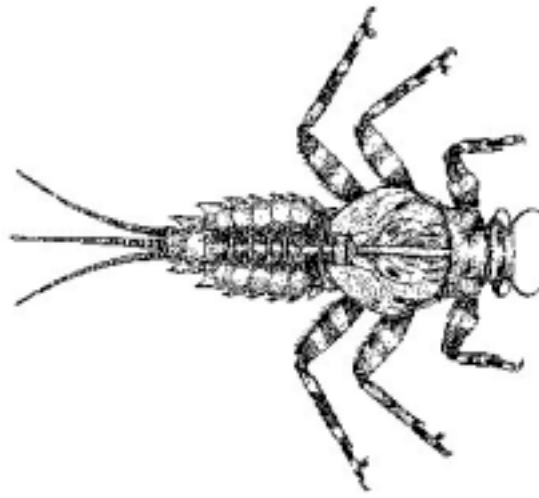


Analysis of Macroinvertebrate Data from the
Grande Ronde Long Term 319 NPS Project
1993 - 1996



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Introduction

The Grande Ronde 319 project was initiated in 1992. It is a multi-year study of five tributaries to the Grande Ronde River. Several potential watershed pairings within this study will enable assessment of stream conditions in relation to different land use regimes. In addition, a major aim of the study is to track the response of a specific stream segment to ongoing enhancement/restoration activities.

This report examines macroinvertebrate data collected from the period 1993 to 1996. It is hoped that these initial four years of data collection will satisfy three objectives:

- 1) establish the prevailing biological integrity of each of the study sites;
- 2) examine the effect of seasonal variation on macroinvertebrate data; and,
- 3) determine the range in "natural" variability at reference sites.

Methods

Survey Sites and Sampling Schedule

A list of sites and their sample schedules for the study period is presented in Table 1. The location of these sites within the Upper Grande Ronde basin is shown in Figure 1. For ease of analysis, sites are grouped into three condition categories: Reference; Intermediate; and, Most Disturbed, henceforth referred to as Categories 1, 2 and 3 respectively. These categories have been derived from best professional judgement by considering both past and present land use activities as well as prevailing stream habitat condition.

Table 1. Survey Sites and Sampling Schedule

Site	Year											
	1993		1994			1995			1996			
	June	Sept	April	July	Sept	April	July	Sept	April	July	Sept	
<i>Reference Sites - Category 1</i>												
Limber Jim Creek - Upper Reach	-	X	X	X	X	X	X	X	X	X	X	
Limber Jim Creek - Lower Reach	-	X	X	X	X	X	X	X	X	X	X	
Lookout Creek	-	X	X	X	X	X	X	X	X	X	X	
<i>Intermediate Condition - Category 2</i>												
Dark Canyon - Upper Reach	X	X	X	X	X	X	X	X	X	X	X	
Dark Canyon - Lower Reach	X	X	X	X	X	X	X	X	X	X	X	
Meadow Creek - Upper Reach	X	X	X	X	X	X	X	X	X	X	X	
McCoy Creek - Upper Reach	X	X	-	X	-	-	-	-	-	-	-	
<i>Most Disturbed - Category 3</i>												
Meadow Creek - Lower Reach	X	X	X	X	X	X	X	X	X	X	X	
McCoy Creek - Middle Reach	X	X	X	X	X	X	X	X	X	X	X	
McCoy Creek - Lower Reach 1	X	X	X	X	X	X	X	X	X	X	X	
McCoy Creek - Lower Reach 2	X	X	X	-	-	X	X	X	X	X	X	

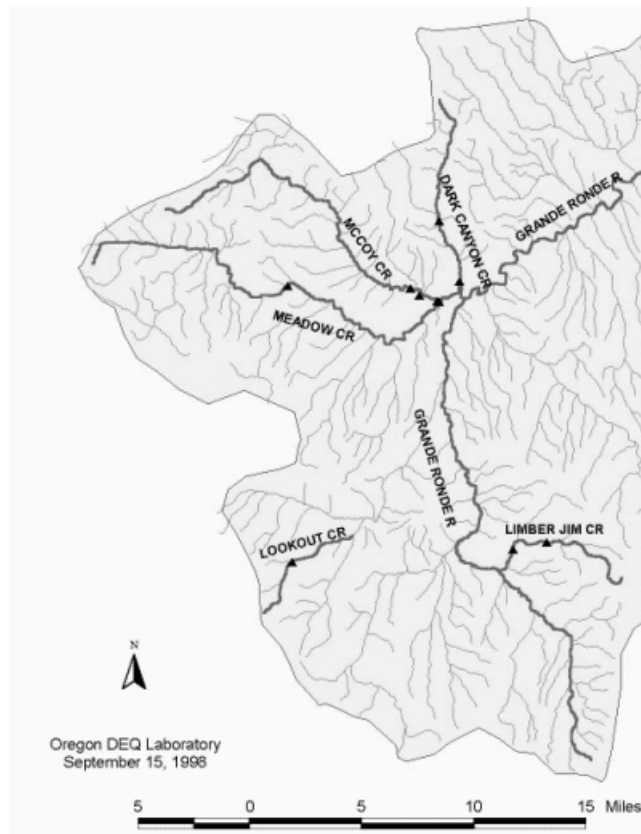
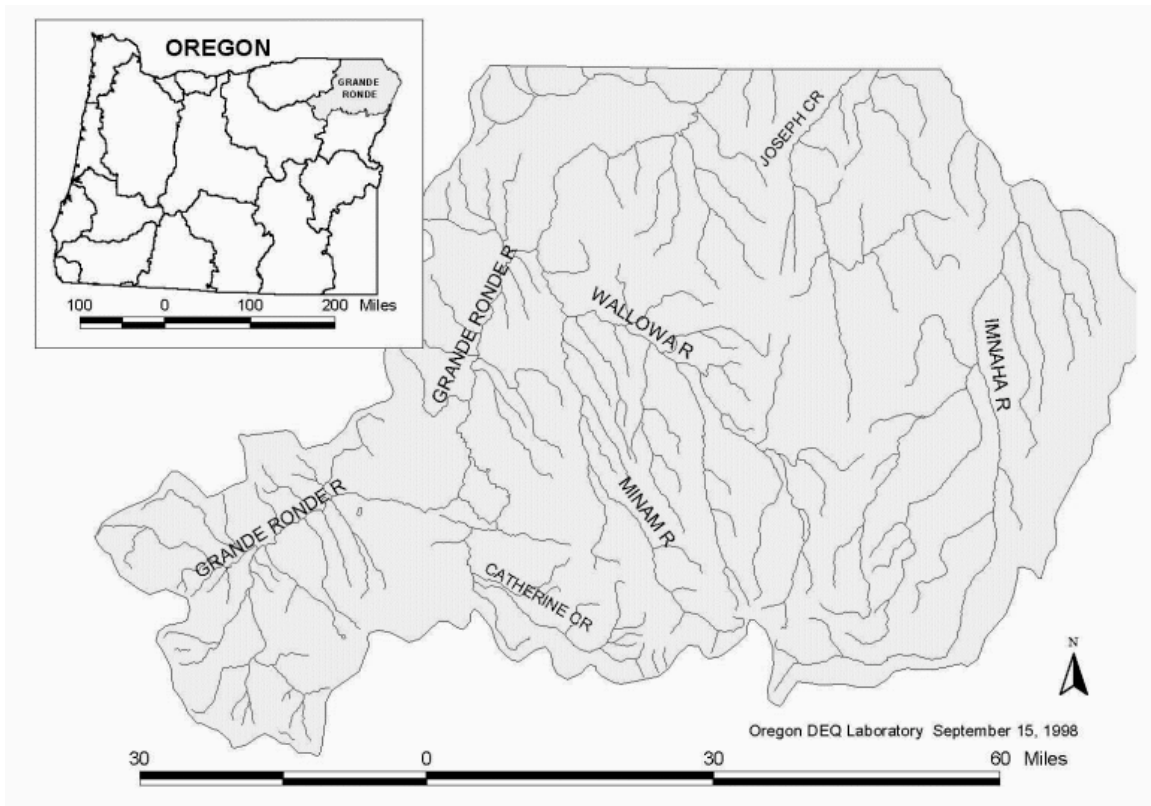


Figure 1. Location of Grande Ronde Basin and Sample Sites

Ten sites form the core stream segments sampled regularly during this time period. One other site (Upper McCoy Cr.), is not considered in the analysis below as it was dropped following the 1994 field season (this was a headwaters site and experienced intermittent flows during the summer months). The data used for analysis cover June and September 1993 and April, July and September for 1994 through 1996 (see Table 1).

Macroinvertebrate Collections

Macroinvertebrates were collected using the standard Level 3 DEQ assessment protocol (Hafele et. al., 1998). Both riffle and pool samples were taken at each site using a D-frame kick net of 500 μm mesh size. Two random kick samples were collected from each of two habitat units (e.g. two riffles). These samples were composited, preserved in alcohol and returned to the laboratory where a 300 count subsample was sorted from the debris. Identification of macroinvertebrates was taken to best practical level, genus/species in most cases with certain groups such as the Chironomidae left at higher taxonomic levels. Approximately 8 square feet of total stream bottom was disturbed in each collection effort. The following analysis considers the riffle data set only.

