

Using Stream Invertebrates to Monitor Water Quality on Lake Creek

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Introduction

Habitat destruction is the primary cause of biodiversity loss in the world and this is true regarding hundreds of thousands of miles of river habitat in the United States converted to human residency (EPA 2006). To stem biotic simplification, habitat restoration projects have been implemented across the country especially since the rise of restoration ecology in the 1990's (Young, 1999). Stream restoration is a subset of restoration ecology that is concerned with improving the water quality and the riparian habitat of moving bodies of water by restoring the natural functions of the stream. Many species of flora and fauna, including sensitive fish, depend upon streams to have proper rates of turbidity, flow, respiration, productivity, as well as heterogeneous riparian vegetation. In order to know how to restore a stream though, managers must know the amount of degradation that has taken place and use this information to influence clearly defined, attainable, and quantifiable goals for their specific project (CGER, 1992).

In Camp Sherman, Oregon, 725 ft. (221 m) of meandering Lake Creek was converted in the 1930's to a large pond by concrete retaining walls because of the development of Lake Creek Lodge. The retaining wall degraded the meandering nature of the stream that the local biotic communities had grown accustomed to; it also raised stream temperatures, and the project's primary building material, concrete, replaced much of the riparian vegetation. In 2004, the Upper Deschutes Watershed Council

partnered with the Deschutes National Forest and proposed a plan for restoring the stream to the owners of the land, the Lake Creek Lodge (LCL, 2006).

The Lake Creek Restoration Plan's goal is to restore the 725 ft. of naturally-functioning stream channel for the benefit of the native anadromous fish populations, primarily the sockeye and Chinook salmon and bull trout. The project will cost \$175,000 and involve removing the concrete retaining wall to re-meander the stream as well as replace the concrete sides with riparian vegetation (Matt Shinderman, personal communication, 9/6/06).

In order to determine the amount of degradation that the stream has undergone and the opportunity for restoration, a baseline water quality must be established. Water quality can be observed many ways, including measuring temperature, pH, turbidity, and dissolved oxygen (EPA, 2006). Observation of biological community dependent upon a water body, also known as bioassessment, can be more revealing as to the general stream health than the other more specific, previously listed methods.

Macroinvertebrates are aquatic insects that can be seen without a microscope. Through surveying their population in a given water body, a biologist can assess the overall ecosystemic health in a relatively timely and inexpensive manner. Macroinvertebrates live their whole lives in water and are therefore totally dependent on high ecosystemic health for their population to thrive. Where there is a high diversity of environmentally-sensitive macroinvertebrates, then there is usually well-functioning ecosystemic processes (EPA, 2006).

Of particular note to macroinvertebrate bioassessment are three orders of insects distinctly sensitive to habitat disturbance: ephemeroptera (mayflies), plecoptera

(stoneflies), and tricoptera (caddisflies). A rapid collection and appraisal of the population size of these three orders versus other orders of insects in a water body can tell much about the health of the water body. In order to establish a baseline of Lake Creek's health, we collected three macroinvertebrate samples: one from the project area that will be restored in October of 2006, as well as one upstream sample, and one downstream sample.

Methods

Our study was based on the Xerces Society's "Guide to Pacific Northwest Macroinvertebrate Monitoring and Identification." The guide provides sampling protocol developed by the Oregon Department of Environmental Quality and is consistent with the Environmental Protection Agency's protocols. The Xerces Society also provides advice on study design, site selection, and multimetric analysis. This testing was done in late summer, September 6th, because late summer is the season with the lowest water level in the Pacific Northwest and therefore macroinvertebrates are the most restricted in their habitat (Sampling Process: Setting Goals).

Study Sites. We collected our macroinvertebrate samples from five sites we chose in the project area as well as four sites upstream, and four sites downstream. We tested each within project site twice for a total of twenty-six collections. These sites were in shallow, quick riffles in the stream that would allow us to collect large numbers of macroinvertebrates in our nets. The sites were approximately 1 - 2 ft. in depth, and were marked at the bottom edge of each grid on the nearest shoreline with a pink flag that read "9-6-06 Macroinvertebrate Monitoring #." We then noted on a map of the Lake Creek where each site was located. Also, each flag was marked, as it related to its site, in our

records along with its bearing, distance, and a note about a nearby tree that stood out. (Description of sampling sites is in a hand-written appendix, on file in Matt Orr's "field course" files.)

Sampling. Once the D-frame kick net with 500-um mesh openings was set down and established against the current, the large rocks in a 1 ft. by 1 ft. area in front of the net were cleaned of any material sticking to them. After the large rocks were hand-cleaned and discarded from the collection site, we would agitate the soil directly in front of the net by dragging our heel across and into the soil and letting the current pick up the material for deposition in the net. Cleaning the large rocks and agitating the soil had the effect of extracting all macroinvertebrates that would be in our small sample riffle. In total, the extractions represented a composite sample of the macroinvertebrate populations from twenty-six sq. ft. of Lake Creek bottom.

After extraction from the river, each net collection was then drained on a 500-um metal sieve and transferred into one of three wide-mouthed plastic bottles (1 liter vol.), then labeled (upstream, within project, or downstream), and preserved using 94% ethanol.

