Cacapon

Cacapon Volume 8 Number 2 Published by Cacapon Institute Winter 1998-1999

Learning From Life On The Bottom

Streambed creatures provide clues to the Cacapon's health

Fishfly (*Nigronia*)

AN ADDENDUM TO PORTRAIT OF A RIVER: THE ECOLOGICAL BASELINE OF THE CACAPON RIVER

This issue explores what the small creatures that live on the streambed tell us about the river's health.

"*In 1989, the Pine Cabin Run Ecological Laboratory (now Cacapon Institute) began an intensive, four-year effort to assemble an ecological baseline of the Cacapon River.*"

So began Portrait of a River, the Cacapon Institute's landmark 1993 study that offered the first detailed picture of the river's water quality. Portrait revealed that the Lost, North, and Cacapon rivers were relatively healthy, but periodically burdened by nonpoint source pollution—such as elevated fecal bacteria levels — created by certain land uses.

In the four-year process of producing Portrait, Cacapon Institute staff collected hundreds of water samples and a wealth of other ecological information from sites all along the river. Among the scientific treasures were hundreds of vials filled with benthic macro-invertebrates — the small animals without backbones (invertebrates) that live on the river bottom (benthos) and are visible without magnification (macro). They include the water-living larval stages of flying insects such as mayflies and dragonflies, small shellfish such as the white Asian clams that litter parts of the Cacapon's bottom, and many other kinds of life. The samples were collected because these small animals, which often live their lives hidden from view, can provide important clues to the river's health.

When *Portrait* was published, however, Cacapon Institute researchers hadn't had a chance to fully examine and analyze this invertebrate treasure trove. Over the last five years, however, staff have had both the time and money to take an in-depth look at the samples.

This report provides the results of the Cacapon Institute's study of the benthic macroinvertebrate information collected as part of the baseline project. It is, indeed, an appendix to the original report. Although it is written in relatively technical terms, the primary finding can be easily summarized. Overall, the study's results reinforce the conclusions presented in Portrait: with few exceptions, the river is relatively healthy. We found diverse benthic communities throughout the Ca-

(Continued on page 2)

Cacapon Institute, Route 1 Box 326, High View, WV 26808
(304) 856-1385 pcrel@mountain.net www.cacaponinstitute.org

(Continued from page 1)

capon watershed. In the Lost River headwaters, however, unexpectedly high species diversity suggests moderate nutrient enrichment. This is of concern. If the river's nutrient load increases, numerous studies suggest benthic communities will suffer. Just as too much fertilizer on a lawn can kill grass, too many nutrients in a stream can overwhelm life.

Like Portrait, we believe this study will provide information critical for assessing the health of our river in decades to come. We provide it with the hope that future researchers will be able to determine how the river's health has changed over time by comparing the results of then-own invertebrate surveys to this one.

Background

The idea that aquatic organisms can be used as indicators of water pollution has a long history. An indicator species is one that, by its presence, absence, or abundance relative to other organisms, indicates environmental conditions. For example, the presence of numerous midge (chironomid) larvae in a stream can indicate severe organic pollution.

The advantage of using aquatic organisms over chemical indicators of water quality - such as the amount of a certain chemical in a water sample-is that animals are constantly "sampling" their environment and the communities found in benthic samples are indicative of water quality conditions over time. Chemical measures, in contrast, provide a momentary snapshot of conditions in a constantly changing environment.

The main difficulty in using aquatic organisms, however, comes in understanding what die animals are telling us. For instance, during the baseline study of the Cacapon, Institute researchers noted that they found no freshwater mussels at any Lost River sampling site, but often found them in other river sections. The absence of mussels alone, however, doesn't tell us very much. We don't know, for instance, if they were once present and then disappeared, or why they might have disappeared.

Over the past four decades, researchers have generally moved away from the use of individual indicator species and toward "indices" that look at groups of species. A typical index, for instance, might look at the total number of different species or the relative abundance of different species. For instance, if a researcher finds that species tolerant of degraded water quality outnumber kinds that are intolerant of pollution, it is more likely that degraded conditions exist But the mere presence of pollution-tolerant organisms does not necessarily equate to water quality problems, because these organisms are often widely distributed.

