Benthic Macroinvertebrate Sampling: Integrating Stream Ecology, Nested Sampling Designs, and Bundled Research Strategies

Benjamin J. Schoville, Alisa Hjermstad, Todd Wellnitz, and Lawrence C. Todd

ABSTRACT

The Greybull River Impact Zone (GRIZ) project seeks to understand human impacts, prehistoric, historic, and present within the Greybull River drainage system, Northwest Wyoming. Stream ecology is valuable for an integrated understanding of human ecology in the region. By incorporating a nested sampling design specifically for benthic macro-invertebrate recovery which is also utilized by plant ecologists, terrestrial entomologists, and recently, archaeologists, a comparable sample may be created with which researchers are capable of integrating the otherwise disjointed datasets. Preliminary research completed during the 2002 field season indicated that an adapted version of the Modified-Whittaker sampling design quickly and efficiently recovered a wide range of the aquatic insects often used in measures of stream health. Additional research during the 2003 field season sought to compare the adapted Whittaker method with more traditional macro-invertebrate collection procedures. For methods comparisons, 27 samples of traditional benthic invertebrates were recovered involving ~5cm x 20 cm surber-kick-net sampling. While being a valuable baseline for monitoring the stream ecology with increased human presence, the data also may prove a valuable tool in the stream ecologist's toolkit for benthic macro-invertebrate collection procedures. The small, "mini-mod" sample units may also be effectively applied to high density surface archaeological materials.

The Greybull River Impact Zone (GRIZ) project seeks to understand human impacts, prehistoric, historic, and present within the Greybull River drainage system. Within this effort, the stream ecology of the river itself is highly valuable for an integrated understanding of human ecology in the region. The headwaters of the Greybull lie in northwestern Wyoming in the Absaroka Mountains. The area has experienced very limited human impacts during the historic period. With exception to some limited mining endeavors and small-scale ranching, the region is essentially in its pre-Colombian state. Plant ecologists from CSU noted in 2002 that during the 20 days of field school they didn't find a single invasive plant species. However, more recently the Greybull trail has been built which parallels and crosses the river for approximately 12 miles. With this trail there is expected to be a large increase in fishing, hunting, camping, and recreational tourism. The region lies within the Greater Yellowstone Ecosystem, which anticipates more than 3 million visitors every year to the region. Documenting the present landscape conditions will be essential for understanding how increased human impacts alter this landscape in the future. Monitoring the archaeological landscape through a catch and release framework (Todd, this symposium) for site recording is essential to monitoring human impacts on the archaeological record. Alongside this dataset, it is of interest to know how increased human presence is altering the ecology and to what degree the archaeology and the ecology are coupled. Do artifact density and insect populations both go down with increased human occupation in the area or are they inversely related? Understanding the present and monitoring the future will provide a substantial body of research to the Greater Yellowstone Ecosystem and aid in the management and maintenance of healthy environmental conditions (Hobbs 2003; Liu 2001).

To sample the stream macroinvertebrates, a new sampling method called a mini-Modified Whittaker was tested in 2002. The Modified Whittaker was shown by Stohlgren and others (1995; 1998) to capture more data on rare and exotic rangeland plant species, independent frequency data and more accurate species area curves.

A.)

B.)

C.)

