Atlantic Slope Consortium Annual Report Summary

EPA Grant Number: R-82868401
Center: The Atlantic Slope Consortium
Center Director: Robert Brooks
Title: The Atlantic Slope Consortium - Developing Ecological Indicators for Aquatic Ecosystems of the Atlantic Slope Region
Investigators: Robert Brooks, Denice Wardrop, James Shortle, Robert O'Conner, Egide Nizeyimana, Dennis Whigham, Charles Gallegos, Donald Weller, Anson Hines, Thomas Jordan, Peter Marra, Carl Hershner, Kirk Havens, Lyle Varnell, Mark Brinson, Rick Rheinhardt, James McElfish, Kent Thornton
Institutions: Pennsylvania State University, Smithsonian Environmental Research Center, Virginia Institute of Marine Sciences, East Carolina University, Environmental Law Institute, FTN Associates
EPA Project Officer: Barbara Levinson
Project Period: March 1, 2001 through February 28, 2005
Research Category: Environmental Indicators

Objective of Research

The goal of the Atlantic Slope Consortium (ASC) is to develop and test a set of indicators in freshwater and coastal systems that are ecologically appropriate, economically reasonable, and relevant to society. Specific objectives, as presented in the original proposed scope of work, included: (1) develop and test ecological and socioeconomic indicators of aquatic resource condition, construct models that use environmental, geographic, and stressor data to predict indicator responses, and use models to link upstream watersheds and downstream estuaries; (2) develop large scale measures for characterizing landscape attributes and land-use patterns to serve as predictors of a range of environmental conditions; and (3) deliver a nested suite of indicators to managers, where the implications of aggregating models at various scales are considered, and for which reliability is known.

These objectives were restated in the project vision statement, developed collaboratively by the project team, as follows:

> The ASC uses a universe of watersheds, covering a range of social choices, and asks two questions:
> 1. How "good" can the environment be, given those social choices?
> 2. What is the intellectual model of condition within those choices, i.e., what are the causes of condition and what are the steps for improvement?

The vision can be expanded to encompass the following tools and concepts:

How "good" can the environment be, given those social choices?

- What are the major patterns of social choices, i.e., what are the major watershed types.
- What is the range of condition of aquatic resources for each of the watershed types?

What is the intellectual model of condition within those choices, i.e., what are the causes of condition and what are the steps for improvement?

- What are predictive models of aquatic resource condition, utilizing local landscape characteristics?
- What are predictive models of condition at the estuarine/coastal level, incorporating both local and upstream characterization?
- What are relevant expressions of condition to resource managers?
- How do we communicate restoration procedures to managers, and what influences their implementation?

Following development and articulation of the vision statement, many of the project tasks were oriented to specific portions of this statement. This ensures that a common vision is consistently pursued throughout the project.

Progress Summary and Preliminary Data Results

Year 2 of the ASC project was characterized by extensive field data collection, additional exploration of landscape-level indicators, socioeconomic surveys and modeling, and continued progress toward integration. These activities will be summarized below, and preliminary results will be noted.

Facilitation of All-EaGLes Thematic Meeting, "Moving Towards Integration"

In December 2002, the ASC facilitated the annual all-EaGLes meeting. A theme was established in order to focus discussions and improve the effectiveness of the annual meeting process. An analytical workshop was developed and held the entire first day of the meeting, and involved presentations on analytical methods appropriate for integration tasks. Both EaGLe members and outside experts from EPA-STAR Statistical Centers were involved, resulting in a body of analytical techniques relevant to integration efforts by various EaGLe projects.

Watershed and Estuarine Data Collection and Analysis

A large amount of effort this year has been devoted to collecting field data that will allow development of a variety of site-level indicators of aquatic ecosystem health. In many cases these measurements are being supplemented by existing data sets. Information has been collected in both estuarine and upland waters, with emphasis on the former. Sampling includes measurements of biota (e.g., fish and prey communities, benthic macroinvertebrates, birds, amphibians, vegetation) as well as abiotic condition (e.g., water quality, sediment, in-stream habitat). Shoreline surveys and measurement of optical properties have also been undertaken. In two North Carolina watersheds, beaver ponds are being characterized as a subclass of headwater riverine wetlands, due to their importance in this area. All of the above sampling is being conducted as a series of independent but integrated studies, so not all parameters are measured for all locations.