Stonefly nymph

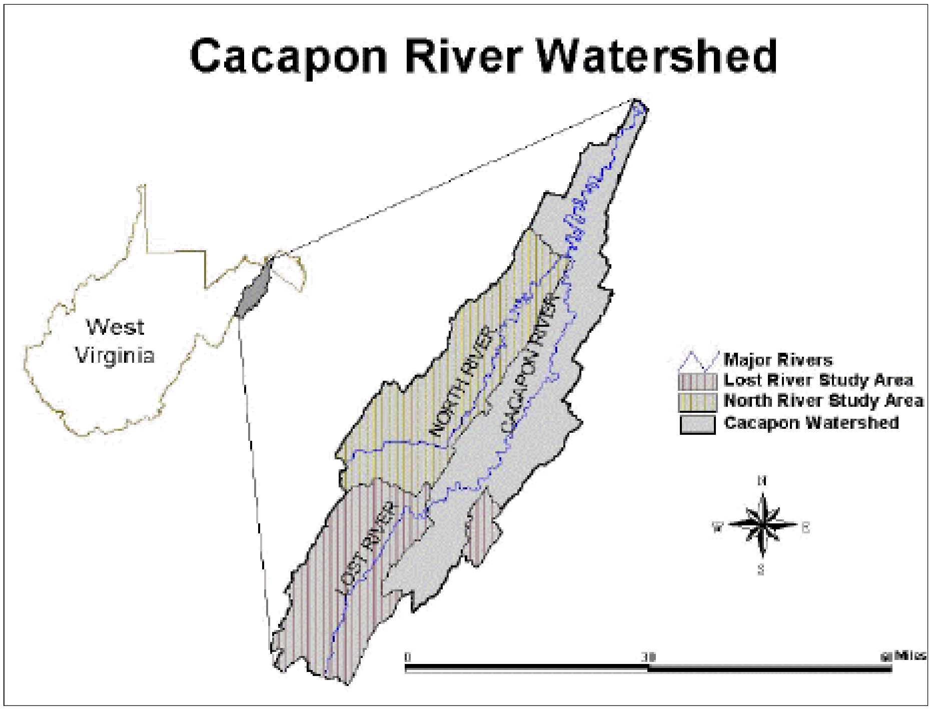
Water quality scientists have traditionally used benthic macroinvertebrate techniques to assess point sources of pollution, such as sewage flowing from a pipe. By sampling up- and downstream of the pipe, researchers can reach conclusions about the impact of the pollution. The use of benthic macroinvertebrate methods for assessing nonpoint sources of pollution, such as silt or fecal bacteria washing off the landscape, is more recent. Many state environmental agencies, including West Virginia's Division of Environmental Protection, now use benthic macroinvertebrates as a primary tool for assessing the health of the waterways.

(Continued on page 3)

(Continued from page 2)

Study Area

The 178 km long Cacapon River is located in the eastern panhandle of West Virginia, in Hardy, Hampshire and Morgan counties. It is an important tributary of the Potomac River, with a drainage area of 680 square miles, about 7% of the Potomac drainage upstream of Virginia. The watershed contains only two incorporated communities and no heavy industry.



Cacapon River Watershed

The majority of the land in the Cacapon watershed is forested -roughly 79% of the total area, while 19% is agricultural; the remaining 2% consists of residential develop-ment, barren lands and water.

The Cacapon watershed has four distinct regions: the Lost River, Middle Cacapon, Lower Cacapon and North River. The headwaters area is the Lost River, so called because it disappears into the ground at low water. The Lost region — 26% of the Cacapon's total drainage area - contains the watershed's most intensive agricultural operations, which are dominated by the integrated poultry industry. Fields often extend to the river's edge and little riparian forest remains.

The Lost River reappears just above Wardensville as the Middle Cacapon. While still an agricultural area, farming is much less intensive in the section between Wardensville and Capon Bridge because there are few poultry farms. The nature of the lands along the Cacapon change from forested or agricultural to mostly forested and light residential between Capon Bridge and the Cacapon's confluence with the Potomac at Great Cacapon; we call this region the Lower Cacapon.

The largest tributary of the Cacapon is the North River, which is similar in size to the Lost, meets the Cacapon at the small community of Forks of Cacapon. Land uses here are similar to the Middle Cacapon.

