USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Nutrient Impacts on Macroinvertebrate and Periphyton Community Structure.

Focus Categories: Nutrients, non point pollution, water quality

Descriptors: Nutrients, animal waste, periphyton, benthic macro invertebrates, non-point pollution, agriculture, poultry

Duration: March 2000 to February 2001

Fiscal Year 2000 Federal Funds:

$32,836	$32,836	$0
Total	Direct	Indirect

Non-Federal funds allocated:

$80,213	$47,622	$32,591

Principal Investigators:

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W. Neil Gillies, Cacapon Institute

Congressional District: 2nd WV

Critical Regional or State Water Problems

Agriculture, led by the integrated poultry industry and beef cattle production, is a key element in the West Virginia Potomac Headwater regions economy. The rapid expansion of the poultry and beef production in this region beginning in the early 1990's has raised concerns over the potential water quality problems caused by this industry.

The USEPA has charged the States with development of nutrient criteria for environmental protection. This project will provide critical data in high gradient streams on the effects of nutrients on the plant periphyton and animal macroinvertebrate community.

Results, Beliefs, and/or Information Expected

The major result and benefit of this proposal will be a biological assessment of the streams in two Potomac Headwaters watersheds - one with a high density of integrated

poultry agriculture, the other with much lower density agriculture. The study focuses on the interactions between periphyton, benthic macroinvertebrates, nutrients and quality of the physical habitat. The proposed collaboration between the West Virginia Division of Environmental Protection (WVDEP), Cacapon Institute (CI) and the Institute for Environmental Studies at Shepherd College will provide information leading to a more detailed understanding of the biological, chemical, and physical parameters important to stream health.

This proposal will also provide a unique opportunity for internship training. Supervised by the principal investigators, students will be trained in impact assessment methodologies in aquatic systems. The internship will also allow them to work with professionals in the field, providing them with the opportunity to conduct hands on research on important environmental issues.

Nature, Objectives and Scope of the Research

Poultry production in the Potomac Headwaters region of WV has more than doubled since the early 1990's. The waste byproducts of this industry are typically land applied, leading to concerns over potential impacts on water quality.

This proposal addresses a unique opportunity to leverage resources and expand existing, cooperative, water quality studies by Cacapon Institute (CI) and the West Virginia Division of Environmental Protection (WVDEP) in the Cacapon River, a Potomac Headwaters basin with high density poultry production in the headwaters region. CI's multi-year studies are designed to determine the nutrient characteristics of streams in relation to land use, with an emphasis on agricultural impacts. The WVDEP will conduct their periodic chemical, microbiological, physical and benthic macroinvertebrate assessment of the Cacapon River watershed during the summer of 2000.

We request funding from the West Virginia Water Resources Research Institute to add critical biological and chemical components to the above studies. These components are collection and analysis of the macroinvertebrate community. The goal is to provide a comprehensive picture of the relationship between nutrients, periphyton and benthic macroinvertebrates, and physical characteristics, in a high priority watershed impacted by animal waste.

Objectives

This proposal has two major objectives. The first objective evaluates the biological integrity of the studied streams in conjunction with nutrient analysis and site specific physical parameters. Periphyton and macroinvertebrate metrics will be utilized to characterize the existence and severity of biological impairment to streams in the West Virginia Potomac Headwater region. These data will be instrumental in helping to identify sources and causes of impairment. This leads directly to the evaluation of control

actions and restoration activities. The second objective is training of future professionals in aquatic environmental issues and is discussed below in the “Training Potential” section.

We address several questions in the context of this grant and in context with the collaboration with other partners.

· What species of periphyton are present in the Lost and North Rivers and in what abundance?

· How are periphyton communities affected by physical and chemical characteristics of the water?

· Do nutrient loads contained in benthic sediments help explain periphyton growth patterns?

· Are there particular periphyton species better suited for assessment? If so, more specific and less labor intensive metrics could be developed.

· How are benthic macroinvertebrates affected by physical and chemical characteristics of the water?