Statistical Analysis

Multivariate analyses were performed using the software program PATN (Belbin, 1995). Bray-Curtis dissimilarity measures were derived from log transformed taxa abundance values. Ordinations were performed using Semi-Strong Hybrid Multi-Dimensional Scaling (SSH).

Mean Dissimilarity Dendrograms

The separation of site groups is often difficult to portray on an ordination plot. Mean Dissimilarity Dendrograms summarise the information contained in a complex ordination and present it in a simpler form.

In the approach taken here, adopted from Van Sickle (1997), the mean dissimilarity is calculated for sites within each group and between each group. A graphical presentation of the mean dissimilarity values then shows the degree to which objects within the same group are more similar to each other than they are to objects in other groups. For example, in Figure 2, two hypothetical groups of sites are shown, A and B. The mean within group dissimilarity is located at the left end of each horizontal bar (lower values along the X axis reflect greater similarity between objects in a group). The vertical bar represents the mean dissimilarity between sites in the two groups. In this type of display, long horizontal bars indicate a high degree of discrimination between groups.

This approach will assess the validity of the three categories shown in Table 1 above, as well as helping to determine which of the three sampling seasons produces the most discriminating data set.

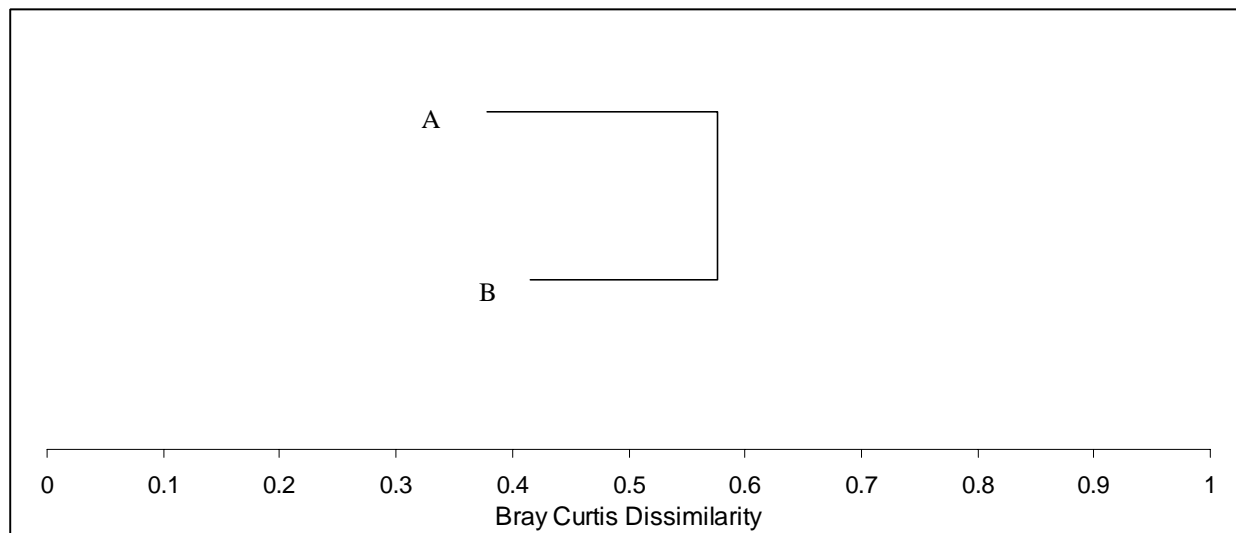


Figure 2. Mean Dissimilarity Diagram for two hypothetical site groups.

Impairment Assessment

Assessment of macroinvertebrate community status was achieved through application of BORIS (Benthic evaluation of ORegon river S; Canale, 1999). Its predictions are based upon the taxa typically found at reference streams. A sample list of predicted taxa is given in Appendix 1. Separate models were constructed for each of the three months sampled in order to accommodate seasonal change in macroinvertebrate composition. BORIS is a RIVPACS type model. A list of papers on this modeling approach is supplied in the Reference section below.

The score a site receives is simply the ratio of taxa that were actually found to that predicted by the model. The mean score of reference sites in the model is 1.0 and this is used as a benchmark or target level, indicative of reference condition. Progressive deviations from 1.0 indicate progressive levels of impairment. In BORIS, a confidence limit of 95% (1.96 X standard deviation of reference site scores) is used for a determination of impairment. Further levels of impairment are assigned incrementally. The impairment categories for the three monthly models are presented in Table 2. This approach follows Reynoldson et. al. (1997) and aims to incorporate normal variation in reference condition into decision criteria.

This assessment relies upon a reference group comprised of only three sites. This falls well below the six minimum recommended by Wright (1995). Wright suggests that RIVPACS type models lose predictive capability with too few reference sites. Greater noise in the final scores is likely to result. Even so, an examination of QA data suggests the model to be working relatively well. The 95% confidence interval associated with values from QA analysis is ± 0.08 (see Appendix 2).

Reference data from only 1995 were used to construct the model. This allowed an examination of year to year variability at reference sites to be made. Another approach would be to "average" the taxa across the time period but this would limit our ability to look at the issue of year to year change. However, as more data becomes available it is likely that the model will be adapted to incorporate reference data from more than a single year's sample event. Periods of three years might initially be considered. This should broaden the predictive capabilities of the model and stabilize its noise component.

Table 2. Impairment Categories (BORIS)

Category	Score		
	April	July	September
No impairment detected	>0.79	>0.75	>0.77
Moderate impairment	0.60 - 0.79	0.52 - 0.75	0.56 - 0.77
High impairment	0.40 - 0.59	0.28 - 0.51	0.34 - 0.55
Severe impairment	<0.40	<0.28	<0.34

Results & Discussion

Ordinations

Figure 3 presents an ordination of all sample events. Two patterns are of interest in this plot:

- 1) sites cluster according to month sampled; and,
- 2) there is a distinct separation of reference sites from all other sites.

There is a strong seasonal component to the taxa collected at these sites. This is particularly true of the April samples. A close inspection of Figure 3 reveals that the July and September reference samples cluster fairly close to each other, indicating a high proportion of common taxa across this time period. The April reference samples are somewhat removed from the July and September clusters.

As a combined unit, Category 2 and 3 sites are consistently spaced away from the reference clusters in all three sample months. Separation between these two groups is not quite so evident although there is a tendency for Category 3 sites to be located furthest away from the reference clusters, (in Figure 3, samples from Category 3 sites have been given a lighter shade of each seasonal colour code in order to make this pattern more obvious).

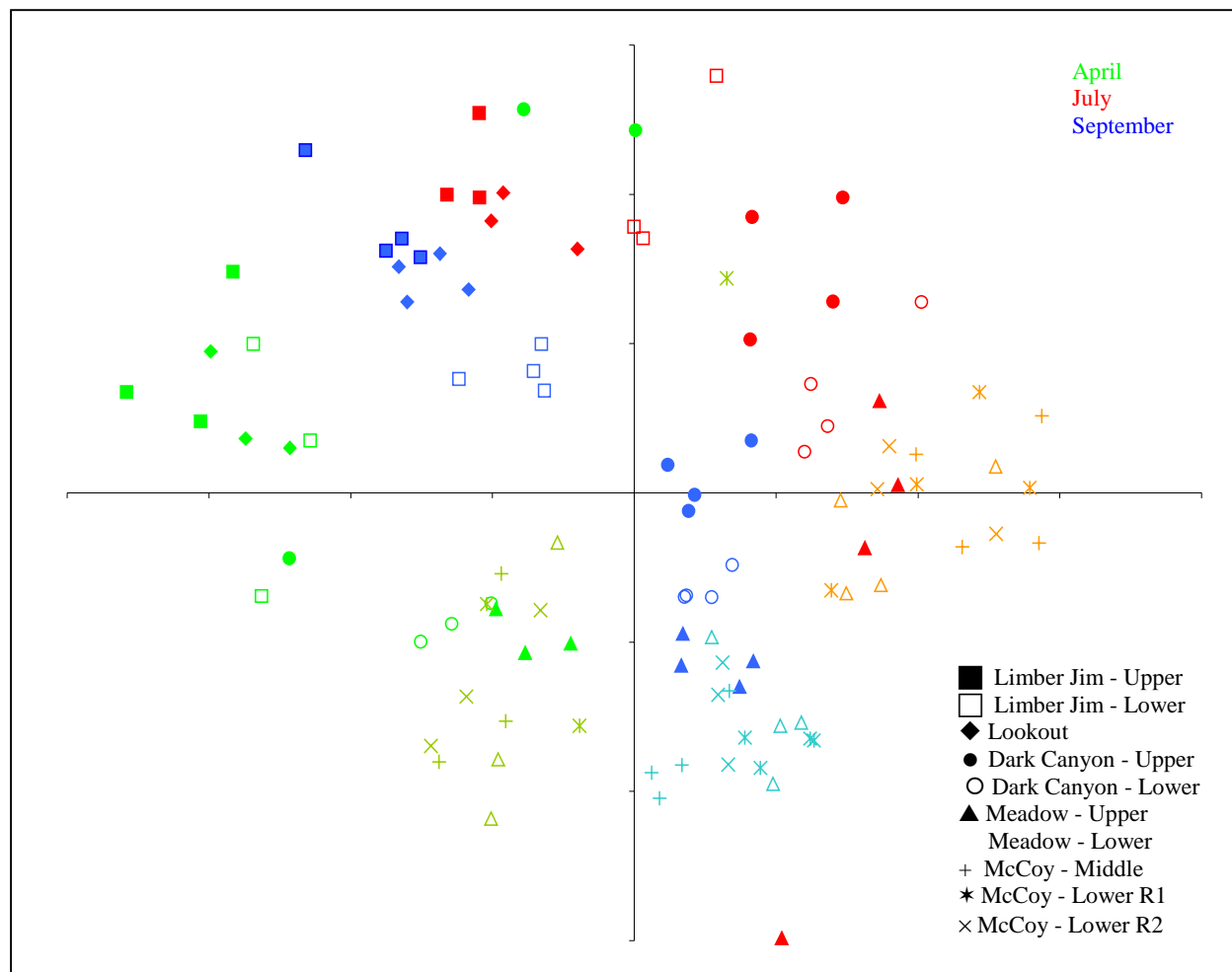


Figure 3. SSH Ordination of all samples from period 1993 - 1996.