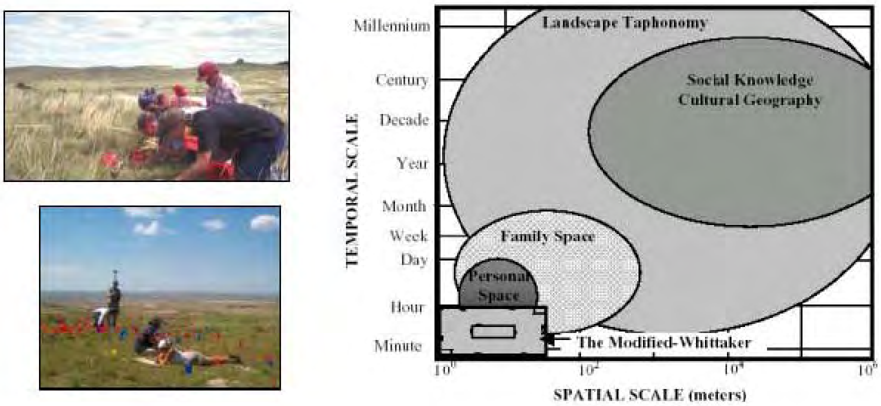

Figure 1. a) archaeological crawling survey in process; b) detailed recording of Whittaker; c) model of modified Whittaker within temporal and spatial scales relevant to Anthropology (adapted from Burger 2001).

This increase in cost efficiency leads to more accurate extrapolations to larger non-sampled areas. Similar results for archaeological survey sampling were reported by Berger (2001). For the archaeological survey design (Figure 1), intensive walking surveys are performed, followed by ground crawling, thus capturing the multiple scales inherent in the initial Whittaker. Intuitively, a scaled version of the Modified Whittaker makes sense for stream environments. The goal is to capture a representative sample of what species are present, how many of the rare species are present, and what the species richness is for the stream sampling corridor.

Along the Upper Greybull, near the confluence of Venus Creek, samples of aquatic macroinvertebrates were taken using a “Mini” version of the 20 x 50 m Modified Whittaker sampling design (Figure 2). The new “Mini” Whittaker is a 5m x 2m unit, with a total of fourteen different subplots within. It contains a K unit which is the outer 200 cm x 500 cm; two 20 x 50 cm plots (A and B located in opposite corners); a 50 x 200 cm plot (C located in the center of the K); and ten 5 x 20 cm subplots, six that are spaced around the interior of the K plot and four that are spaced around the C plot interior.

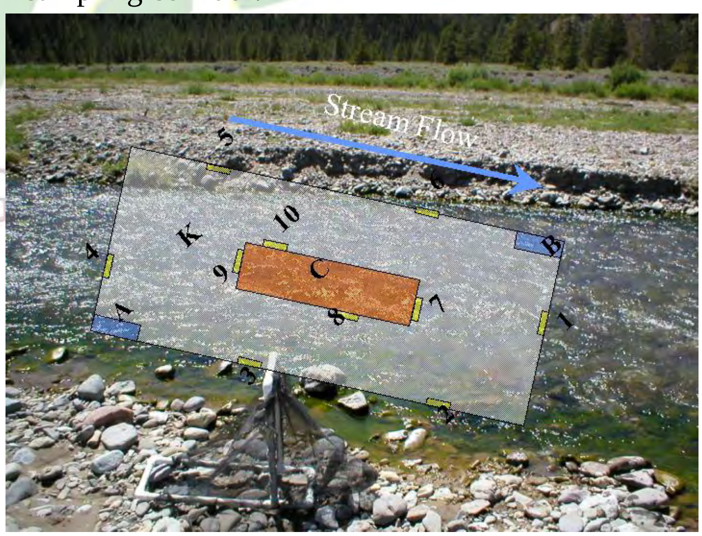

Figure 2. The mini Modified-Whittaker sampling design.

The methodology for the 2002 sampling was as follows. Two screens were constructed: a 10x50 cm screen was constructed using window screen, a Rubbermaid container and window chalking; and a 200 x 100 cm screen was made by sewing window screen around two fiberglass rods. The screens were placed downstream using the width of the sample area touching the bottom (Figure 3). The disturbance was done by kicking up rocks and sand in the entire unit for a fixed time of 30 seconds for the ten subplots and the A and B plots, one minute in the C plot and two minutes in the K plot. Once the screening samples were taken the screen contents was taken ashore, removed, and placed in a solution of alcohol (50% alcohol, 50% river water). The screen was once again looked over and then cleaned with river water for the next screened sample.

Figure 4. Stream sampling in process in the Greybull River.