· Has benthic macroinvertebrate diversity and abundance changed in the Lost River in the last 8-10 years due to increased agricultural production in the watershed? This study will produce a data set that allows comparison to baseline macroinvertebrate conditions recorded by Cacapon Institute prior to the areas recent increase in poultry production (Gillies 1998a). This will allow interpretation of the WVDEP data using a long-term, rather than a one-time snapshot of water quality at specific sites.

· Do standard and modified Save Our Stream (SOS) benthic macroinvertebrate protocols provide end results comparable to the more scientifically rigorous method used by the WVDEP? The widespread use of volunteer monitoring of streams produces large amounts of information for assessing health of streams. This study will address the level of detail, and thus the resources required, to accurately sample and identify macroinvertebrates.

Background

The Potomac Headwaters region of West Virginia is located in the states eastern panhandle and contains Hampshire, Hardy, Grant, Mineral and Pendleton counties. Agriculture is a key element in the regions economy and is dominated by the integrated poultry industry and beef cattle production. Rapid expansion of the Headwaters poultry

industry beginning in the early 1990's fueled concerns over the potential for water quality problems caused by this industry (Constantz et al. 1993; Ramsey 1997).

In 1992, due in large part to the Headwaters rapidly expanding poultry industry, state and federal agencies recognized the need for a coordinated and comprehensive approach to protecting and enhancing ground and surface water quality in the area. In 1993, local, state and federal agencies formed the Potomac Headwaters Interagency Water Quality Office (PHIWQO), which was charged with protecting the waters of the Potomac while maintaining a strong agricultural industry.

Water quality in the regions was assessed in 1994 and 1995 by a cooperative venture between the USDA-Natural Resources Conservation Service and the U.S. Geological Survey (USGS) (PHIWQO 1996). Nineteen sites in the South Branch drainage and four in the Lost River (headwaters of the Cacapon) drainage were sampled approximately monthly (Mathes 1996). While high nutrient concentrations were not found at any site, Mathes noted significant algal growth during summer and suggested that this might be related to nutrient loading. The low nutrient levels found by Mathes (1996) and other studies by Cacapon Institute (Constantz et al, 1993; Gillies 1998b) were not expected given the high density of agriculture. In March of 1997, Cacapon Institute started an intensive study of land use influences on water quality in the Lost River watershed with a focus on nutrients. Storm sampling was included as an integral component of the study design, an important element lacking in previous studies.

The Lost River was selected because it ranked first on the PHIWQO list of watersheds in need of best management practice implementation. This basin produced twice as much poultry litter, or manure, than the available agricultural land could use as a fertilizer (USDA-NRCS 1996). The Lost River watershed is only 2% of the Potomac Headwaters drainage area. However, it contains 21% (approximately 185) of the regions poultry houses at more than one poultry house per square mile. This is the highest density found in the Potomac Headwaters.

The North River watershed was added as a comparative watershed in June 1998 to establish nutrient levels in a low intensity agricultural basin. This watershed is similar in characteristics and size to the Lost River, but contains less than ten percent of the poultry production.

Study Area

The study area is located in the eastern panhandle of West Virginia. This is a mountainous region which lies within the Valley and Ridge physiographic province in West Virginia. Major rivers in this area are the North and South Branches of the Potomac and the Cacapon (including the Lost and North Rivers). All of these rivers flow into the Potomac, which in turns flows into the Chesapeake Bay.

The Lost River headwaters of the Cacapon River, in Hardy county, drain 179 square miles; 26% of the total Cacapon drainage area. The small towns of Baker and Mathias are

found in this watershed. Agriculture is forced by topography to remain largely confined to the narrow valleys and gentle slopes. Over 80% of the basin is forested. Some residential developments occur on ridge tops overlooking the valley.

The North River, the largest tributary of the Cacapon River, is located in Hardy and Hampshire counties. The North River watershed drains 205 square miles; 30% of the total Cacapon drainage area. The small towns of Rio and Hanging Rock are found in this watershed. Land use in the North River basin is very similar to the Lost, the major difference being the lower intensity of agriculture.