Mean Dissimilarity Dendrograms

Figures 4 through 6 present the Mean Dissimilarity Dendrograms for each sampling season. Horizontal bars (and hence, the relative discrimination between groups), are greatest for September. Discrimination between groups is poorest in April. In all three months, a distinction is clearest between Category 1 sites and all other sites. Category 2 and 3 sites display a much smaller between group separation, though dissimilarities are most evident during the September sampling event.

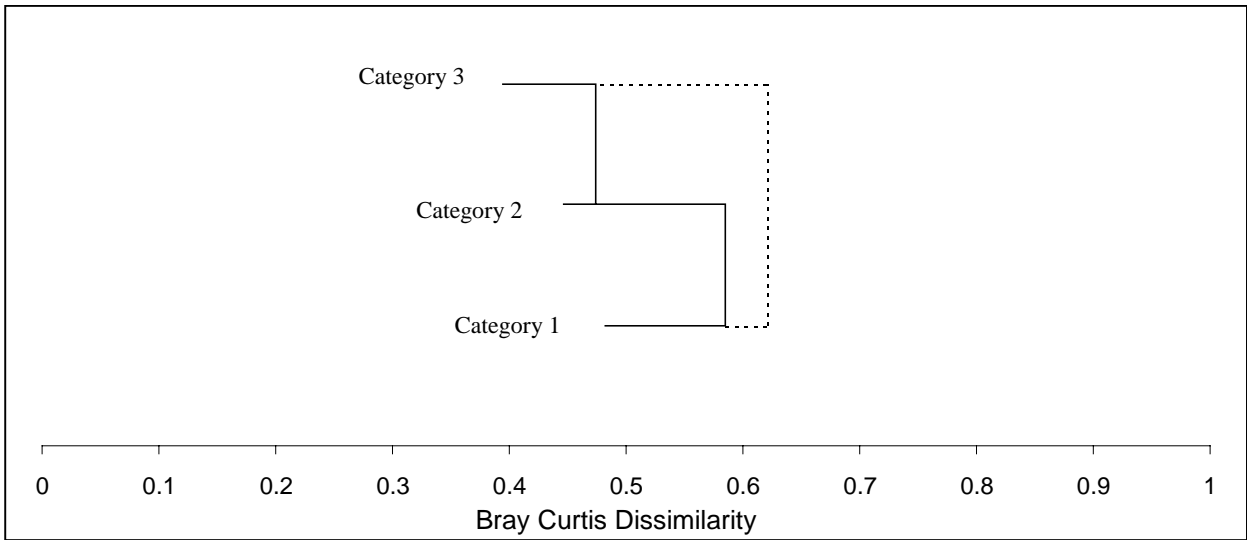


Figure 4. Mean Dissimilarity Dendrogram for April Samples.

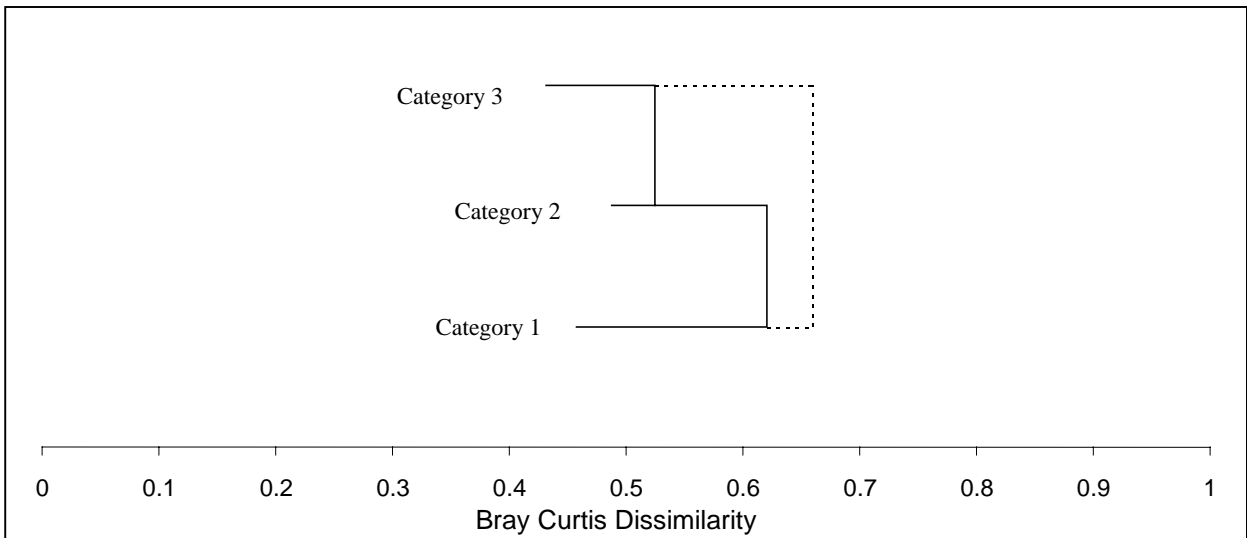


Figure 5. Mean Dissimilarity Dendrogram for July Samples.

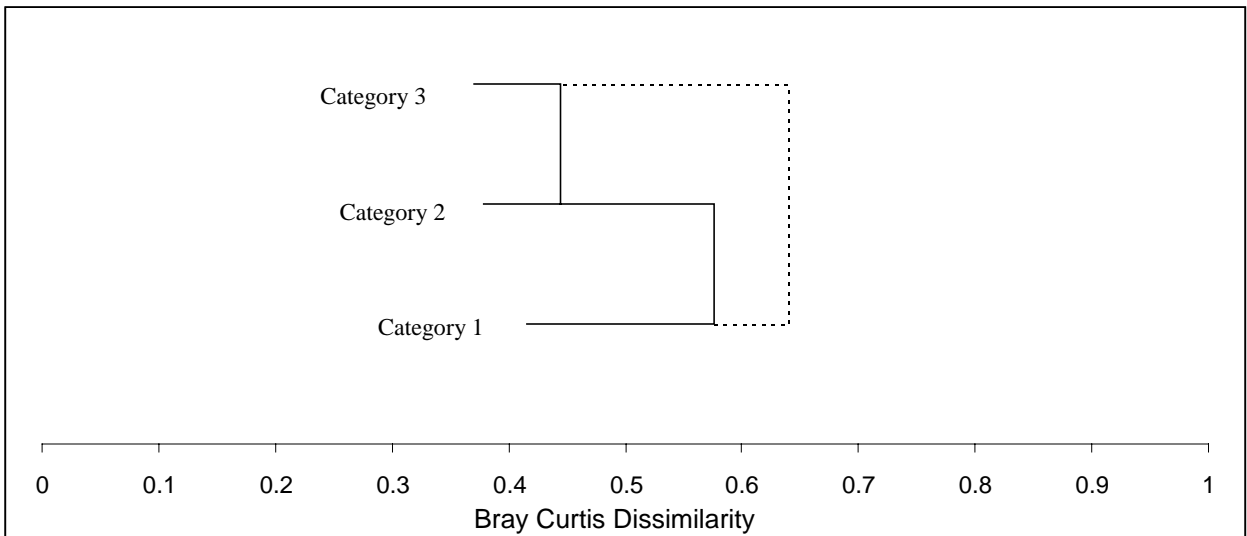


Figure 6. Mean Dissimilarity Dendrogram for September Samples.

Community Evaluation

As indicated above, BORIS is a predictive model. To score well a sample must contain a high proportion of the taxa predicted by the model. Scores for all sample events are presented in Table 3 where those that fall within the moderate impairment category are shown in blue and those within the high impairment category are shown in red. No sites fell in the most severely impaired category.

As might be expected, scores for reference sites are typically 0.85 and above. Recalling that the reference benchmark for the model is based upon samples collected in 1995 only, then it is apparent that the macroinvertebrate communities at both reference sites and non-reference sites have remained fairly stable over the time period in question. That is, larger and more consistent differences in scores exist across seasons and between impairment categories than is the case for annual change at a specific site.

From these data it seems that for the most part, Category 2 and 3 sites in the month of April exhibit macroinvertebrate communities either within or close to, the normal range of reference variation (Figure 7). In the months of July and September, however, sites in these categories display marked deviation from the reference community condition (Figures 8 and 9 respectively). This is most evident for September samples and Category 3 sites overall.

