EPA Grant Number: R-82868401
Subproject: 003
Center: The Atlantic Slope Consortium - Developing Ecological Indicators for Aquatic Ecosystems of the Atlantic Slope Region
Center Director: Robert Brooks
Title: Integrated Assessment of Watersheds
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Project Period: March 1, 2001 through February 28, 2005
Project Amount: See main project abstract
Research Category: Environmental Indicators

Objective

This is the third of four subprojects under the Atlantic Slope Consortium (ASC) center. The goal of this subproject is to develop and test indicators of the biogeochemical health and integrity of watersheds, relate those indicators to environmental conditions, assess the predictability of landscape characteristics to indicator responses, and use those predictions to characterize the effects of watershed discharges on downstream riverine and estuarine health.

Progress Summary

Several interactive teams are working on this multi-institutional subproject. Their activities in 2003 are discussed below.

SERC Watershed and Spatial Analysis Team

As part of the overall objective to develop and verify geographical indicators to predict water, sediment, and nutrient losses from watersheds, this team's primary goal is to improve existing statistical models predicting nutrient and sediment losses from geographic data. A secondary goal is to quantify the impact of wetlands and riparian conditions on watershed discharges. Our approach involves (1) exploring the efficacy of additional geographic data (beyond physiographic province and land use/land cover) and (2) incorporating information about the spatial arrangement of landscape features, particularly source areas and riparian forests, to test hypotheses about nutrient and sediment transport.

Research activities for Year 3 included:

- Explored the effects of different land cover data sets on predictions of nutrient discharge. Results suggest that choice of landcover data has a significant impact on the relative proportions of landcover classes and resulting relationships with measured nutrient concentrations. A manuscript is in preparation on these results.
- Explored the relationship among soil properties and nutrient discharge, and evaluated the correspondence between wet soils mapped by soils maps with NWI wetland maps. We

found that soil maps have potential for predicting unmapped wetlands, but pre-analysis summary and synthesis required for analysis, as well as poor resolution of STATSGO data, added to predictive error.

- Explored the effects of improved hydrologic characterization on watershed predictions of nutrient export. We found that models with map-based hydrologic models as a single independent predictor accounted for nearly 60% of baseflow yields in SERC study watersheds. Combined with landcover estimates, such predictions may augment watershed scale nutrient predictions.
- Evaluated the influence of wetlands in watershed predictions of nutrient discharge. Initial analyses suggested that mapped wetlands had variable and inconsistent influence on nutrient export across physiographic regions. In addition, the significance of certain hydrologic classes (saturated, seasonally inundated) varied with physiographic province and the nutrient species under consideration.
- Used geographic and hydrologic information to parameterize TOPMODEL in several watershed clusters. We used resulting saturated area predictions to model wetlands and predict nutrient concentrations, and then compared these results to our NWI predictions. An analysis is in progress.
- Developed and tested new methods for automated watershed delineation and flowpath modeling. Initial assessment suggested manual watershed delineation methods could be augmented and improved by integrating digital elevation and hydrographic information. A manuscript describing this analysis is in preparation for winter 2004 submission.
- Evaluated the effect of stream map resolution on riparian buffer summaries. Initial analyses suggested that map resolution had a significant impact on stream buffer characteristics. These results have implications for indicator studies that use stream buffers as predictors. A manuscript is currently in preparation for spring 2004 submission.
- Explored the effects of spatial arrangement of source areas on nutrient discharge. We found that distance weights improved assessment of biotic thresholds in watersheds and improved nutrient discharge predictions by 22% in Coastal Plain watersheds. A manuscript is currently under review.
- Explored the effects of improved mapping/characterization of riparian buffers. Analyses demonstrated that new metrics, if first constrained by flowpaths, improved predictions of nutrient discharge by nearly 18% across physiographic regions. NWI wetland predictions did not improve predictions significantly. A manuscript on these results is in preparation for summer 2004 submission.
- Finally, we developed a novel method for estimating subsurface connectivity among landcover, riparian areas, and stream channels for further analysis.

ECU Watershed Team

Using data collected from sites in the three ASC study watersheds in North Carolina and from data collected in an ongoing study for the North Carolina Wetland Restoration Program (WRP), ECU developed a preliminary assessment procedure for headwater riparian systems. The procedure was field tested by NCWRP personnel and presented to other members of the ASC Watersheds group during a field trip prior to the ASC all-hands meeting at ECU in November. The assessment protocol is in the process of being revised to reflect reference conditions in North Carolina watersheds and to meet specific needs of the NCWRP program.