Methods

Macroinvertebrate samples were collected from June through September between 1988 and 1992 at 77 different sites along the river. Nine sites were sampled more than once. At each site, three samples were collected with a kick net at river left, center and right (if possible), in moving water 30 to 60 cm deep with a cobble bottom. For each sample, roughly six square feet of river bottom was disturbed so that benthic organisms were swept into the net by the current The material collected in the net was dumped into a white tray.

The macroinvertebrates were picked out of the tray in the field without mag-

(Continued on page 4)

(Continued from page 3)

nification and preserved in bottles with 80% ethyl alcohol. Macroinvertebrates were identified to genus (where possible) using a stereo microscope. Specimens that could not be identified to genus were identified to family; these were usually early instar nymphs and Larvae. Organisms smaller than 3mm were not retained, with the exception of adult elmid and dryopid beetles. Representative specimens of all taxa were retained in the Lab's reference collection.

Analysis

Data from each site was pooled prior to analysis. The data was considered to be generally qualitative in nature because it is difficult to collect quantitative data in a riffle; the bottom is uneven and sampling devices do not seal closely to the bottom. While estimates of total abundance were not considered appropriate, measures of relative abundance of taxa (different kinds of animals) at the site were judged reasonable.

The measures used to represent the community in this analysis were:

- **Richness** - a simple measure of diversity, in this case the total number of genera found at each site. This measure decreases with increasing degradation.
- **EPT Index**-the number of mayfly, stonefly and caddisfly genera found. These groups of aquatic larvae are considered to be generally intolerant of pollution; a large number of EPT taxa should indicate good water quality. This measure decreases with increasing degradation.
- **% EPT Abundance**- This is the percent of organisms in the sample that are EPTs. As with the EPT Index, a high proportion of EPT taxa at a site should indicate good water quality. This measure decreases with increasing degradation.
- **% *Leptoxis*** - the ratio of the *Leptoxis* snail count to the total count of all organisms in a sample. *Leptoxis* was the most common organism found at most sites.
- **Modified Hilsenhoff Biotic Index (MHBI)** - this index combines number of individuals collected and a level of pollution tolerance for each taxa in a sample, sums this for all taxa at the site and divides by the total organism count. This index was originally designed to detect the impact of organic pollution. Lower MHBI scores indicate a higher proportion of pollu-

(Continued on page 5)

Volunteers Protecting Our Streams

In recent years, the science of using animals to assess the vitality of a river ecosystem has gone public. Volunteer monitoring programs, such as the Izaak Walton League's Save Our Streams (SOS) program, have sprouted up around the country. In such programs, volunteer stream monitors wade into a river and "kick up" the stream bed and bottom sediments, collecting invertebrates in a seine. They then sort their catch and identify the critters using simple field guides. Based on the diversity, number and kind of invertebrates found, stream monitors can make an assessment of the stream's health at that site.

While the SOS and similar volunteer methods are less scientifically rigorous than the methods used by professionals, in overall design they are very similar. The typical techniques used today by many state and federal agencies in assessing the condition of their flowing waters are outlined in Environmental Protection Agency's Rapid Bioassessment Protocol:

1) Sites for analysis are selected, either at random or to assess some specific condition.
2) A reference site(s) is selected. A reference site should be representative of the natural condition and have a minimum of human influences. The reference site serves as a basis for comparison to other sites that have been impacted in various ways. In practice, "pristine" reference sites can be difficult if not impossible to find.
3) Samples are collected, usually by net, from well-defined habitats in a standardized way. Benthic macroinvertebrate collected are counted and identified by a professional (usually either to family or genus).
4) Indices are calculated from the raw data to indicate the condition of the site and to compare to the reference condition.

(Continued from page 4)

TABLE 1: Commonly encountered organisms.