Table 3. Sample Scores (BORIS analysis)

Site	April			July				September			
	94	95	96	93 ¹	94	95	96	93	94	95	96
<i>Reference Sites - Category 1</i>											
Limber Jim Creek - Upper Reach	0.94	1.15	1.15	-	1.01	1.23	0.98	0.99	0.85	1.13	0.96
Limber Jim Creek - Lower Reach	1.01	0.87	0.94	-	0.88	1.01	0.85	0.80	0.77	0.88	0.83
Lookout Creek	0.91	0.98	0.87	-	0.92	0.82	0.85	0.88	0.91	0.96	1.13
<i>Intermediate Condition - Category 2</i>											
Dark Canyon - Upper Reach	0.70	0.70	0.70	0.60	0.88	0.60	0.73	0.52	0.58	0.50	0.44
Dark Canyon - Lower Reach	0.84	0.77	0.84	0.76	0.57	0.57	0.73	0.66	0.63	0.55	0.50
Meadow Creek - Upper Reach	0.73	0.77	0.70	0.51	0.63	0.60	0.51	0.58	0.63	0.52	0.63
<i>Most Disturbed - Category 3</i>											
Meadow Creek - Lower Reach	0.87	0.52	0.63	0.47	0.63	0.60	0.60	0.58	0.58	0.44	0.50
McCoy Creek - Middle Reach	0.84	0.66	0.77	0.41	0.38	0.44	0.54	0.39	0.55	0.44	0.39
McCoy Creek - Lower Reach 1	0.73	0.66	0.70	0.44	0.54	0.54	0.66	0.55	0.55	0.44	0.58
McCoy Creek - Lower Reach 2	0.80	0.80	0.77	0.54	-	0.54	0.63	0.58	-	0.52	0.50

