Report for 2002KY7B: Linking land use to water quality in the Muddy Creek subbasin, Kentucky River Watershed

- Conference Proceedings:
  - Sturgill, JoAnn, Jennifer Curra, Kathryn Takacs, and Danita LaSage, 2002, Characterization of Water Quality in an Eastern Kentucky Stream, in GSA Abstracts with Programs, Volume (34), Number 6. ISSN 0016-7592.
  - Jones, Alice L., Danita LaSage, and Mark Wiljanen, 2003, Linking Land Use to Water Qaulity in the Muddy Creek Subbasin, Kentucky River Watershed, in Proceedings Kentucky Water Resources Annual Symposium, Kentucky Water Resources Research Institute, University of Kentucky, Lexington, Kentucky, p. 57-58.

Report Follows:

Problem and Research Objectives

The purpose of this project is to investigate whether watershed data currently collected by regulatory and other agencies is sufficient to characterize the relationship between land use and water quality in a 4th order watershed, and to identify gaps that exist between currently available data and the information needed to adequately characterize this relationship.

The study area is the Muddy Creek subbasin of the Kentucky River Watershed, located in south-central Kentucky in northeastern Madison County. Muddy Creek enters the Kentucky River upstream of Fort Boonesborough, and its watershed covers about 45,000 acres to the east of Richmond and extending south to include much of the Bluegrass Army Depot.

Identified threats to water quality in the subbasin include pathogens from agricultural sources or ineffective septic systems, extensive sedimentation, potential cumulative downstream stormwater impacts from expanding suburban development from the Richmond area, and potential contamination from the U.S. Army Bluegrass Depot which is a storage facility for conventional and chemical weapons including nerve gas, and is also leased as grazing land to local cattle operators.

Methodology

In the Spring of 2002, students in Dr. Alice Jones's (Geography) Environmental Land Use Planning course assembled a GIS database of map layers available from public sources including soils, drainage, topography, geology, and land use of the area. The class also "ground-truthed" these layers by performing field surveys of these layers on an area of the Bluegrass Army Depot. They then used an overlay analysis to identify critical terrestrial habitat areas within the watershed and threats to these habitats.

Meanwhile, under the supervison of Danita LaSage (Earth Sciences), student researchers collected monthly water samples at eight sites along the length of the stream. In the initial proposal, the Summer 2002 samples were to be collected by students in a "Chemistry Methods for Teachers" class taught by Dr. Diane Vance (Chemistry). However, the class was cancelled, so the samples were taken, instead by three earth sciences students under LaSage's supervision.

Following the initial Spring 2002 GIS assembly period, Jack Phillips under the supervision of Dr. Mark Wiljanen, continued to synthesize and analyze the GIS information and added the water testing information. He then examined the data looking for spatial relationships between land use that could be linked with water quality.

In the early Spring of 2002, further field checking of the land use layer was performed by two wildlife management students under the supervision of Fish and Wildlife Conservation Biologist Tom Edwards.

Principal Findings and Significance

There are four areas where current information is insufficient to characterize stream structure and health:

1. *Critical pollution problems.* There are indications of critical pollution problems in the upper reaches of the watershed — particularly pathogenic activity indicated by total fecal coliform counts. Other parameters of concern include low dissolved oxygen levels (below 5 ppm) in both the study samples and those collected by Watershed Watch volunteers and high levels of orthophosphate in more than 2/3 of the samples, most likely associated with agricultural impacts.
2. *A lack of stream hydrology and discharge information*. Even the most basic information on stream hydrology and discharge rates is absent at the 4th-order watershed scale. There is no permanent discharge monitoring station anywhere in the watershed, and available topopraphic maps of the region are 30 to 50 years old.
3. *A lack of ecological and biological information in both the aquatic and terrestrial ecosystems*. The only aquatic biological information available was informal site assessments performed during the initial selection process. These assessments indicate severe degradation from sedimentation, and a lack of macroinvertebrate activity, particularly in the upper reaches of the watershed—which is consistent with the critical pathogenic and phosphorous pollution problems discussed previously. During the spring of 2003, Dr. Guenter Shuster's graduate aquatic biology class used four Muddy Creek sites for the field portion of the class. Analysis of the data is still in process.
4. *Land use/Land cover scale refinement issue*. The best available land use/land cover layer reflecting distinct vegetation and ecosystem structures as well as developed landscapes is the GAP analysis developed by the Kentucky Department of Fish and Wildlife at a 30-meter pixel resolution. While this resolution is adequate for gross assessments, field surveys indicated that the two most frequent GAP land uses throughout the watershed—"Pasture/Grassland" and "Agricultural/Other" bear little relationship with what is found on the ground. Field studies indicate that areas with intensive cattle grazing are found in areas classified as "Pasture/Grassland" and "Agricultural/Other" but at the same time, large uninterrupted areas of undisturbed prairie grasses with no livestock are also found in these same GAP categories. Since the most critical water problems—pathogen and sediments—are associated with livestock operations, the inability to distinguish grazed pastureland from other grasslands makes tying land use to water quality from currently existing land use data difficult.

Significance

These preliminary results indicate that data collection by regulatory and other agencies is too irregular and sporadic to adequately characterize the relationship between land use and water quality in a typical fourth-order watershed—a landscape scale at which it would be reasonable to expect that land management practices should produce observable results in water quality.

As state's watershed management efforts shift focus from the broad basin-wide scale to the local-level subbasin scale, it is essential to determine whether the information currently collected by regulatory and other agencies is sufficient to characterize the relationship between land use and water quality in these smaller subbasins.

This project resulted in cooperative efforts involving students and faculty in Earth Sciences, Geography, Chemistry, and Wildlife Management at Eastern Kentucky University. In addition, members of the general public were drawn into the effort by distributing water testing kits to community volunteers as a part of the Year of Clean Water Monitoring Day, October 18, 2002. Twelve volunteers collected samples at a total of 21 sites throughout the county through this linkage.

The project generated several additional offshoot collaborations that are significant in that they may lead to continued interdisciplinary, interinstituional, and interagency collaborations.

1. Water quality testing was conducted on the Eastern Kentucky University Meadowbrook Farm. As a result of arranging access to the farm for regular water testing, Farm Manager Michael Judge initiated efforts to improve water quality on the farm land including enrolling a 3-mile section along Muddy Creek into the federal Conservation Reserve Program.
2. The Spring 2003 graduate Aquatic Biology class at Eastern Kentucky University (Dr. Guenter A. Schuster) used Muddy Creek as its study area and performed macroinvertebrate analysis at four of the project's eight sampling sites. This activity began closing the information gap on biological indicators of water quality in the study area.
3. Dr. Gail Brion (Civil Engineering) of the University of Kentucky Environmental Research and Training Laboratory performed tests for nitrates and other water-quality indicators at no cost to the project. She has expressed an interest in continuing to develop collaboration between Eastern Kentucky University and the University of Kentucky on issues related to water quality.
4. Mapping of several grassland sites related to field checking of the GIS layers led to increased interest by management at the Bluegrass Army Depot in encouraging regeneration of remnant prairie grasses on that site and implementing best management practices to protect water quality in the vicinity of the Depot.