Wolf Creek Community Alliance

Preliminary Benthic Macroinvertebrate Sample Analysis

Purpose

This report is a brief analysis of benthic macroinvertebrate (BMI) samples collected in September and October of 2007, June and October of 2008, and June of 2009 at 4 selected sites within the Wolf Creek watershed. The report contains significant results and associated interpretation of what the BMI collections demonstrate regarding the health and integrity of Wolf Creek, as well as suggestions for further sampling and analysis. It also contains notes and concerns regarding the original data, and caveats when considering the interpretation presented.

Methods

BMI data were first reformatted and the two datasets (one from 2007 and one from 2008-09) were merged by site and species. Data were then entered into PC-ORD to run a Bray-Curtis ordination to visually and numerically assess site similarities based on composition. Ordination is a statistical technique that ranks samples along synthetic (i.e. imaginary) gradients in direct relation to one another based on statistical similarity in sample composition. By doing this multiple times and on multiple axes, analysts can visually assess differences in a number of samples, and begin to understand where those differences exist. This technique is also useful for assessing the relative importance of any measured environmental parameters (e.g. water quality, physical habitat, etc.) in determining site benthic community composition.

In conjunction with the ordination, an MRPP (multi-response permutation procedures) test was also used to quantitatively assess differences between each pair of sites, as well as differences among all sites collectively. This is a non-parametric test (which is preferred for ecological data) that looks for statistical differences between groups of samples, again based on sample composition. In MRPP, the more negative T is, the larger the degree of separation between groups, while a larger A means more within-group agreement than between-group agreement.

Summary statistics were also listed for each site, including: average tolerance value, overall richness, organism count, IBI scores (see below for explanation), and newly calculated %EPT, % Tolerant, % Intolerant, and % Predator metrics. Values were recalculated excluding Arachnid taxa to make them comparable to Deer Creek reference sites, as SSI does not use Arachnid counts. Total number of organisms per sample was also compared by site.

Species data were converted back into family-level data and entered into the recently completed Deer Creek Family-Level IBI (Index of Biotic Integrity). An IBI is a numerical tool that uses a scoring system to grade the biological integrity of a site based on an agglomeration of metrics. The Deer Creek IBI is based on 8 metrics that were selected after an exhaustive analysis of correlations with other metrics, metric response to various disturbances, and real-world interpretation, and has a low score of 8 (highly impaired) and high score of 40 (reference conditions/pristine). By putting the Wolf Creek data into this IBI, overall integrity of the selected sites as well as differences between them can be easily summed up in one number, and comparisons can be made to reference sites in nearby similar watersheds.

Results

Summary statistics are listed in **Table 1**, including the IBI score for each site. The score is out of 40, and the relative percentage score is also listed for interpretation. Site 1 and site 10 from Deer Creek are included for reference. DC1 is near the headwaters of Deer Creek and represents minimal anthropogenic disturbance and a very healthy aquatic habitat and benthic community. Site 10 is in Lower Deer Creek, below Lake Wildwood and above the confluence with the Yuba River, and is representative of a site with approximately 10% urban development, and high levels of disturbance demonstrated in both degraded habitat and benthic community. Site 5 had the lowest total number of organisms, and October samples had more organisms than June samples for site 6.

Table 1. Summary of selected sites on Wolf Creek and Deer Creek. IBI score is from Deer Creek Family-Level IBI and is out of a max score of 40. Note that all summary statistics and IBI were calculated without Arachnid taxa, which may cause slight differences from original dataset. "Count" is only listed for 2008-09 data as 2007 data only included the final 500 individual subsample. The three highest ranking values for each variable among the Wolf Creek sites are in bold.

Site	Date	IBI Score	Grade	Richness	Tolerance	Count	% EPT	% Tolerant	% Intolerant	% Predators
2	10/8/2007	29	0.725	38	3.5	**2811**	53.37	**0.613**	50.511	5.316
2	10/2/2008	**32**	**0.8**	39	**3.46**		54.19	1.226	55.419	11.656
5	10/20/2007	27	0.675	31	3.7	489	**94.04**	**0.410**	**77.823**	4.106
5	10/26/2008	28	0.7	**47**	4.69		**90.92**	**0.843**	48.101	2.320
6	10/7/2007	**33**	**0.825**	**41**	3.9	**1479**	53.28	3.281	63.706	**18.532**
6	6/21/2008	28	0.7	36	3.63	886	46.99	3.118	**74.610**	**32.293**
6	10/8/2008	**31**	**0.775**	**43**	**3.14**	**1509**	**65.21**	1.830	**83.295**	**29.748**
6	6/14/2009	27	0.675	36	4.26		45.71	3.061	62.040	5.918
10	9/28/2007	26	0.65	39	4.6	1339	41.17	3.853	45.436	15.415
10	10/5/2008	28	0.7	31	**2.87**		34.86	11.273	48.225	18.162
DC1	10/1/2007	36	0.9							
DC1	6/1/2008	38	0.95							
DC1	10/1/2008	36	0.9							
DC10	10/1/2007	18	0.45							
DC10	6/1/2008	20	0.5							
DC10	10/1/2008	10	0.25							