¹ 1993 "July" collections were actually taken in June

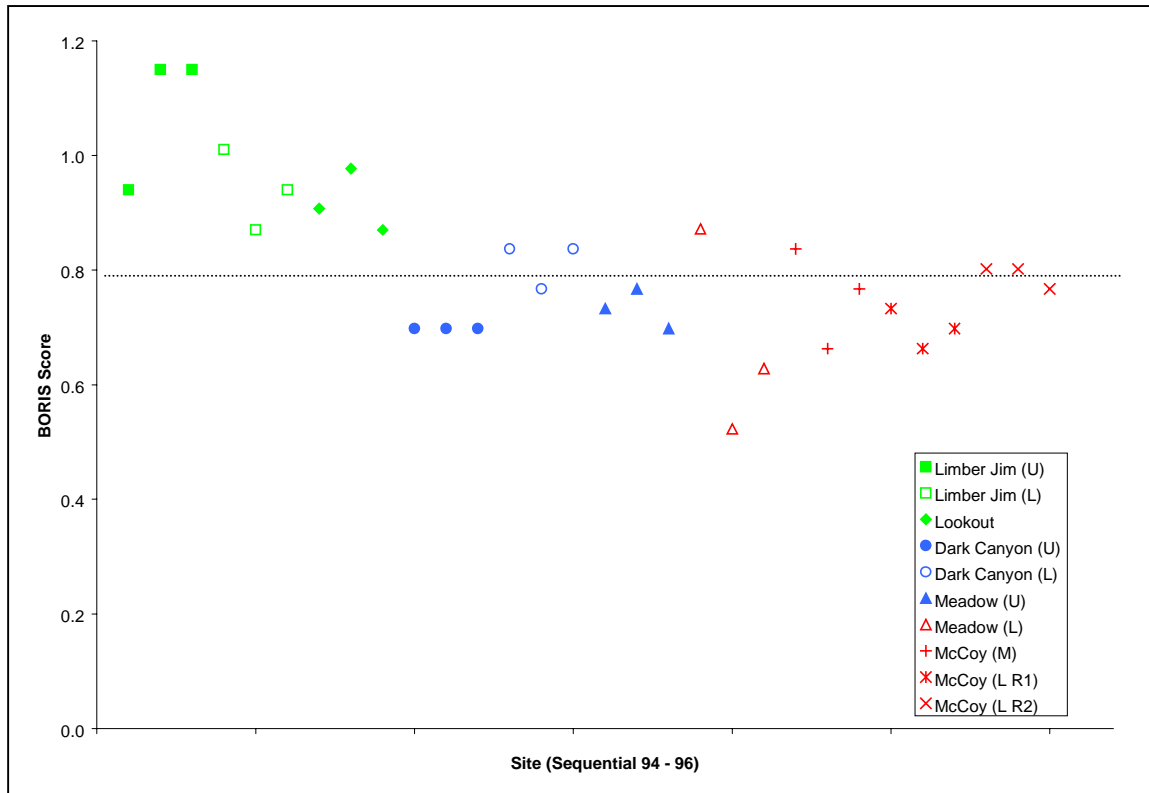


Figure 7. April Scores

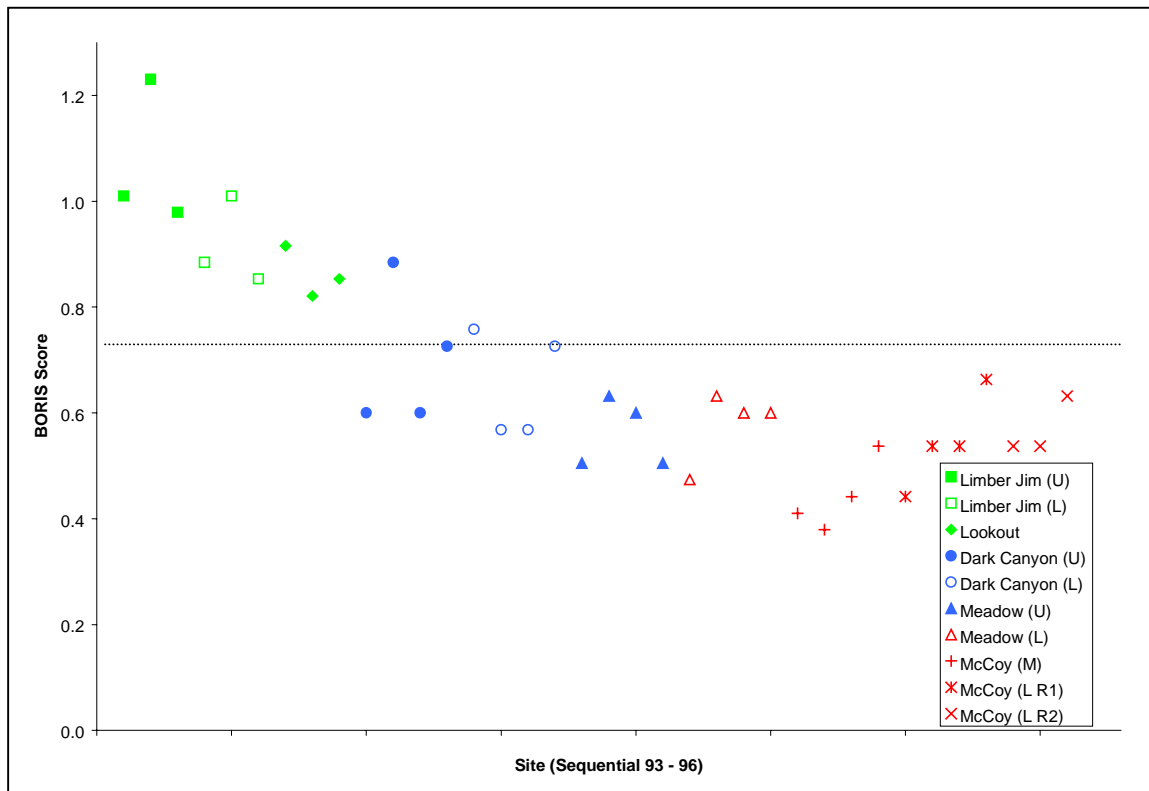


Figure 8. July Scores

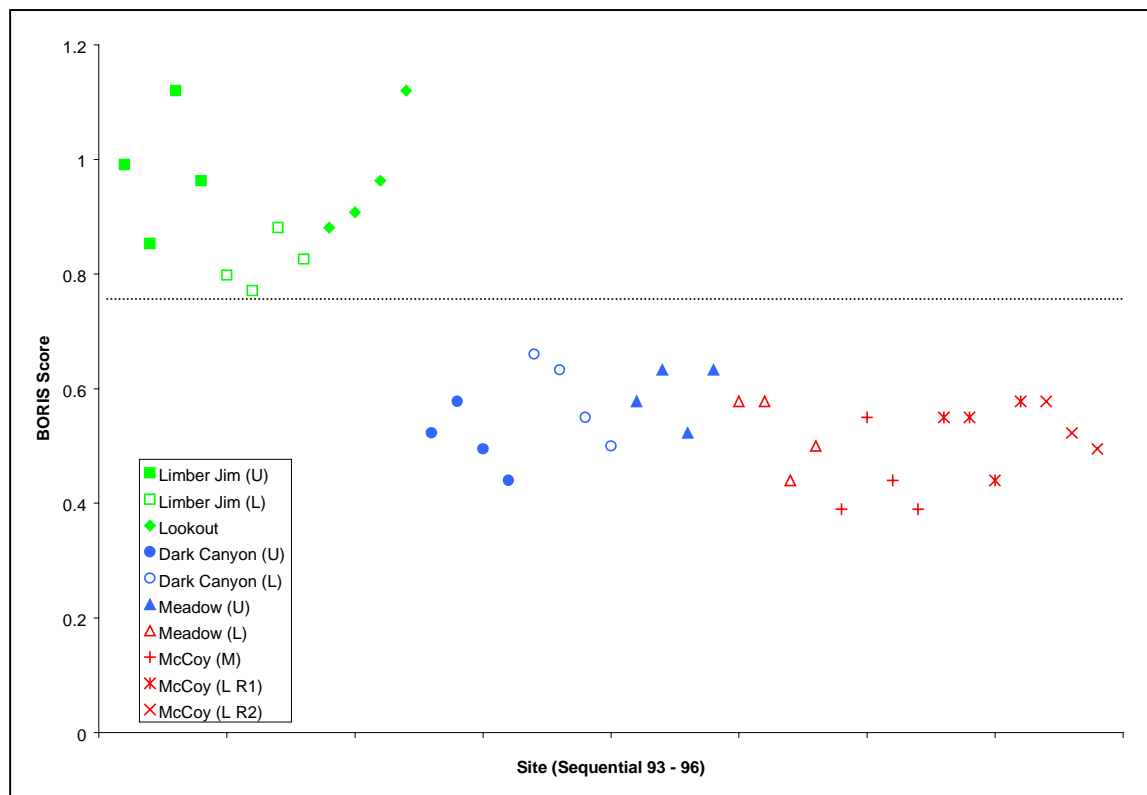


Figure 9. September Scores

April Taxa

For the most part, non-reference sites contain a high proportion of the taxa found at reference sites at this time of year. Scores are somewhat lower than typical reference site scores and this is largely due to the absence of the following group of predicted taxa (note that some of these taxa do occasionally occur at some non-reference sites, but typically they are absent): *Baetis bicaudatus*, *Caudatella*, *Cleptelmis*, *Glossosoma*, *Hesperoperla*, *Heterlimnius*, *Pericoma* and *Rhyacophila*. *Baetis bicaudatus*, *Caudatella* and *Glossosoma* are considered to be either sensitive or sediment intolerant taxa. The remaining taxa are all Collector-gatherers or Predators with moderate to high sensitivity to disturbance.

July Taxa

A much longer list of predicted taxa tend to be missing from non-reference sites in July, these include: *Doroneuria*, *Drunella*, *Glossosoma*, *Glutops*, *Hesperoperla*, *Heterlimnius*, *Leuctridae*, *Micrasema*, *Paraperla*, *Rhyacophila*, *Seratella*, *Visoka cataractae* and *Zapada Oregonensis Gr.* In addition, the following predicted taxa were not uncommon at Category 2 sites but usually absent at Category 3 sites: *Amaletus*, *Cinygmula*, and *Zapada cinctipes*. Many of the listed taxa are either sensitive or sediment intolerant. The remainder have generally low tolerance to disturbance.

September Taxa

Predicted taxa not appearing in non-reference sites include most of those already listed for April and July. Although some of the Category 2 sites in July tended to have higher scores than Category 3 sites, in September the two groups are essentially scoring equally poorly. Predicted taxa typically missing from

non-reference sites in September include: *Amaletus*, *Baetis bicaudatus*, *Brachycentrus*, *Capniidae*, *Caudatella*, *Cinygmula*, *Cleptelmis*, *Drunella*, *Glossosoma*, *Glutops*, *Hesperoperla*, *Heterlimnius*, *Micrasema*, *Pericoma*, *Rhyacophila*, *Visoka cataractae*, *Yoraperla*, and *Zapada Oregonensis Gr.*

Other Measures of Impairment

In the absence of a full assessment against the BORIS model, other useful measures of macroinvertebrate community status include various taxa richness and relative abundance metrics. While not a comprehensive assessment of stream biologic condition, these measures are easily calculated from taxonomic lists and give an immediate feel for the site. Three measures in particular, Total and EPT Taxa Richness and % Dominant Abundance (top three taxa), can be usefully applied to a taxonomic list for a quick appraisal of a site and for raising warning flags about its macroinvertebrate community status.

Figures 10 through 15 present BORIS scores plotted against values of the two richness measures for each of the sample months. From these plots it seems that a richness of less than 30 and 18 for Total Taxa and EPT Taxa respectively, represent a critical level below which impairment can be confidently assigned. These values seem to be fairly consistent across all sample months. There seems to be considerably more noise associated with the % Dominant measure (Figures 16 through 18), and a higher degree of variation with time of year. In April this measure does not discriminate the sites well. In July and September a value of greater than 40% and 50% respectively seems to be a consistent critical level above which impairment can be assigned with some confidence.

For the most part these metrics fail to make a clear distinction between the Reference Sites and sites assigned to the Moderately Impaired category. This is particularly so for the April sample events.