Taxa	Common Name	% Sites Found
Stenonema	Mayfly	99%
Stenelmis	riffle beetle	93%
Hydropsyche	Caddisfly	90%
Isonychia	Mayfly	90%
Leptoxis	snail	90%
Baetis	Mayfly	84%
Corydalus	Hellgrammite	83%
Psephenus	beetle	81%
Acroneuria	Stonefly	78%
Cheumatopsyche	Caddisfly	75%
Chimarra	Caddisfly	74%
Leucrocuta	Mayfly	73%
Serratella	Mayfly	70%
Nigronia	Hellgrammite	67%
Optioservus	Beetle	53%
Chironomidae	Midge	53%
Stenacron	Mayfly	50%
Argia	Damselfly	48%
Tricorythodes	Mayfly	47%
Epeorus	Mayfly	47%
Oligochaeta	Worm	41%
Macrostemum	Caddisfly	41%
Psisdium	Mussel	39%
Atherix	Fly	38%
Helicopsyche	Caddisfly	35%
Chironominae	Midge	34%
Neureclipsis	Caddisfly	34%
Heterocloeon	Mayfly	32%
Lepidostoma	Caddisfly	31%
Caenis	Mayfly	23%
Prosimulium	Blackfly	23%
Helichus	Beetle	22%
Brachycentrus	Caddisfly	20%

tion intolerant organisms in a sample.This measure increases with increasing degradation.

It is important to recognize that a difference in biotic measures between sites does not necessarily mean that one site is "better" than the other. Species richness generally increases along with stream size and differences between sites may occur naturally due to ecoregion, elevation or some other condition that is not the result of human activity.

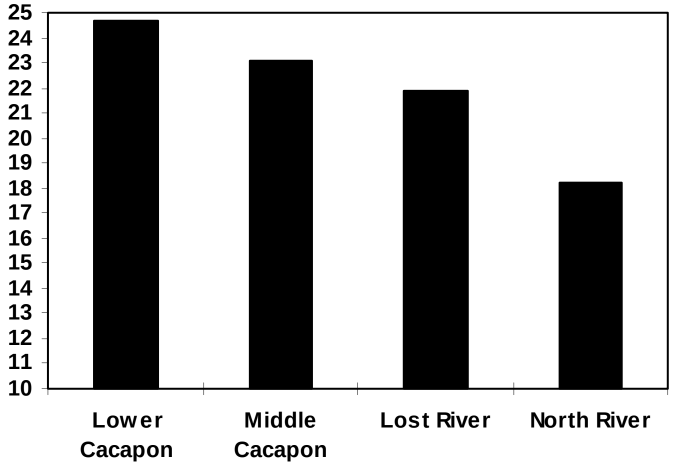
Results and discussion

•Richness - Riverwide, a total of 104 taxa were listed as present in the watershed. Seventeen taxa occurred at more than 50% of the sampling sites, 33 at more than 20% and 46 were found at less than 5% of the sites (occurred less than four times). The Lower Cacapon contained the largest number of taxa; 85. Seventy-four taxa were found in the Middle Cacapon and 60 in both the North and Lost rivers. Table 1 presents the names and some statistics for the 33 most commonly encountered taxa. The mayfly *Stenonema* and the riffle beetle *Stenelmis* occurred at nearly all sampling sites. Tied for third in occurrence at 90% of the sites were the web-spinning caddisfly, *Hydropsyche*, the mayfly *Isonychia* and the snail *Leptoxis*. *Leptoxis*, a pollution tolerant species, was numerically dominant in most samples where it occurred. On average, 33% of the individual organisms found at each site were *Leptoxis*, with a range from 0 to 78%.

Certain types of benthic macroinvertebrates are often considered representative of clean, well-oxygenated water. Paramount among these are the predatory stoneflies and hellgrammites. One stonefly (*Acroneuria*) and two hellgrammites (*Corydalus* and *Nigronia*) were widespread in all river segements. The stonefly *Acroneuria* was the most abundant in the North River. The dobsonfly *Corydalus* was found at all sites in the Middle Cacapon and was less abundant at sites in the North River than elsewhere. The fishfly *Nigronia* was most commonly encountered in the North River (at 88% of sites) but was never abundant The reasons for the regional variation in the relative abundances are

(Continued on page 6)

FIGURE 1.
Mean Species Richness per site by river segment



(Continued from page 5)

not clear.

Overall, the average richness per site (number of taxa) was 22.5, with a range from eight to 35. Richness in the North River was significantly lower than richness in the Middle and Lower sections of the Cacapon, but was not statistically distinct from the Lost River (Table 2 and Figure 1). Richness increased in a downstream direction from the headwaters of the North River through the North's confluence with the Cacapon and on to the Potomac. Headwater streams are typically low in nutrients and aquatic animals rely on food that comes from outside of the stream itself (from leaves and other detritus falling in or washed in from the land). As a river moves downstream and drains a larger area, food resources in the river increase and life becomes less reliant on outside food inputs. The river becomes increasingly autotrophic -which means that the river feeds itself. Species richness typically increases along with the increase in food resources.