Key
- Undisturbed
- Relatively Undisturbed
- Moderately Disturbed
- Highly Disturbed
- Extremely Disturbed

Site 6 in general, with the exception of June samples, is considered to have the highest biologic integrity. It should be noted that only site 6 was sampled in June, and when these samples are excluded, site 6 is consistently the most undisturbed site. Site 2 is also consistently relatively undisturbed, with moderate IBI scores, and the highest total number of organisms.

There was no significant seasonal difference between fall and summer among all sites (T = -0.11, A = 0.004, p > 0.05). While there may not be statistical significance, June samples showed substantially lower benthic community integrity at site 6, and thus analysis of seasonality should be interpreted on a case by case basis, and with a larger dataset. Also note that the trend was reversed at the Deer Creek sites, with June samples having higher IBI scores. Sites were significantly different from each other (T = -3.36, A = 0.21, p < 0.01). **Table 2** shows the degree of difference among sites. Site 6 was the only site that was significantly different from all other sites. The significant T but insignificant A for site 2 vs 5 and 10 vs 5 demonstrate differences between the sites, but that there was not enough within-group agreement within the sites. In other words, site 2 may be different from site 5, but site 2 in 2008 is also significantly different from site 2 in 2007, negating a significant difference between the sites. This means only site 6 has constant benthic composition that is also different from the other sites.

Table 2. MRPP values for comparing differences between seasons and among sites. Bold values are significant.

MRPP	T	A	p
Seasonality	-0.11629	0.004225	0.401026
All Sites	-3.35878	0.213523	**0.00244**
6 vs 2	**-1.95846**	**0.087724**	**0.041984**
6 vs 10	**-1.94673**	**0.17106**	**0.040165**
6 vs 5	**-2.34348**	**0.212957**	**0.025849**
2 vs 10	-0.94183	0.120373	N/A
2 vs 5	**-1.03064**	0.177963	N/A
10 vs 5	**-1.23754**	0.211275	N/A

Figure 1 shows the difference among sites based on absolute abundances of each taxa. The closer two sites are together in the ordination space, the more similar they are, and farther-spaced sites are compositionally dissimilar. Site 6 is substantially different from the other sites sampled. **Table 3** lists all taxa that could be considered "polar"; that is, they are found primarily toward one end of the two axes in the ordination diagram. For example, *Epeorus sp.* has an Axis 1 r of -0.649, but not a highly significant Axis 3 r, meaning it is likely found in any site toward the left side of Axis 1, including both site 6 and site 2, and possibly site 10.

Sites 2 and 10 in 2007 were similar to site 5 in 2008, and all three sites seem to show a similar pattern from 2007 to 2008, shifting down on Axis 3. This shows increased relevance of all taxa listed in **Table 3** with a highly negative Axis 3 r (*Argia sp.*, Non-distinct Ephemerellidae, and *Paraleptophlebia sp.*) in the samples taken in 2008. Non-distinct Ephemerellidae should be excluded based on the fact that they simply were not able to be identified. Total numbers of Ephemerellidae were relatively unchanged, but many more were "non-distinct" in 2008. *Paraleptophlebia sp.* (tolerance value = 4) abundance approximately doubled at sites 2 and 10 from 2007 to 2008, and went from absent to a few organisms (3) at site 6. *Argia sp*. essentially disappeared from site 2 and 10 samples from 2007 to 2008. It is an Odonate (dragonfly) with a tolerance of 7, and its disappearance could be a small sign of stream health improvement.

Table 3. List of "polar" taxa from ordination, along with Axis 1 and 3 pearson correlations (r) and tolerance values. Higher values represent the right or top end of an axis, while negative values represent the left or bottom end of an axis.