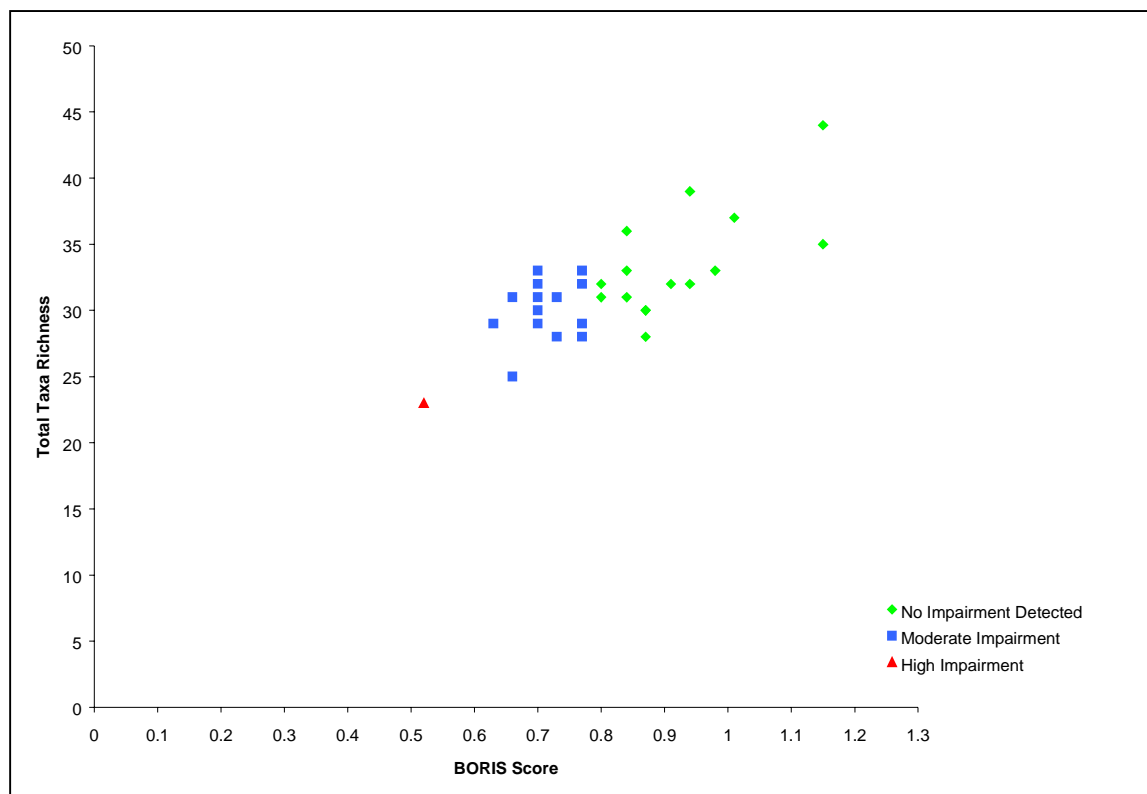


Figure 10. April BORIS Scores vs Total Taxa Richness

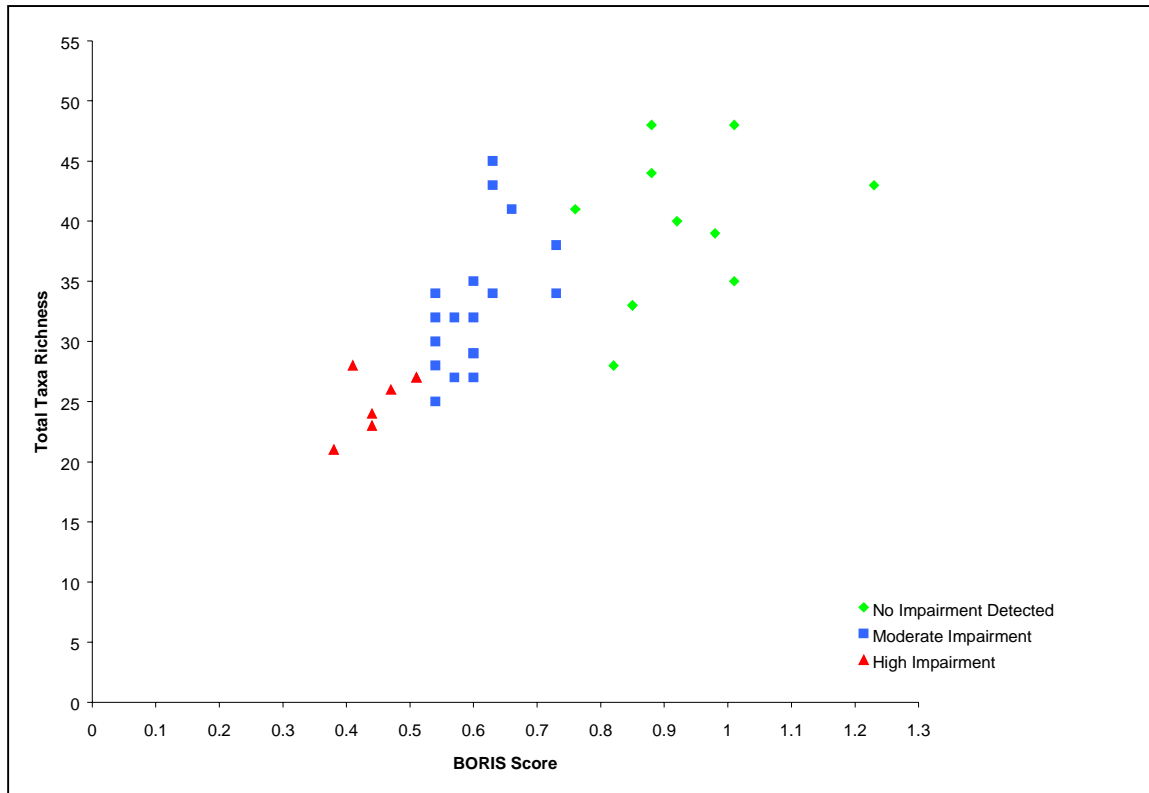


Figure 11. July BORIS Scores vs Total Taxa Richness

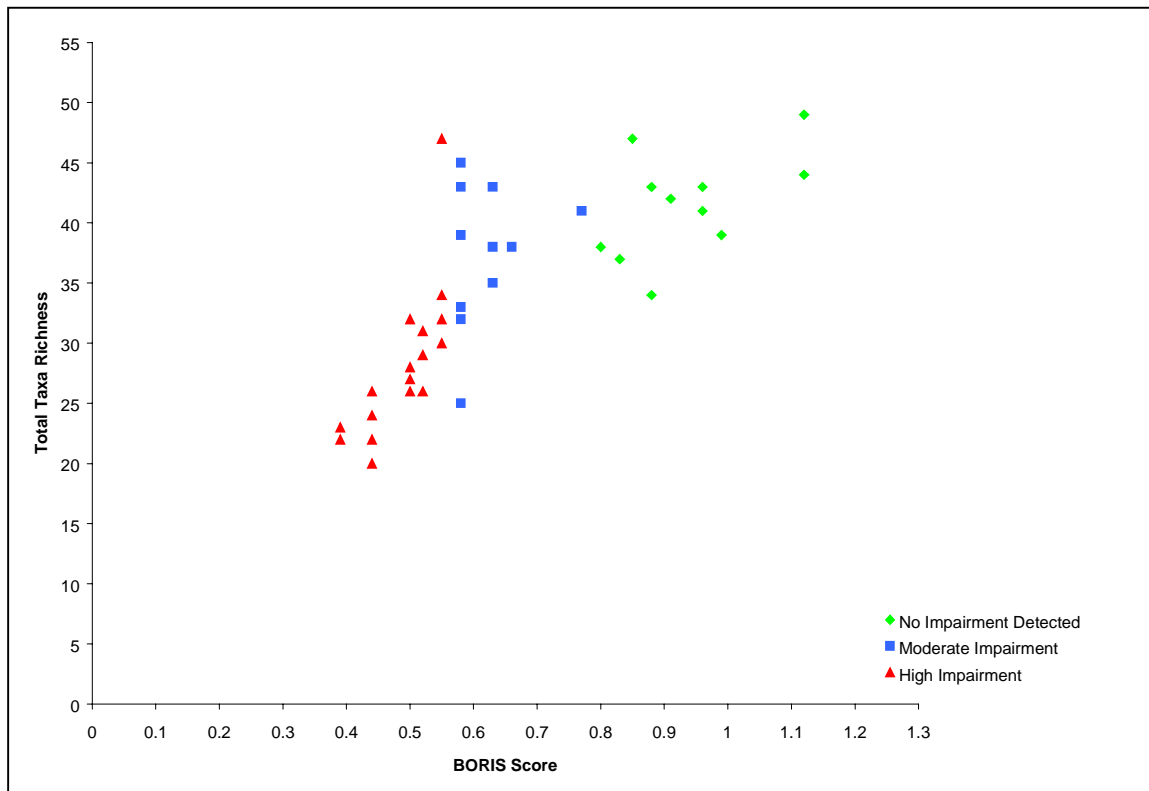


Figure 12. September BORIS Scores vs Total Taxa Richness

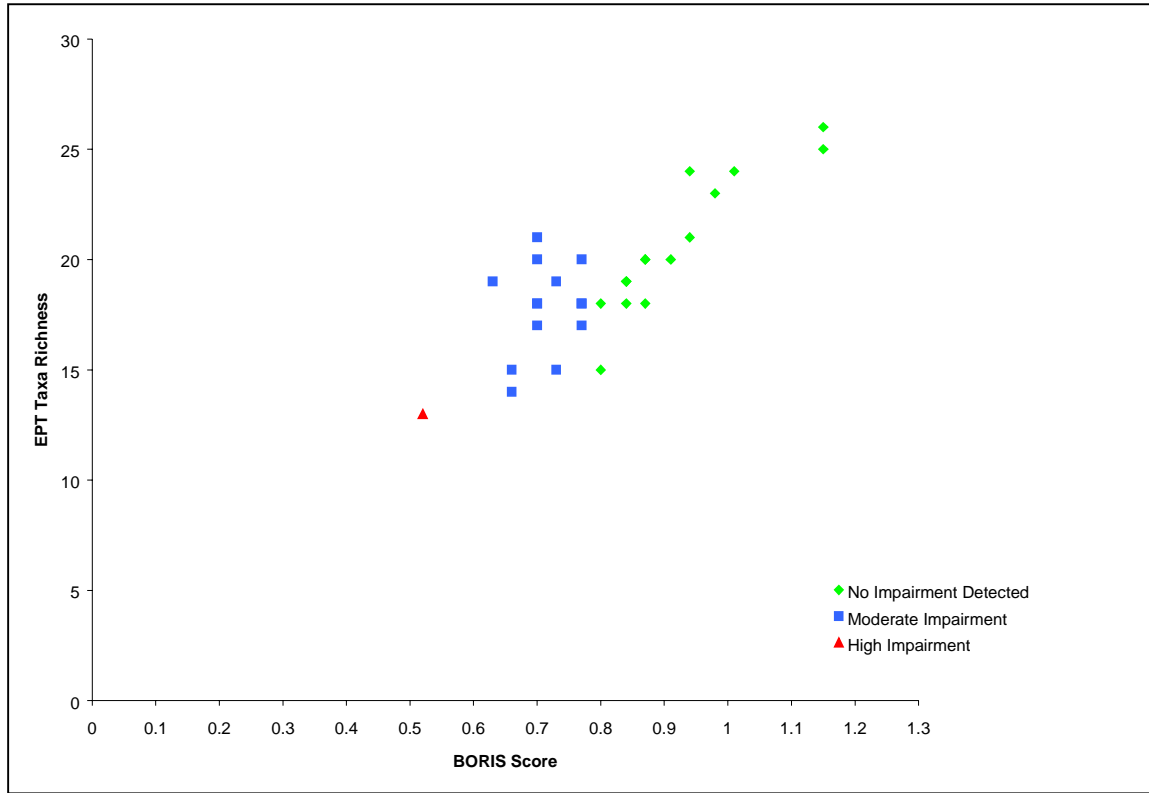


Figure 13. April BORIS Scores vs EPT Taxa Richness