On the other hand, we did not detect a statistically significant trend towards increasing richness downstream from the Lost River headwaters through the Cacapon watershed On average, sites in the Lost River contained nearly as many species as the Lower Cacapon. Many researchers have noted that moderate nutrient enrichment of headwater streams can increase diversity and abundance of benthic macroinvertebrates and fish by increasing food resources. It seems likely that the relatively high species richness in the Lost River is a consequence of nutrients and organic material from agricultural activity in this basin, which have been documented by the Institute's other studies.

- EPT Index (EPT Richness)

-Overall, the average number of EPT taxa per site was 12 and counts ranged from 3 to 21. As with total richness, EPT richness was lower in the North River than the Middle and Lower sections of the Cacapon, but was not statistically distinct from the Lost River (Table 2 and Figure 2). EPT richness increased significantly in a downstream direction from the headwaters of the North River through the North's confluence with the Cacapon and on to the Potomac. This

TABLE 2: Mean Results By River Section	**Lower Cacapon**	**Middle Cacapon**	**Lost River**	**North River**
Species Richness (# Taxa)	24.7	23.1	21.9	18.2
EPT Index	13.8	12.9	10.8	9.6
% EPT	57%	57%	49%	53%
% Leptoxis per site	37%	34%	28%	26%
MHBI	5.47	5.19	4.97	4.71
MHBI- w/out Leptoxis	3.96	3.73	3.82	3.53

(Continued on page 7)

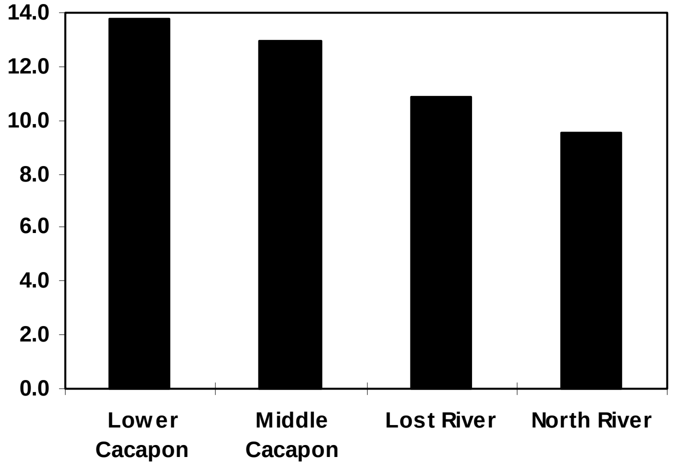
(Continued from page 6)

echoes the pattern observed for total richness in the North River, probably for the same reasons.

Unlike total richness, the Lost River had significantly lower EPT richness than the Lower Cacapon and we detected a statistically significant trend towards increasing EPT richness downstream from the Lost River headwaters through the Cacapon watershed to the Potomac River.

•**% EPT Abundance.** Overall, the average % EPT abundance was 55%, ranging from 30 to 76%. This index tended to be slightly higher in the lower sections of the river than the North or Lost River areas, and % EPT in the North River tended to te higher than the Lost, but these differences were not statistically significant (Table 2). We did detect a statistically significant trend towards increasing %EPT downstream from the Loft River headwaters through the Cacapon watershed to the Potomac River, this trend was not detected in the North River.