Existing Studies

Existing studies in the watershed are being conducted by CI and by the WVDEP. Studies by CI are correlating stream nutrient levels and fecal coliform bacterial determinations to agricultural land use. Physical and chemical data in the Lost and North Rivers has been collected since 1997 and 1998, respectively, with major support form the U.S. Fish and Wildlife Service (USFWS). This study will continue until September 2000. This data will provide a water quality backdrop to help interpret results from biological studies and determine how closely biological parameters relate to the physical and chemical conditions in these streams.

During the summer of 2000, the WV Division of Environmental Protection (WVDEP) will conduct their periodic watershed assessment of the Cacapon River watershed. The WVDEP protocol includes chemical, microbiological, physical and benthic macroinvertebrate assessments. The WVDEP has agreed to conduct rapid bioassessments at existing Cacapon Institute sampling sites and share the results.

Proposed Studies

Periphyton: periphyton samples will be collected concurrently with the water quality and benthic macroinvertebrate survey. The perphyton assemblage serves as a useful biological indicator of nutrient and chemical characteristics of streams because of the naturally high number of species and a rapid response time to exposure and recovery from various environmental influences (USEPA 1997). Nutrients, especially limiting nutrients, can vary in time an space in the water column and be quite transient (Pan et. al. 1996; Gillies 1998b). As a resident biotic component in streams, periphyton can register and incorporate transient o episodic changes of nutrient conditions, or act as nutrient sinks.

Sediment Nutrients: benthic sediment samples will be collected in pools near all regular sampling sites for total P and total N. Analyses will be performed the WV University Soil Sciences laboratory.

Algal growth patterns are influenced by a complex set of environmental factors, such as current, light, and substrate and water column nutrient levels may not correlate well with periphyton abundance (unpublished data Cacapon Institute). Nutrient enriched agar

placed in clay pots demonstrate that nutrient enriched substrate can greatly increase algal production (Lowe et al. 1986: Pringle and Bowers 1984). Thus, sporadic pulses of nutrient additions in the water column may not be as important to alga populations than the more stable supply of nutrient s supplied by sediments.

Methods, Procedures and Facilities

Benthic macroinvertebrates, periphyton, sediment and water quality samples will be collected at Cacapon Institutes twenty tributary and mainstem sampling sites in the Lost and North Rivers. These sites, selected with assistance from the USDA-NRCS, West Virginia University Extension Service, the USFWS, and Potomac Headwaters Resource Alliance, represent different mixes of land uses within each basin, ranging form 100% forested to prodominantly agricultural. Additional sites will be selected along the mainstem of each river for comparison to invertebrate baseline data.

Benthic Macroinvertebrate Sampling and Comparisons Between Methods

WVDEP will collect and analyze benthic macroinvertebrates using their standard procedures based on USEPA's Rapid Bioassessment Protocol II method. This involves collecting six samples at each riffle using a D0frame and/or Surber fine grade net sampler. The rocky substrate is disturbed by hand the width of the net and for one foot upstream of the net. Samples are combined into one sampling jar and preserved. Samples are sorted in the laboratory and identifications are made to the family level on the first 100 invertebrates in a subset of each sample. Data is then analyzed using a number of indices.

Cacapon Institute will use the volunteer Save Our Streams (SOS) benthic macroinvertebrate monitoring method as a presented by WVDEP to volunteer monitoring groups. This involves using a coarse kick net to collect samples. In contrast to the WVDEP method, benthic macroinvertebrate identifications of a subset of the sample are made to the ordinal level in the field. The streams biological health is then described using a single numeric indicator.

Indices will be determined separately for each of the methods. The methods will then be analyzed and evaluated to determine similarity of results.

New Study Elements

We seek funding from WVWRRI for three elements: 1) periphyton collection and analysis, 2) benthic macroinvertebrate data entry and analysis for comparison to baseline conditions, and 3) nutrient sediment analysis.

Periphyton

Periphyton will be collected according to USEPA rapid bioassessment methods (USEPA 1997). This method involves scraping periphyton from rocks inside a template with a

known diameter and area. Periphyton samples are then transferred into a sampling jar and preserved for analysis.