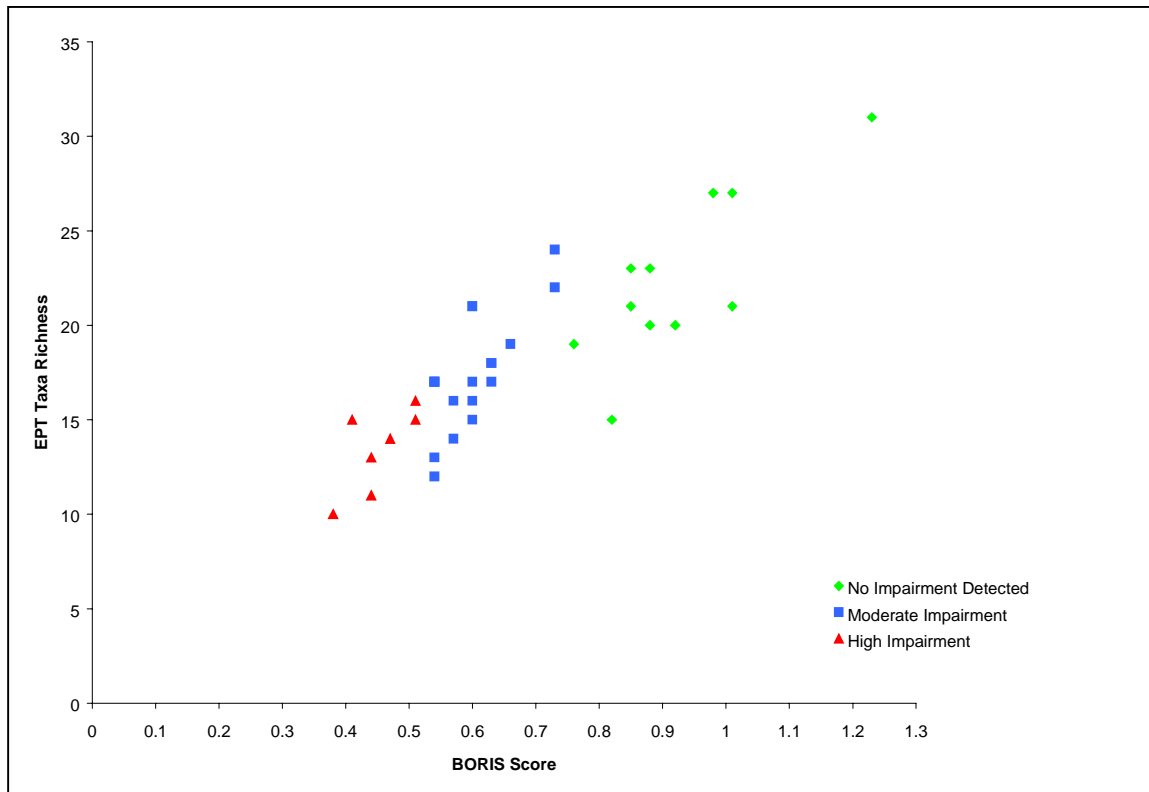


Figure 14. July BORIS Scores vs EPT Taxa Richness

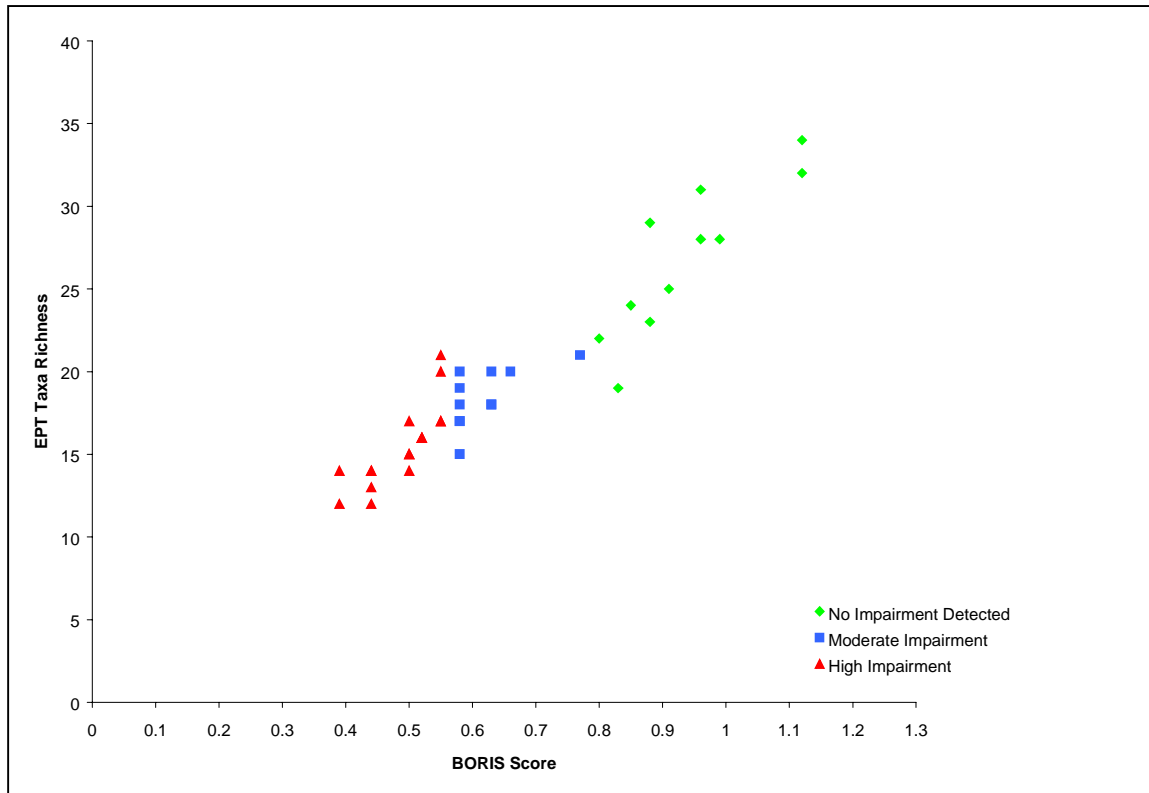


Figure 15. September BORIS Scores vs EPT Taxa Richness

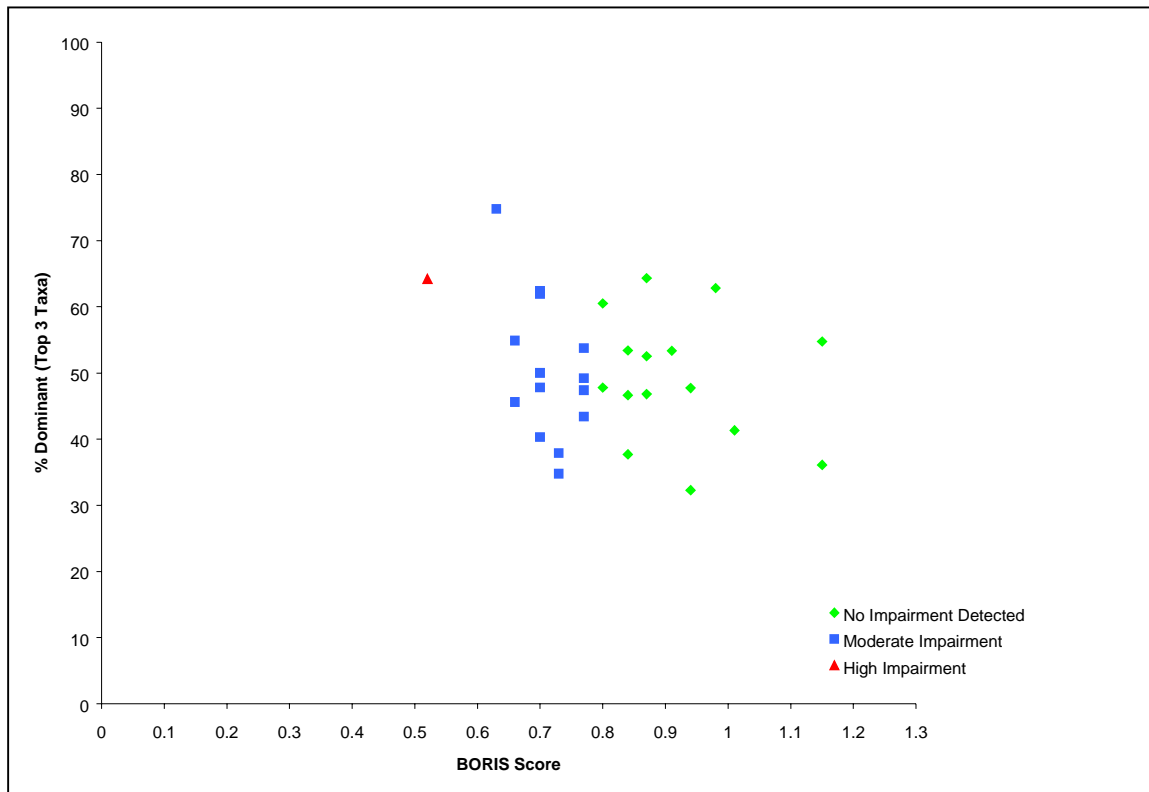


Figure 16. April BORIS Scores vs % Dominant (Top 3 Taxa)

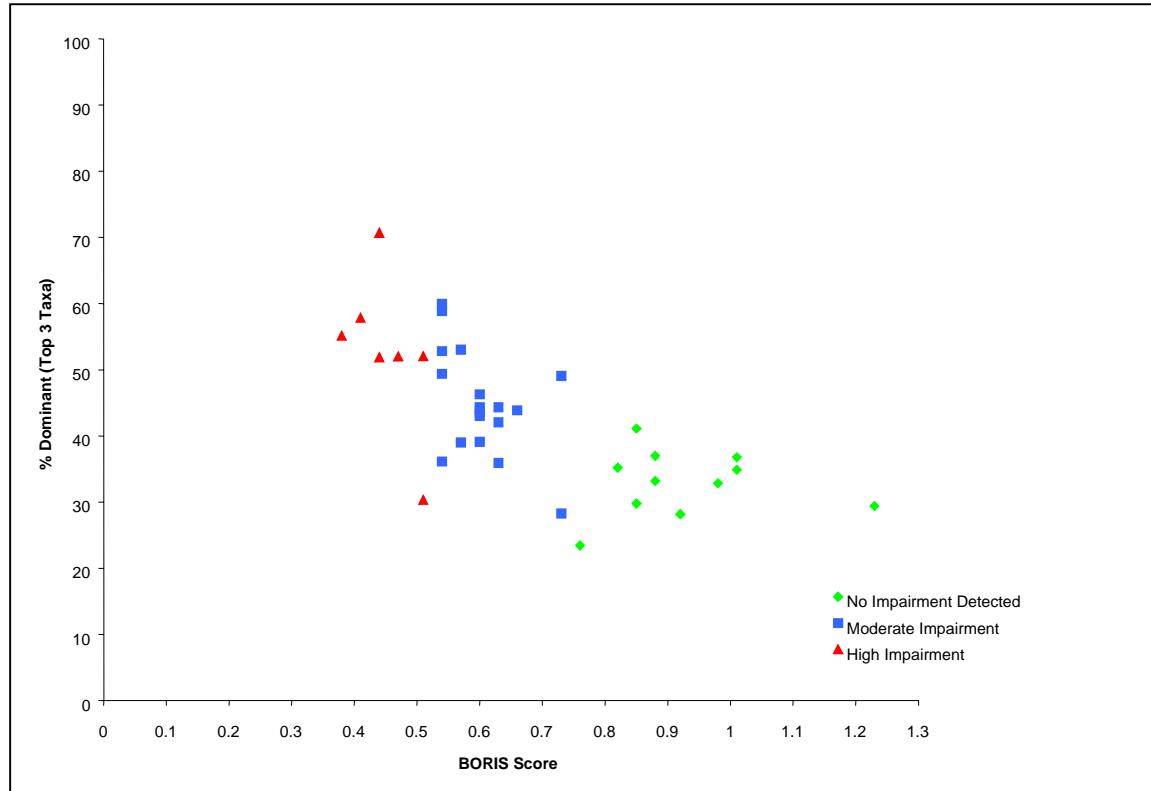


Figure 17. July BORIS Scores vs % Dominant (Top 3 Taxa)

