **score** | **value** | **score** |
| total taxa richness | 55 | 5 | 47 | 5 | 51 | 5 |
| Ephemeroptera richness | 12 | 5 | 9 | 5 | 9 | 5 |
| Plecoptera richness | 10 | 5 | 13 | 5 | 14 | 5 |
| Trichoptera richness | 8 | 3 | 7 | 3 | 9 | 5 |
| # of taxa sensitive to organic pollution | 9 | 5 | 8 | 5 | 10 | 5 |
| # of taxa intolerant to fine sediment | 2 | 5 | 1 | 3 | 2 | 5 |
| Modified HBI | 3.9 | 5 | 3.3 | 5 | 3.3 | 5 |
| % individuals tolerant to organic pollution | 7.9 | 5 | 11.9 | 5 | 4.6 | 5 |
| % individuals tolerant to fine sediment | 3.4 | 5 | 9.3 | 5 | 2.9 | 5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| % dominance (single taxon) | 16.7 | 5 | 14.5 | 5 | | 27.1 | 3 |
| **B-IBI** | | **48** | | **46** | | | **48** |