In a separate but related effort, existing bio-monitoring data, along with water chemistry and physical habitat data, have been compiled from federal, state, and other sources. Analysis of these data will supplement our ability to make cross comparisons among site-specific biological, chemical, and physical habitat data, and landscape-level GIS data as predictors of ecological condition.

In a collaborative effort, representatives from each of the core ASC institutions developed and pilot tested a protocol for sampling Stream, Wetland, and Riparian (SWR) areas to yield a rapid, site-level assessment of watershed condition that can be correlated with water quality discharge models developed for selected watersheds. GIS was used as a tool to overlay the geographic locations of existing biological sample points with a watershed classification system developed in Year 1 for the purpose of selecting 20-30 representative, data-rich watersheds for intensive study. The SWR protocol will be applied in Year 3 to each of the watersheds selected for intensive study. The wetland portion of the SWR assessment is being compared with an alternate, 3-level assessment developed by VIMS.

In addition to site-level indicator development, analysis of geographic data is underway on several fronts. An existing nutrient discharge model and GIS are being used to explore the efficacy of geographic data (beyond physiographic province and land use/land cover) in predicting nutrient discharges. Information about the spatial arrangement of landscape features, particularly source areas and riparian forests, is also being incorporated. This modeling will allow linkages between geographic data and water chemistry data, and ultimately, biological condition.

We continue to pursue unique statistical methodologies to explore relationships between landscape and site-specific data, and how these relationships change across a variety of spatial scales. Collaboration between statisticians and ecologists occurred in a series of weekly meetings during the spring and summer of 2002. One product of this effort was the use of SATScan software to recognize critical areas, or hot spots, of human disturbance and vulnerability of watersheds. The result was a map of statistically derived critical areas, which can then be compared to existing biological data. Refinement of this tool is continuing, and it appears to hold great promise in future indicator testing efforts.

Some examples of preliminary findings/ accomplishments of the estuarine and watershed analyses include the following:

- Analyses using a nutrient discharge model and geographic data showed that watershed morphologies differ significantly across physiographic regions of the Atlantic Slope, and that to varying degrees these differences were expressed via water yields and drainage networks. These differences have implications for our interpretation of nutrient export across the entire study area.
- Preliminary results of nutrients and metals analysis of *Phragmites* leaf samples indicate that N and P concentrations in *Phragmites* are highly elevated in developed estuarine segments, but are similar among forested, mixed land use, and agricultural segments.
- Preliminary analyses of optical water quality measurements indicate that, though the water quality conditions differ widely among the mesohaline Chesapeake sites, absorption and

scattering coefficients per unit mass do not differ systematically among sites that have been sampled intensively enough to make such comparisons. This contrasts with preliminary comparisons made with similar measurements made by the ACE-INC EaGLes, which come from a polyhaline site.

- A hierarchical classification framework was developed for all wetlands in the Atlantic Slope, following the conceptual model used in wetland hydrogeomorphic classifications. This was a joint effort among all ASC member institutions and working groups.
- SATScan software, and other early detection methods, can be used effectively to test the explanatory power of various indicators and landscape variables in biological assessment data.

Human Dimensions Working Group

The Human Dimensions group's data collection and data analysis activities fell in four areas during the reporting period. In the first, interviews were conducted with state and federal agency officials to gather information about what indicators are being used by water quality managers in the ASC, what these indicators are used for, and attributes of indicators that make them particularly useful. We expect the results to guide the selection of a suite of indicators that will be useful for water quality management decisions as well as understandable by stakeholders.

Another line of investigation examines the value of various types of information in aquatic ecosystem management. The *Susquehanna Nitrogen Management Model* is being used to conduct simulation experiments for estimating the value of alternative information sets required to assess the costs and benefits of controlling nitrogen pollution loads to the Chesapeake Bay from the Pennsylvania portion of the Susquehanna River Basin. The Wetland Monitoring Matrix developed by ASC team members Wardrop and Brooks has been represented in a decision theoretic framework that allows estimation of the value of various indicators in wetlands assessment.