Presorting. All of our macroinvertebrate samples were mixed with large amounts of sediment from soil agitation. In order to sort out the samples from the sediment, 1/3rd of the bottle was placed into a 17" x 20" wash tub, then water was added to a depth of 6" or more, then the sample was agitated until macroinvertebrates floated above the sediment, and finally, the aqueous layer was decanted into a 500-um sieve. This process was repeated ten times for each 1/3rd portion of the sample and an effort was made to remove obvious vegetation and rocks from the sample while separating rock cases and

adding them to the sample. After this presorting was finished we closely observed the sediment with a magnifying glass to find any macroinvertebrates or rock cases that the presorting missed.

Sub-Sampling. A 15" x 12.5" sub-sampling tray consisting of a wooden frame covered with a rigid wire screen for support and a fine mesh for containing the invertebrates was used. A grid consisting of thirty 2.5" squares was used; (the thirty squares had been hand-drawn onto the fine mesh net with a permanent marker and then were labeled "1-30"). The frame was then placed within a 17" x 20" plastic tub and immersed in 1" of water. The sample was poured into the frame, then evenly distributed by agitation, and then the frame was lifted straight out of the water. A square was selected at random and the entire contents were removed from the tray using a spoon and forceps and then placed into Petri dishes for further analysis.

Macroinvertebrates were identified using dissecting scopes, the "Guide to Pacific Northwest Aquatic Invertebrates," and the "Macroinvertebrates of the Pacific Northwest." When identified to its order, a macroinvertebrate was then placed into one of four ice cube dishes filled with ethanol that was labeled E, P, T, and O(ther).

After sub-sampling had reached at least 500 total macroinvertebrates, we stopped, and began placing sub-samples of our findings into vacuum-sealed tubes marked accordingly for future use. One sample had more than 500 because we had that many during the first count after reaching 500. Also, we put the unused samples back into their respective bottles for future observation. We were able to sample two out of our three collection bottles: the "within project" bottle and the "downstream" bottle.

Data Analysis. Our comparison of tolerant to sensitive orders of macroinvertebrates yielded Table 1. There are two ways in which this data can indicate overall stream health: either these results should be compared with an independent macroinvertebrate community composition standard or it should be compared with an “after restoration” sample. Either option will transform this raw data into a score indicating the overall condition of Lake Creek but the former option will tell its current overall health whereas the latter option will tell of the changes that the restoration has brought to the stream’s health.

There is a certain level of disagreement amongst scientists as to whether sub-sampling is a legitimate practice, and if so, which method is most valid. Arguments are found in support of a fixed count method using anywhere from 100-900 individuals, others claim a volume based method is most accurate, and some scientists believe that the entire sample must be analyzed (Doberstein et. al. 2000, EPA 2002b). 500 individual samples, though, is consistent with most opinions of what sample size should be.

Results. Our results indicate that Lake Creek has an abundance of sensitive macroinvertebrates relative to the number of other, more tolerant macroinvertebrates. Within the project area the sensitive insects comprised 75% (375/500) of our sample with a slight decrease downstream to 72.0% (420/583).

Amongst the sensitive orders, the more tolerant trichoptera order made up the largest share of sensitive insects both in the project. Within the project area trichoptera accounted for 57.4% (287/500) of total insects sampled and 76.5% (287/375) of sensitive insects sampled. Downstream of the project trichoptera accounted for 41.6% (240/583) of total insects sampled and 57.1% (240/420) of sensitive insects sampled.

Raw totals for all insects were 70 E, 18 P, 287 T, and 125 O within the project reach, and 129 E, 51 P, 240 T, and 163 O below the project reach.

Discussion

Any discussion of these results would have to compare them with background data for Lake Creek, comparison to a reference site, or use these results as indicators of the stream's current health before the restoration and then compare them to samples taken after the restoration. All three of these comparisons would yield different yet equally appropriate discussions of the data and be within experimental design. From a cursory look at the data, two points stick out though: first, the abundance of trichoptera in both sites; and second, the similarity between the two sites.

It is encouraging that even before restoration, there is a higher percentage of sensitive insects compared to the percentage of tolerant insects in Lake Creek. However, it is disconcerting that they are dominated by one order and that order is the most tolerant of environmental damage.

It should not be surprising that there is so much similarity between the two sites because of their proximity to one another and the effect that the in project site has downstream. It is interesting that there was slightly more heterogeneity among the sensitive species downstream as evidenced by an 12.1% increase in Ephemeroptera and a 7.3% increase in Plecoptera, although these differences were not tested for statistical significance. These might indicate a slightly healthier environment further downstream from the pond but more tests would be needed in order to indicate how significant these statistics are. In order to test this hypothesis, biologists could take samples at sites further downstream from the project site and observe amount of heterogeneity. If heterogeneity

increased the further downstream that one got from the project site then this would support our hypothesis.

In general, we recommend that this data be compared to samples taken after the restoration to observe whether the restoration increased the heterogeneity of the macroinvertebrate community. Increased rates of heterogeneity post-restoration, would support our hypothesis that the retaining wall and other Lake Creek Lodge changes was hindering ecosystemic health. The results of this comparison would provide valuable data for stream restoration activities worldwide as well as indicate the success or failure of Lake Creek's restoration project.

Also, comparing our sample data to a reference site would indicate the ecosystemic health of Lake Creek. A good reference site might be Lake Creek upstream of the project site because that would indicate how much of a disturbance the retaining wall and other changes have done to Lake Creek. If "upstream" data is similar to "within project" and "downstream" data then that would indicate that Lake Creek Lodge may not be the primary cause of poor health and therefore biologists could hypothesize other reasons for poor health. Conversely, if "upstream" samples yield higher rates of heterogeneity, then this would support our hypothesis that the retaining wall is hindering health of Lake Creek.

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