In 2003, more traditional surber-type samples were also collected to compare the usefulness of the mini-Whittaker in assessing stream Bio-Diversity and abundance. For each Whittaker sample taken, 9 surber samples were taken to make the total sample area approximately equal. Frames were constructed from PVC tubing and 1/16th inch mesh screen which was held strongly onto the stream bottom from the top horizontal handle and contained mesh sides to capture more of the debris as it was disturbed off of the stream bottom (Figure 4). The disturbance was done by hand for approximately equal lengths of time within each subplot. The 1-9 subplots were converted to what are called "Rock-roll's", which is basically taking an approximately 15cm rock out of the stream and quickly flipping it into a mesh bag. In the process of the Rock-Roll, the insects underneath the rock are collected, as well as the rock itself was fine brushed to collect the smaller worms attached to the rock. The rock-roll samples were also foil cast for surface-area calculations. The rock-roll is analogous with the ground crawling for archaeologists and the intensive plant scrutiny of the subplots by plant ecologists, which captures the multiple scales of observation in the Whittaker plot.

Figure 3. 2003 sampling in process.

The sampling technique was essentially the same for the surber samples as well. Samples were randomly spaced along a linear transect which was alternated upstream or downstream from an adjacent Whittaker plot (Figure 5). Once the samples were taken the screen contents were taken ashore, removed, and placed in a solution of formalyn preservative. The screen was once again looked over and then cleaned with river water for the next screened sample.

Figure 5. 2003 mini-Whittaker layout with the surbers placed along linear transects downstream.

Results of the 2003 collections are still pending, however the 2002 data indicate a few preliminary results of interest. Without the aid of experienced entomologists taxonomic designations were not performed on any of the insects. In sum, there were 32 recognized different species collected (A-AF). The ten 5x20 cm subplots recovered on average 8.8 different species (27.5% of total recovered species). The A and B plot samples contained an average of 9.5 species (29.7%). The C and K plots contained statistically significant more species, 19 and 25 respectively. The K plot accounted for ~78.13% of the total recovered species in the survey area.

Sorting of the 2003 collections is still in process. The results will compare the survey methodology of the modified Whittaker sampling design with traditional surber sampling methods. Additionally, any differences between the 2002 and 2003 assemblages will be calculated for across plots and the variation explained in terms of ecological differences between the collection years.

This preliminary study of macroinvertebrate sampling tentatively supports a quantification technique that has a high recovery rate with relatively low costs, both financially and time expended. The mini-modified Whittaker sampling design provides an adequate way of understanding stream macroinvertebrate populations through ease of documentation and analysis, as well as the additional ability to use multiple datasets collected from similar survey procedures. As of yet there have been no studies that develop a cohesive sampling unit with which to understand the evolution of landscapes, but it is the hope of this study this survey method is leading us onto the right path. As Hobbs (2003)(2003) points out, the "mismatch between scales of investigation and scales of management is problematic because observations of many phenomena depend on the scale at which those observations are made." The scaled samples of the Modified-Whittaker create comparable datasets with which landscape management can better be assessed. A model in which axes of spatial, temporal, and a somewhat ill defined measure of "health" scales are lain helps to understand the integration of the multiple datasets that are to be coupled (Figure 6). The process of determining stream health is measured as the fluxuation around a baseline dataset determined from the population extrapolated out of