Soft algae and diatoms are identified to the species level if possible. Species identificatins and enumeration will be performed by a periphyton taconomist. Algal biomass will be determined using chlorophyl-a (spectrophotometric method) and Ash-free Dry-mass (AFDM) (APHA 1992).

Sediment

Quantitative benthic deposits samples collected with a corer will be analyzed for Total Nitrogen and Total Phosphorus by the WVU Soil Sciences laboratory, using their standard methodology.

Time Table

March 2000	Receive Grant. Project startup paperwork.
April 2000	Coordinatin and planning meetings between WVDEP, Cacapon Institute and Shepherd College.
May 2000	Training in field methodology, order supplies.
June 2000	Field work conducted during this period. Periphyton and sediment samples sent to consultants for analysis.
July-August 2000	Data entry of data gathered by CI and Shepherd College, preliminary analysis, rework CI benthic invertebrate baseline data from genus to family level.
Sept-Nov 2000	Receive data from WVDEP, data entry and analysis.
Dec 2000-Feb2001	Prepare reports/papers on results.
May 2001	Final report due to WVWRRI.

Facilities

Shepherd College Institute of Environmental Studies

The Shepherd college Institute of Environmental Studies was formed in 1999 in response to a surge of interest in environmental issues. The program is designed to provide students the skills, the field experiences, and conceptual approaches necessary for a successful career in the fields of conservation and environmentally sustainable development. Major components of the program are the emphasis on practical field

experience and in training with tools needed to secure employment in the enviromental field. This training provides students not only with the conceptual knowledge on how tho approach environmental problems but provide students the practical means and tools with which to solve a particular environmental problem.

The new environmental program is a dynamic and growing program. The Institute has recently added a geographic information system (GIS) laboratory which will allow for the collection, storage, and analysis of data in which geographic (or spatial) location is an important characteristic or is critical to the analysis. This provides a critically needed skill for environmental studies students.

Cacapon Institute

Founded in 1985, Cacapon Institute (formerly Pine Cabin Run Ecological Laboratory) is a non-profit corporation dedicated to using science and education to protect the Cacapon, the Potomac and other Applachian rivers. Located in High View, WV, the Institute became a WV Certified Laboratory for surface water analysis in 1996. CI has successfully completed two baseline studies for river continua, with results published in Portrait of a River: the Ecological Baseline of eh Cacapon River (1993) and Greenbrier: A Scientific Portarait of a West Virginia River (1998). The Institute currently has four active water quality programs - the Lost River Water Quality Study, North River Water Quality Study, South Branch of the Potomac Water Quality Study and the Cacapon River Monitoring Study. These programs are designed to work together to answer both narrowly defined and large scale questions about water quality.

Related Research

Pan, et. al. (1996) reported that diatom distributions in relation to environmental conditions in streams have not been well established. Unlike lakes, where diatom assemblages may accumulate over several years, periphyton in streams is routinely washed away by high water (Stevenson 1990) and the assemblage found may be only as old as the last high water event. Pan, et. al. (1996) and Vis et al. (1998) found that diatom and periphyton assemblages could be used to accurately predict pH. However they were much less successful at modeling phosphorus levels in their broad-based study and questioned the sensitivity of the method when pH and varied physical habitat variables were important. In this study we will address the question of whether nutrient conditions can be predicted from the periphyton assemblage in an environment with variable pH and habitat.

Like the periphyton, environmental conditions in streams, particularly nutrient concentrations, are quite variable through time, particularly in watersheds such as those in the proposed study area that are primarily impacted by non-point pollution sources. Over 75 percent of annual watershed runoff can occur during a small number of severe events. Because phosphorous primarily moves in runoff 90% of the annual phosphorous load can be delivered by these few events (Sharpley 1995). Data collected by CI since 1997 confirm that peak loads and high concentrations of phosphorous are extremely short

lived in these watersheds. CI's work also indicates that significant sources of nutrients occur in these watershed in addition to the obvious agricultural activities, including varying nutrient levels in springs and some subsoils naturally high in phosphorous.

One of the challenges found in relating biotic assemblages to in-stream chemistry is that chemistry data is often quite limited in time. This project has the advantage of long term nutrient and other water quality data at all primary sampling sites.