In another project, models were developed for integrated assessment of the quality of life and the quality of environment. The primary goal is to provide methods for ranking the relative efficiency of communities in the region in producing a high quality of life and environment using minimal value judgments, and for explaining differences in their relative efficiency.

The human dimensions group has also been conducting research on the legal aspects of ecological indicator use. State laws from the Atlantic Slope states were collected and analyzed to determine where such laws authorized the use of ecological indicators in decision-making. In addition, a baseline analysis is being conducted of the status of ecological indicators as a management tool in state programs across the nation.

Interactions with other EaGLes

Brooks and Wardrop continue to work with the Directors of other EaGLe projects and Coordinator of the USEPA's STAR Grant EaGLes Program through monthly conference calls, correspondence, and face-to-face meetings. The Atlantic Slope Consortium hosted the 2nd Annual EaGLe Meeting in Edgewater (Annapolis), Maryland in December 2002. Significant progress was made addressing integration and data management issues. Brooks and Wardrop are co-authoring an overview paper with the EaGLe Project Directors and Coordinator, and have participated in several meetings to accomplish that task. Several avenues of inter-EaGLe collaboration are beginning to emerge, and will be further explored in the coming year.

Future Activities

The third year of the project will see continued field sampling by ASC members, with increased emphasis on using these data for indicator development and evaluation. EPA's approach described in *Methods for Evaluating Ecological Indicators* (Jackson et al., 2000) will be applied for this latter purpose. There will also be increased attention given to integration across scales, and from upstream watersheds to downstream estuaries. Projected activities of specific working groups include:

Estuary Group – Sampling will continue of the physical, chemical, and biological components of near-shore areas of estuarine segments and the non-tidal stream, wetland, and riparian portions of estuarine watersheds. Continued refinement of the nutrient discharge model with geographic data will be undertaken. The resulting improved statistical models will be used to provide expectations for the SERC estuarine study.

Watershed Group – Additional field sampling using the revised SWR protocol will take place during spring/summer 2003 in approximately 20 watersheds. Integrated analysis will be undertaken of existing biological, chemical, and habitat data, and new data collected as part of the SWR sampling. These analyses will be coordinated with those of SERC's watershed team and with those of the Estuarine Working Group to examine linkages between upstream and downstream conditions. The relationship between site-level and landscape-level indicators will also be explored.

Human Dimensions Group – The major activity in Year 3 will be to conduct focus groups and random sample surveys of stakeholders about diverse indicators in selected ASC watersheds. Efforts will continue on projects underway on the value of information modeling and quality of life/ quality of environment. Investigation of the legal aspects of ecological indicators will continue, including targeted research linking state and local laws in selected case study watersheds.

GIS Team – Acquisition of data will continue, including the National Wetland Inventory, time series of census of population and housing, and specific data attributes for selected watersheds in the study region. In conjunction with the watershed group, analyses of landscape metrics will be performed. The GIS group will also represent the ASC project on the EaGLe data committee.

Project Management and Integration within the ASC

The large number of ASC investigators poses unique integration challenges, and we continue to address them in a number of ways, including: (1) collaborative development of a project vision statement and document, (2) bi-annual "all hands" meetings that emphasize integration, (3) additional sub-group meetings and conference calls, as needed, to focus on more specific issues, (4) the creation of functional working groups that cross institutional boundaries, (5) inclusion of one investigator (Kent Thornton of FTN Associates) whose primary role is to facilitate integration of the project, and (6) creation of a new and improved web site that will facilitate communication among team members.

Inter-institutional coordination has occurred on many aspects of the project including watershed classification, estuarine sampling, shoreline assessment, development of bird community indices, and geographic data acquisition and analysis. Collaborative products produced thus far include a new watershed classification scheme that was subsequently used as the basis for the experimental design, a new protocol for rapid assessment of stream, riparian, and wetland areas, and a paper describing a new hierarchical classification framework for all wetlands in the Atlantic Slope. Inclusion of the Human Dimensions group in the ASC has added a perspective to indicator development that is unique among EaGLe projects, and which has provided much "food for thought" among more traditionally trained natural scientists in the group.

We are also working toward integrating three main areas of our analyses. These are (1) integration of upstream watersheds with downstream estuaries, (2) integration across geographic scales, and (3) integration of scientific and human dimensions evaluations of indicators. Specific activities are documented in each of the institutional reports.