From North Carolina reference data, an indicator of riparian condition was developed based on the biomass of cover types typical for headwater riparian zones in the coastal plain and nutrient signatures in stream water. The rationale for developing the indicator and supporting data were summarized in a poster presented at the December 2003 all EaGLes meeting Bodega Bay, California.

Data from the three ASC watersheds in North Carolina (60 sites) are being analyzed further to determine which of the measured indicators are most applicable for estimating condition of headwater ecosystems in North Carolina. Results of preliminary analysis will be presented at the all hands ASC meeting in March 2004.

During the 2003–2004 project year, ECU worked with the other members of the ASC Watersheds working group in developing methods and the final version of the stream/wetland/riparian field data sheets. ECU assisted the PSU field crew in collecting field data from 20 random reaches in three watersheds in North Carolina. In the process, the assessments sheets designed for stream condition, originally developed by EPA, were overhauled to reflect reference conditions in coastal plain headwater streams and riparian zones.

Penn State Watershed Team and Multi-Institutional Activities

Application of Stream, Wetland, Riparian (SWR) Protocol: In Year 2, PSU, SERC, VIMS, and ECU collaboratively developed and pilot tested a protocol for sampling Stream, Wetland, and Riparian (SWR) areas. The sampling protocol yields an on-the-ground, rapid assessment of watershed condition, which will be used to verify and calibrate assessments performed using remote sensing. Following pilot testing and refinement of methods in the late summer/fall of 2002, twenty-four watersheds were selected for intensive sampling. These watersheds were chosen to represent a cross-section of physiographic provinces and land cover classes, with consideration also given to factors such as the quantity, quality, and location (e.g., headwaters vs. downstream) of existing biological data points, the geographic dispersion of watersheds, stream size, and known impacts.

Field data collection using the SWR protocol occurred during the spring through fall of 2003. Sample points were chosen in advance, using GIS to randomly select points along streams in the watershed, stratified by stream order. Approximately 20 points were sampled in each selected watershed. Field data were then entered into a Microsoft Access database using a web-based interface developed specifically for this project. QA/ QC and analysis of the data are currently underway.

Cross-Scale Analyses: To allow for cross-comparisons between the SWR data and landscape-level metrics, we generated information on landcover characteristics in a 1-km circle surrounding each SWR point, and for each HUC-14 watershed, from the National Land Cover Data (NLCD).

Evaluation of Existing Biological Data Sets: During Year 2, we identified and compiled information on existing biological data sets in the Atlantic Slope region. In Year 3, we conducted an in-depth examination of the characteristics of these datasets, including criteria for sample site selection, dates sampled, field methods, and lab processing. This comparison,

accompanied by literature review, led us to conclude that these data sets were dissimilar enough that they could not be legitimately combined for analysis. For this reason, we decided to focus on two of the larger, more comprehensive data sets – EMAP and MBSS – for the purposes of validating our indicators developed at larger scales using indirect measurements of biological integrity (i.e., rapid habitat assessment, analysis of satellite data). Preliminary analyses of these dataset are underway.

Contributions to EaGLe's Data Committee: The ASC has been working with the EaGLes data committee to develop protocols for long-term storage of data, data organization, data catalogues, metadata creation, and backup of this system. The ASC is in the process of compiling metadata (data about data) describing each of the datasets developed over the course of the project. The datasets and associated metadata will be archived in a central location along with that from other EaGLes projects, and made accessible to future researchers at an appropriate point in time.

Future Activities

Watershed and Spatial Analysis Team: Our workplan for Year 4 includes finishing analyses from Years 2–3 and submitting at least five manuscripts for peer review; testing the effects of additional watershed descriptors such as impervious surface, septic density, and population density; using improved statistical models to provide expectations for SERC estuarine study; sharing findings and coordinating analyses with other ASC partners; and sharing analytical findings with other EaGLe groups.

ECU Watershed Team: ECU will continue to work on developing its assessment procedure for headwater riparian ecosystems in NC. A few more iterations are needed before the procedure is turned over to NCWRP for their programmatic use. ECU will continue to coordinate with the other members of the ACS Watersheds group in analyzing field data to identify appropriate riparian indicators for the ASC study area in relation to social choice (land-use) and Physiographic Province. In addition, ECU plans to give several presentations on indicator development.