Taxon	Axis 1 r	Axis 3 r	Tolerance Value
Ampumixis dispar	**-0.546**	**0.74**	4
Argia sp.	0.171	**-0.594**	7
Baetis sp.	**0.861**	0.232	5
Caudatella sp.	**0.578**	-0.153	1
Chelifera/Metachela	-0.179	**0.692**	6
Cordulegaster dorsalis	**-0.547**	**0.733**	3
Drunella sp.	**0.626**	0.273	0
Epeorus sp.	**-0.649**	0.345	0
Estelloxus sp.	-0.179	**0.692**	8
Gumaga sp.	-0.352	**0.699**	3
Hesperoperla sp.	0.376	**0.685**	2
Heteroplectron californicum	**-0.786**	0.401	1
Hydropsyche sp.	-0.179	**0.692**	4
Hydroptila sp.	**0.679**	0.221	na
Hydrodroma sp.	**0.501**	-0.213	5
Ironodes sp.	0.109	**0.593**	3
Juga sp.	-0.403	**0.784**	7
Lara sp.	**-0.586**	**0.689**	4
Lebertia sp.	**0.527**	-0.108	8
Lepidostoma sp.	**-0.548**	**0.809**	1
Meringodixa chalonensis	**-0.631**	0.287	2
Micrasema sp.	**0.511**	0.124	1
Narpus sp.	-0.426	**0.508**	4
Neoplasta sp.	**-0.559**	0.171	6
Non-distinct Ephemerellidae	0.031	**-0.612**	1
Non-distinct Anisitsiellidae	-0.179	**0.692**	5
Non-distinct Chironomidae	**-0.665**	-0.114	6
Non-distinct Empididae (Pupae)	-0.179	**0.692**	na
Non-distinct Muscidae	**0.679**	0.221	6
Ochthebius sp.	**-0.631**	0.287	5
Octogomphus specularis	**-0.642**	**0.651**	4
Paraleptophlebia sp.	-0.049	**-0.821**	4
Pteronarcys sp.	-0.497	**0.644**	0
Soyedina sp.	0.063	**0.703**	2
Spechon sp.	**0.841**	-0.33	8
Sperchonopsis sp.	**0.791**	0.287	8
Stilobezzia sp.	-0.235	**0.684**	6
Tipula sp.	**-0.558**	0.302	4
Zapada sp.	**0.512**	-0.37	2