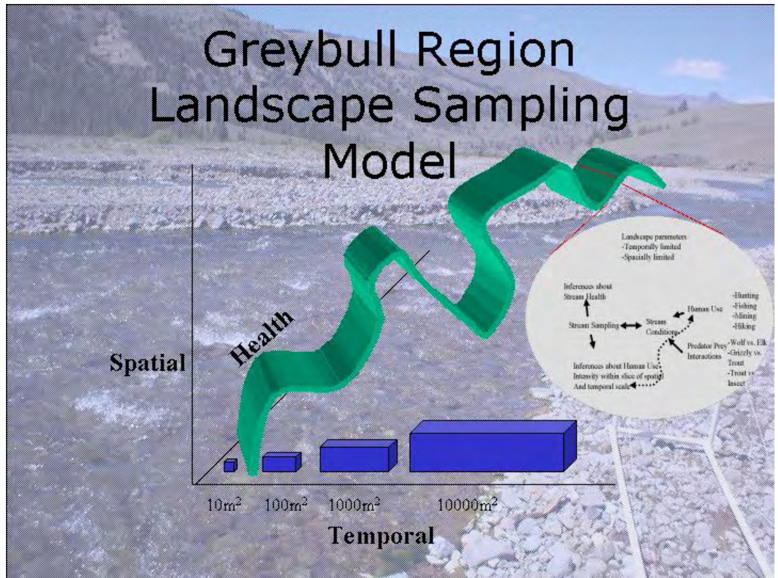

Figure 6. Model of landscape sampling through Modified Whittakers.

the Whittaker samples. The Whittaker sampling method captures a glimpse of the spatial and health scales, while the archaeological record extends into the temporal scale. Examining the past stream condition may be possible through sediment cores and varve lake samples. The coupled nature of the stream insect population with the increasing fishing pressures of human populations makes the stream macroinvertebrate population of interest. With increased fishing, the insect population would be expected to explode. When both populations drop significantly, other environmental factors may be adversely affecting the stream health. Combining these three units of observation is important to understanding past human use patterns, current use, as well as future impacts.

As has been noted, “no man ever steps in the same river twice.” Understanding that river and why it is different each time is one of the main goals of the GRIZ project. This interdisciplinary effort is essential to developing a series of baseline datasets to monitor increased human presence in the area. As a result, several publications have emerged with respect to cultural chronology in the area and the surface archaeological record (Burnett, et al. 2003). While the documentation of heritage resources is a main objective, understanding range conditions, invasive plant distribution, fire history, geomorphology, and recreational use intensity are also viable areas of research in the area. A central theme to understanding all these areas is what may have been bringing people to the area for millennia, the Greybull River itself. Documenting the current stream ecology of the river may not seem like one of the hats an archaeologist would wear, but as scientists we must recognize the need for disciplined interdisciplinary research to gain a better understanding of the processes that are dynamically shaping everything we study. This research is helping to document the macroinvertebrate population as an important bio-indicator for current stream conditions and to serve as a baseline for monitoring changes in the stream ecology over time.

Liu (2001) notes that, “it is crucial to integrate ecology with other social sciences” in an effort to understand the human behaviors as well as human attitudes which contribute to an ecosystem under human pressures. If the insect population is a byproduct of the whole suite of dimensions constraining the surrounding ecology, the archaeological record may be a process in this. The more “healthy” the archaeological record, more collectors may be brought to the area affecting the stream through increased fishing pressures or increased disturbances. By investigating the archaeological record and the stream ecology with comparable sampling techniques, patterns of process can better be understood in terms of human impacts.

References Cited

Burger, O.
2001 *A Multi-Scale Perspective for Archaeological Survey.* Masters, Colorado State University.

Burnett, P., L. Todd, D. Rapson and B. Schoville
2003 Archaeology Along the Upper Greybull River, Absaroka Mtns., Wyoming. *Poster presented at the 2003 Annual meeting of the Society of American Archaeology, Milwaukee, WI.*

Hobbs, N. T.
2003 Challenges and opportunites in integrating ecological knowledge across scales. *Forest Ecology and Management* 181(2003):223-238.

Liu, J.
2001 Integrating ecology with human demography, behavior, and socioeconomics: Needs and approaches. *Ecological Modeling* 140(2001):1-8.

Stohlgren, T., M. Falkner and L. Schell
1995 A Modified-Whittaker Nested Vegetation Sampling Method. *Vegetatio* 117:113-121.

Stohlgren, T. J., K. A. Bull and Y. Otsuki
1998 Comparison of rangeland vegetation sampling techniques in the central grasslands. *Journal of Range Management* 51(2):164-172.