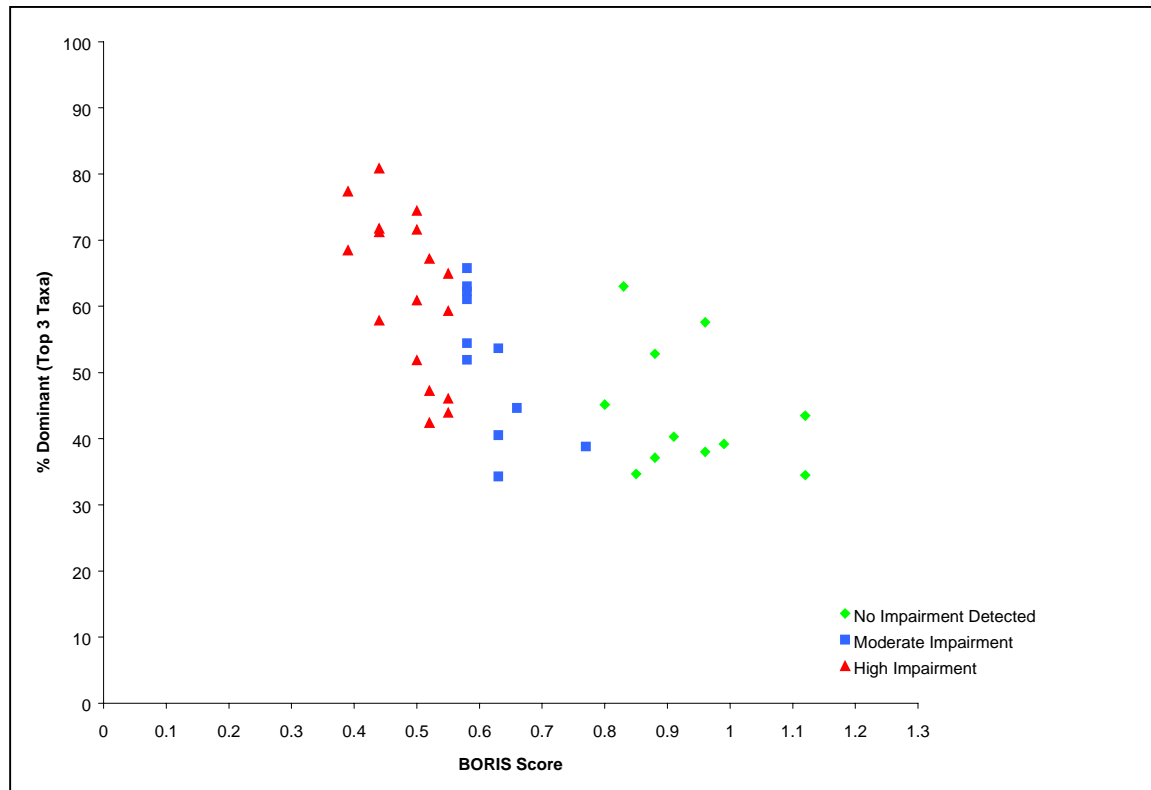


Figure 18. September BORIS Scores vs % Dominant (Top 3 Taxa)

Conclusions

Evaluation of macroinvertebrates at sites within the ODEQ Grande Ronde 319 project indicates that the assignment of the sites to three classes of impairment is appropriate. With the exception of April samples, scores based upon macroinvertebrate modeling of reference condition consistently distinguished between sites in the reference group and all other sites and, to a lesser degree, between sites in moderate condition and those most highly disturbed by human activities (present or historical). Furthermore, the year to year variation in scores at individual sites remained small compared to differences between the range of impairment category scores.

Seasonality in the data set is an important consideration. All site categories undergo distinct changes in macroinvertebrate community composition over the course of a year. Given the relative inability of the April data set to distinguish between the three impairment categories, serious consideration should be given to the winding down of the April component of the monitoring program.

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APPENDIX 1: Predicted Taxa (BORIS)

	April	July	September
Mayflies			
<i>Baetis bicaudatus</i>	X	X	X
<i>Baetis tricaudatus</i>	X	X	X
<i>Dipheter hageni</i>	X	X	
<i>Acentrella</i>			X
<i>Caudatella</i>	X		X
<i>Drunella</i>	X	X	X
<i>Serratella</i>		X	
<i>Ephemerella</i>	X		X
<i>Cinygma</i>			X
<i>Cinygmula</i>	X	X	X
<i>Epeorus</i>	X	X	X
<i>Ironodes</i>		X	X
<i>Rhithrogena</i>	X	X	X
<i>Paraleptophlebia</i>	X	X	X
<i>Ameletus</i>	X	X	X
Stoneflies			
<i>Capniidae</i>	X	X	X
<i>Chloroperlidae</i>	X	X	X
<i>Paraperla</i>		X	X
<i>Leuctridae</i>	X	X	X
<i>Podmosta</i>	X		
<i>Malenka</i>		X	
<i>Visoka cataractae</i>		X	X
<i>Zapada cinctipes</i>	X	X	X
<i>Zapada columbiana</i>		X	
<i>Zapada Oregonensis Gr.</i>	X	X	X
<i>Calineuria californica</i>		X	
<i>Claassenia</i>		X	X
<i>Doroneuria</i>	X	X	X
<i>Hesperoperla pacifica</i>	X	X	X
<i>Cultus</i>			X
<i>Diura</i>	X		X
<i>Perlinoles</i>			X
<i>Skwala</i>	X	X	X
<i>Yoraperla</i>		X	X
<i>Pteronarcys</i>	X	X	X
<i>Taeniopterygidae</i>			X

	April	July	September
Caddisflies			
<i>Lepidostoma</i>	X		X
<i>Rhyacophila</i>	X	X	X
<i>Brachycentrus</i>	X	X	X
<i>Micrasema</i>	X	X	X
<i>Glossosoma</i>	X	X	X
<i>Arctopsyche grandis</i>	X		X
<i>Parapsyche</i>			X
<i>Hydropsyche</i>	X	X	X
<i>Ochrotrichia</i>	X	X	X
<i>Ecclisocosmoecus</i>			X
<i>Onocosmoecus</i>	X		X
<i>Dolophilodes</i>		X	X
<i>Neophylax</i>		X	
Beetles			
<i>Dytiscidae</i>			X
<i>Cleptelmis</i>	X	X	X
<i>Heterlimnius</i>	X	X	X
<i>Lara avara</i>	X		
<i>Narpus</i>		X	X
<i>Optioservus</i>	X	X	X
<i>Zaitzevia</i>	X	X	X
Diptera			
<i>Chironominae</i>	X	X	X
<i>Diamesinae</i>		X	X
<i>Orthoclaadiinae</i>	X	X	X
<i>Tanypodinae</i>	X	X	X
<i>Atherix</i>		X	
<i>Glutops</i>		X	X
<i>Ceratopogoninae</i>		X	X
<i>Pericoma</i>	X		X
<i>Hemerodromia</i>		X	
<i>Prosimulium</i>	X		
<i>Simulium</i>	X	X	X
<i>Antocha</i>	X	X	X
<i>Dicranota</i>	X		X
<i>Hexatoma</i>	X	X	X
<i>Pedicia</i>		X	
Miscellaneous			
<i>Oligochaeta</i>	X	X	X

APPENDIX 2: Standard Errors

x and y represent paired macroinvertebrate sample scores

	x	y	ABS(x-y)
	0.77	0.77	0.00
	0.94	0.86	0.08
	1.01	1.01	0.00
	0.85	0.92	0.07
	0.83	0.72	0.11
	0.63	0.72	0.09
	0.44	0.54	0.10
	0.55	0.58	0.03
	0.73	0.80	0.07
	0.66	0.80	0.14
	0.54	0.54	0.00
	0.44	0.52	0.08
	0.70	0.77	0.07
	0.66	0.63	0.03
	0.58	0.50	0.08
Mean	0.69	0.71	0.063
Std dev	0.17	0.16	0.042

$$\begin{aligned}
 \text{95\% confidence interval applied to standard deviation of paired sample differences} &= 1.96 \times 0.042 \\
 &= \pm 0.08
 \end{aligned}$$