FIGURE 2.
Mean EPT Richness per site by river segment

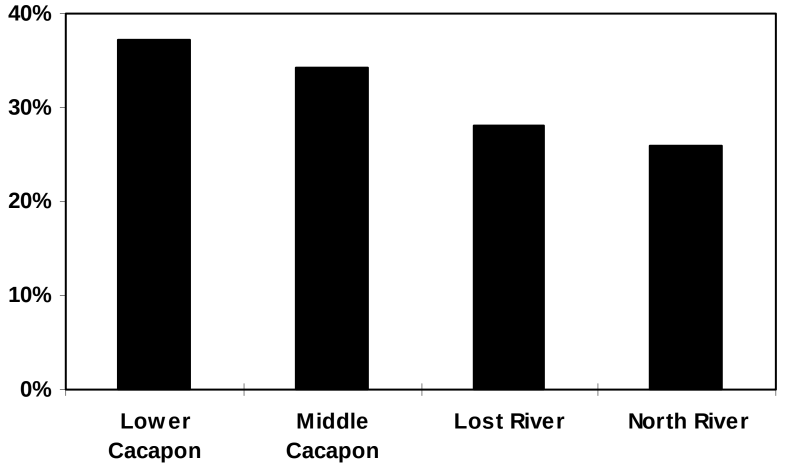


•**% *Leptoxis*.** This index measures the percent contribution to site benthic macroinvertebrate abundance from the common snail *Leptoxis*. Overall, it contributed an average of 32% of the total number of animals counted from each site; this percentage ranged from 0 to 78%. It tended to be more abundant in the Middle and Lower Cacapon than in the Lost and the North Rivers, although the differences among reaches were not significant (Table 2 and Figure 3)

The % *Leptoxis* measure increased significantly in a downstream direction from the headwaters of the North River through the North's confluence with the Cacapon and on to the Potomac. *Leptoxis* was not found at the uppermost four sites along the North. We know from the Portrait that alkalinity in the North River is lower than in the rest of the Cacapon watershed and that the alkalinity in the North increases in the downstream direction. Snails are generally more common in rivers with hard (more alkaline) water than soft water because these waters contain more of the calcium carbonate

(Continued on page 8)

FIGURE 3
Mean % *Leptoxis* per site by river segment



(Continued from page 7)

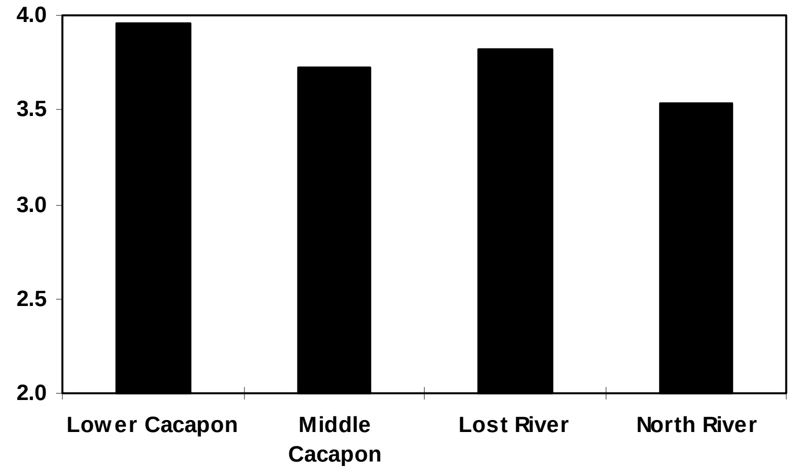
needed for shell growth. It may be that the low numbers of *Leptoxis* in the North River are related to the low alkalinity in the headwaters; the snail was not collected in Lost River headwater samples either, another area with low alkalinity. The upper reaches of the North River tend to dry up during droughts as well, which could also be a factor.

The family of snails to which *Leptoxis* belongs, the Pleuroceridae, typically occurs in high densities in those streams where they are present, but the reasons for the distribution and abundance of snails is a puzzle to many workers in the field. One study in the New River found that snails tend to occur in more alkaline streams regardless of drainage area and large streams regardless of alkalinity (Dillon Jr. and Benfield, 1982). Another benthic study area, in a Pennsylvania watershed with abundant limestone (the source of alkalinity) and dense agriculture, lacks dominant snail populations, despite the abundance of available nutrients and high alkalinity (Jim Greene, *pers comm.).* Snails also tend to be less common in many Maryland streams, although the mainstream of the Potomac has high densities of *Goniobasis* (Dan Boward, *pers. comm.*) - another Pleurocerid snail that occurred in our study at only eight sites located in the Lower Cacapon. At six of those eight sites, it occurred in low numbers at sites with abundant *Leptoxis*. At the other two sites, *Goniobasis* occurred in large numbers and *Leptoxis* was absent.