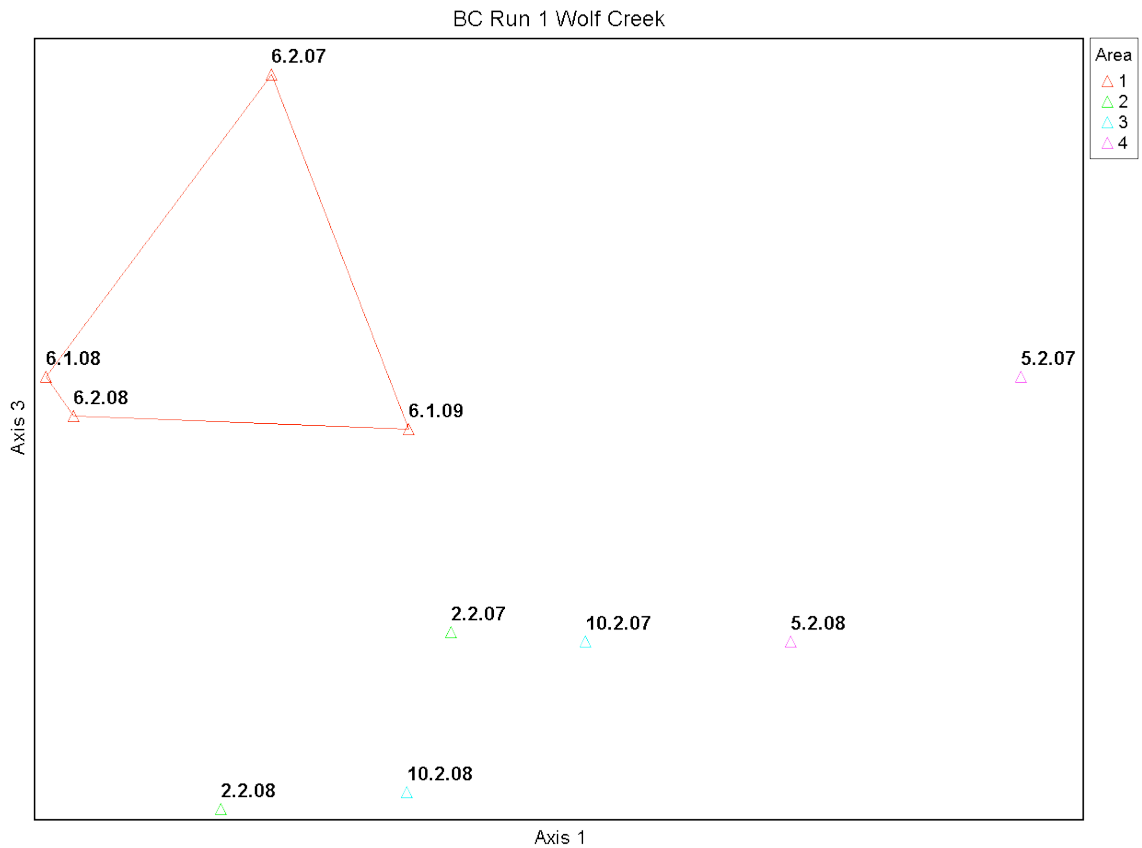

Figure 1. Bray-Curtis (BC) ordination of all selected samples. Sites are labeled with the convention "Site.Season.Year" where 1=Summer, and 2=Fall. In the color key, Area 1=site 6, Area 2 = site 2, Area 3 = site 10, and Area 4 = site 5. The red line is present to show all 4 samples from site 6. Note trend in all sites of downward shift on Axis 3 from 2007 to 2008.

Conclusions and Discussion

The high IBI scores and raw metrics for sites 2 and 6 make sense, as site 2 is fairly high in the watershed, and site 6 is fairly high in a tributary. However, the similarity between site 2 and site 10, with site 5 being dramatically different from site 2, as demonstrated in the ordination, is cause for more analysis. Samples from site 10 would be expected to show at least some slight decline in health being so far downstream and being subject to various inputs that may increase disturbance. There may be some input or other disturbance between sites 2 and 5 causing a decrease in health immediately downstream.

Overall, sites 2 and 6 appear the healthiest and most intact. Site 6 appears to be insulated from changes to main stem Wolf Creek, demonstrating possible effects of irrigation and other disruptions in flow. The fact that the same trend in the change in community composition is shared among all sites shows that these samples can accurately describe the communities in relation to each other and in relation to disturbance (i.e. they are accurate and acceptable, and samples can continually be used to monitor the stream).

Suggestions for Future Samples and Analysis

Due to its insulation and healthy benthic community, site 6 should continue to be sampled. The same can be said for site 2, or even site 1 depending on ease of sampling. Site 5's dramatic difference from site 2, and the fact that this difference seems to drop out of the stream by site 10, shows that a sample, along with water quality measurements, should be focused around sites 3, 4, and 31 to find where/what is causing lower biotic integrity at site 5. As noted in the IBI scores, though, site 5 is still quite healthy compared to heavily disturbed sites along Deer Creek. I would also recommend continuing sampling on lower Wolf Creek, whether that means continuing at site 10 or moving up or downstream depends on your goals. If site 10 seems relatively healthy, I would recommend moving upstream and possibly sampling closer to the bottom end of Grass Valley (site 8 or 9). I would also recommend sampling in both seasons, as this will give you a more consistent and precise look at actual differences among sites.

Future analysis should include multivariate techniques to assess causes for changes in benthic health when they arise. The ordination technique demonstrated above, as well as one known as Non-metric Multidimensional Scaling (NMS) can be used in conjunction with environmental data (water quality) to show the relative significance of various measured environmental parameters in determining benthic community composition (e.g. a very intolerant organism disappeared from a certain site around the same time pH decreased, etc.)

I would also note that some taxa were not recorded one year versus the other. For example, Megaloptera, an order of relatively important predators, were not reported for 2007. I can't tell by the way the data is listed if this means they were simply not present, or if they were actually not reported. The same can be said for Hemiptera. The one family reported in 2008 has a very high tolerance value, and while there are only a few organisms in the sample (3), their presence can definitely alter the community metrics. They didn't change metrics too much in these samples, but be aware of this in the future and make sure they are reporting everything found in the samples, or have a standardized form that just does not list absences but lists all possible organisms.

Overall, all sites seem relatively healthy, and I would recommend collecting more data before making any full conclusions and changing too many things. Feel free to contact me with any more questions regarding interpretation or results.

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