Publications

King, Ryan S. and C. J. Richardson. 2003. Integrating bioassessment and ecological risk assessment: an approach to developing numerical water-quality criteria. *Environmental Management* (in press).

King, Ryan S., M. E. Baker, D. F. Whigham, D. E. Weller, and T. E. Jordan. Spatial considerations for linking watershed landcover to ecological indicators in streams. Invited manuscript to be published in special issue of *Ecological Indicators*.

Patil G.P., R.P. Brooks, W.L. Myers, DJ. Rapport, and C. Taillie. 2001. Ecosystem health and its measurement at the landscape scale: Towards the next generation of quantitative assessments. *Ecosystem Health 7(4):* 307-316.

Patil G.P., R.P. Brooks, W.L. Myers, and C. Taillie. 2002. Multiscale advanced raster map analysis system for measuring ecosystem health at the landscape scale: A novel synergistic consortium initiative. In *Managing for Healthy Ecosystems*, D. Rapport, W. Lasley, D. Rolston, O. Nielsen, C. Qualset, and A. Damania. CRC Press/Lewis Publ. (In press).

Wardrop D.H., J.A. Bishop, M. Easterling, K. Hychka, W. Myers, G.P. Patil, C. Taillie, and R. P. Brooks. Characterization and classification of watersheds by landscape and land use parameters in five Mid-Atlantic physiographic provinces. *Journal of Environmental and Ecological Statistics*. In press.

Presentations

Bilkovic, D.M. and C.H. Hershner. 2002. The applicability of ecological indicators for assessment of fish habitat in the Mid-Atlantic Slope across spatial scales. American

Society of Limnology and Oceanography meeting, Victoria, British Columbia, June 2002.

Gallegos, Charles L. 2003. Development of an optical indicator of habitat suitability for submerged aquatic vegetation in estuaries. Presented a paper at the special EaGLes session organized by Hans Paerl, (UNC ACE INC) at the American Society of Limnology and Oceanography meeting, February 2003.

Marshall, E., and J. Shortle. 2002. Indicators for assessing the ecological impacts of urban sprawl. Northeast Center for Rural Development Land Use Research Workshop. Land Use Research Workshop, Orlando FL, February 2002.

Molineros, J, and J. Shortle. 2002. Assessing the efficiency of deforestation using Stochastic Frontier Analysis. Presented at the Annual Meeting of the Northeast Agricultural and Resource Economics Association, Harrisburg, PA, June 2002.

Patil G.P., J. Bishop, W.L. Myers, C. Taillie, R. Vraney, and D.H. Wardrop. 2002. Detection and delineation of critical areas using echelons and spatial scan statistics with synoptic cellular data. Invited Paper, International Society for Ecosystem Health, Washington, DC, June 2002. http://www.stat.psu.edu/~gpp/PDFfiles/TR2002-0501.pdf

Patil G.P., W.L. Myers, C. Taillie, and D. Wardrop. 2002. Hotspot detection and early warning for synoptic and network-based syndromic surveillance. Invited Poster Presentation, National Syndromic Surveillance Conference, New York City, September 2002.

Wardrop D.H., J.A. Bishop, M. Easterling, K. Hychka, W.L. Myers, G.P. Patil, and C. Taillie. 2002. Use of landscape and land use parameters for classification and characterization of watersheds in the Mid-Atlantic across five physiographic provinces. Healthy Ecosystems, Healthy People Conference, International Society for Ecosystem Health, Washington, DC, June 2002. (Invited paper).

Wardrop D.H., J.A. Bishop, M. Easterling, K. Hychka, W.L. Myers, G. P. Patil, and C. Taillie. 2002. Use of landscape and land use parameters for classification and characterization of watersheds in the Mid-Atlantic across five physiographic provinces. Invited Paper, International Environmetrics Society, Genova, Italy.

Supplemental Keywords: indicators, integrated assessment, aquatic ecosystem, wetland, stream, estuary, watershed, biological integrity, landscape ecology, scaling, socio-economic, decision-making, GIS, Mid-Atlantic.

Relevant Web Site: www.asc.psu.edu