•**MHBI-** The MHBI weights the numeric contribution of organisms in a sample based on relative tolerance to pollution, with increasing tolerance given a higher weight. This index tends to increase with increasing pollution. Numerically dominant species tend to skew this index, especially dominant species that are also pollution tolerant. The snail *Leptoxis*, with a very high tolerance value of 8, was the most abundant organism in the majority of samples and the impact of this species' dominance on the MHBI index were profound.. The percent dominance of *Leptoxis* explained 92% of the variability in the MHBI -which meant the abundance of this species largely controls the index. Equally important, this index did not show any correlation to the %EPT index where a fairly strong negative relationship would be anticipated. Rather than repeat the results of the % *Leptoxis* analysis above, we elected to modify the MHBI by removing *Leptoxis* from the equation (designated MHBI-L). The results are provided in Table 2 and Figure 4.

FIGURE 4

Mean MHBI minus *Leptoxis* per site by river segment



Overall, the MHBI-L index averaged 3.8, and ranged from a low of 2.2 to 5.3. Both the lowest and highest values ware found in the North River but this index tended to be lower in the North River

(Continued on page 9)

(Continued from page 8)

than in the rest of the river, and was significantly lower in the North than I the Lower Cacapon. MHBI-L increased significantly in a downstream direction from the headwaters of the North River through the Cacapon to the Potomac. A much weaker tendency was detected from the Lost River downstream to the Lower Cacapon.

This measure did not detect general degradation from organic pollution in the Lost River, which would have shown up as a high average MHBI-L index in that basin. In fact, the headwaters area of the Lost, which has the greatest density of potential agricultural sources of organic matter, had lower MHBI-L level than the lower Lost, which is primarily forested.

Summary & Conclusions

Overall, with few exceptions, a diverse benthic community was found throughout the Cacapon River watershed. Only minimal disturbances to the benthic macroinvertebrate community were detected. High total and EPT richnesses in the Lost River may be due to moderate nutrient enrichment. Workers in other, more intensely farmed watersheds have found more obvious differences that appear to be related to organic pollution and high nutrient levels. For example, an USEPA project underway in Pennsylvania found total and EPT richness to be much lower in agricultural lowlands than in more forested uplands (Jim Greene, *pers. comm.*), the opposite of the pattern we observed in this study - where downstream sites showed a general richness over upstream sites. These studies suffer from a common problem, however -the lack of good reference sites to describe the condition of unimpaired streams.

The Institute's future benthic macroinvertebrate studies will determine if the increase in agricultural intensity in the Lost River basin has impacted the benthic community. Watch future issues of Cacapon for profiles of common benthic animals in the Cacapon River.

Selected References

Barbour, M.T., J. Gerritsen, B.D. Snyder & J.B. Stribling. 1997. Revision to Rapid Bioassessment Protocols For Use in Streams and Rivers. EPA 841-D-97-002. (www.epa.gov/owow/monitoring/AWPD/R PD)

Boward, Dan. 1998. Personal communication. Maryland Department of Natural Resources.

Constantz, G., N. Ailes and D. Malakoff, 1985. Portrait of a River: The Ecological Baseline of the Cacapon River. Pine Cabin

Dillon, R.T.Jr. and E.F. Benfield, 1982. Distribution of pulmonate snails in the New River of Virginia and North Carolina, U.S.A.: Interaction between alkalinity and stream drainage area. Freshwater Biology (12):179-186.

Green, Jim. 1998. Personal communication. US Environmental Protection Agency -Region III.

Yarrington, Byron. 1992. Creation A validation of a biotic indexing system for the Cacapon River drainage, West Virginia. In fulfillment of requirements for Biology 693 at George Mason University. 22 p.

This report was prepared by Neil Gillies, the Cacapon Institute's Science Director. *Acknowledgements*: Thanks to all the Institute staff and volunteers who collected and sorted Cacapon invertebrates. See Portrait for more detailed acknowledgements of baseline study supporters. Pete Yarrington for his expert work in identifying the invertebrates and reviewing this manuscript Amy Davis for entering the voluminous data into a computer database and to Lightstone Foundation, Inc. for their financial support of her efforts through their Future Stewards Program. Travis Olson for his help in summarizing the data. Thanks also to George Constantz, Pete Yarrington and and David Malakoff for reviewing and improving the manuscript; any mistakes, however, are my own. Analysis, printing and distribution of this report was funded in part by WV Division of Natural Resources Cooperative Projects Program and the patrons of Cacapon Institute.