PSU Watershed Team and Multi-institutional Activities. Analysis of data collected using the SWR protocol will constitute a major activity in Year 4. These data will allow exploration of the relationships among physical habitat metrics. We will also examine the relationship between physical metrics and landscape metrics, as well as biological data. These analyses will provide insight into the relative benefits of collecting detailed, site-specific information at a few locations versus using synoptic-scale but less detailed GIS data in assessing stream health.

Integration: We are also working toward integrating three main areas of our analyses. These are (1) integration of upstream watersheds with downstream estuaries and, related to that, (2) integration across geographic scales. Several activities are underway in this area. The SERC nutrient discharge model described above will be used to provide expectations for the estuarine study. In addition, the SERC wetland/stream team anticipates integrating with the Penn State GIS team to explore the relationship between their Level 1 spatial assessments and the SERC stream assessments. This integration will be one of the key pieces of information that will link

Penn State's data from non-estuarine small watersheds to SERC's estuarine segment data. Additional examples of this type of integration can be found in other sub-reports.

Publications and Presentations

Publications

Baker, M.E., D. E. Weller, and T. E. Jordan. Evaluating measures of riparian buffer configuration in geographic predictions of nutrient discharge. *Ecological Applications.* (In preparation).

Baker, M.E., D. E. Weller, and T. E. Jordan. Mapping watershed boundaries using digital elevation data: some implications for aquatic assessment. *Photogrammetric Engineering & Remote Sensing.* (In preparation)

Baker, M.E., D. E. Weller, and T. E. Jordan. Stream map resolution in measures of riparian character: implications for statistical models of nutrient discharge. *Journal of the American Water Resources Association.* (In preparation)

King, R. S. and C. J. Richardson. 2003. Integrating bioassessment and ecological risk assessment: an approach to developing numerical water-quality criteria. *Environmental Management* 31:795-809.

King, R. S., M. E. Baker, D. F. Whigham, D. E Weller, T. E. Jordan, M. K. Hurd, and P. F. Kazyak. Final draft, to be submitted by 3/04. Spatial considerations for linking watershed land cover to ecological indicators in streams. *J-NABS* or *Ecological Applications*.

King, R. S., M. E. Baker, D. F. Whigham, D. E Weller, T. E. Jordan, M. K. Hurd, and P. F. Kazyak. Land-use thresholds and stream macroinvertebrate assemblages: influence of physiography, watershed size, and spatial arrangement. *J-NABS* or *Ecological Applications*. (In preparation).

Patil, G. P., J. Bishop, W.L. Myers, C. Taillie, R. Vraney, and D. H. Wardrop. Detection and delineation of critical areas using echelons and spatial scan statistics with synoptic cellular data. *Environmental and Ecological Statistics,* in press.

Wardrop, D.H., J.A. Bishop, M. Easterling, K. Hychka, W.L. Myers, G.P. Patil, and C. Taille. Use of landscape and land use parameters for classification and characterization of watersheds in the Mid-Atlantic across five physiographic provinces. *Environmental and Ecological Statistics,* in press.

Presentations

Bason, C. W. and M. M. Brinson. 2003. Effects of beaver impoundments on water quality in the coastal plain. Oral presentation at the 2003 Society of Wetland Scientists meeting in New Orleans, LA.

Brinson, M. M. 2004. General landscape scale concepts. Presented at a workshop: GIS-Based Functional Assessment of Stream in North Carolina, Raleigh, NC. Organized by the Ecosystem Enhancement Program of North Carolina, 21 January 2004.

Rheinhardt, R.D., M.M. Brinson, R.R. Christian, K.H. Miller, and G.F. Meyer. 2003. Developing and calibrating an indicator for biogeochemical condition of headwater riparian ecosystems. Poster presented at the Bodega Bay EaGLes meeting in December 2003.

Rheinhardt, R.D., M.M. Brinson, R.R. Christian, K.H. Miller, and G.F. Meyer. 2003. A series of presentations on reference sites in the Little Contentnea Creek watershed that preceded a half-day field trip demonstrating a preliminary assessment method. Presented to NCWRP in December 2003.