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Nanticoke Wetland Assessment Study

by:

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INTRODUCTION

The overall objective of the study is to assess the ecological conditions of wetlands in the Nanticoke River watershed of Maryland and Delaware. It is one part of a multi-faceted effort coordinated by EPA's Environmental Monitoring and Assessment Program (EMAP), EPA Region III, Chesapeake Bay Program, and Commonwealths of Maryland and Delaware. Following a listing of four objectives and a generalized description of the Nanticoke River watershed, the study plan is divided into four sections. Section I is a description of the Hydrogeomorphic (HGM) approach that we will use to assess wetland conditions. Section II is a description of the proposed activities, Section III contains a preliminary schedule. Section IV is a projected list of products.

Specific objectives are:

1. Use the hydrogeomorphic (HGM) approach to classify and assess ecological conditions in non-tidal riverine and depressional wetlands of the Nanticoke River watershed. The assessments will be performed by conducting field surveys of wetlands in combination with digital spatial data analyzed with a geographic information system (GIS). Completion of Objective 1 will result in measurements of ecological conditions in non-tidal riverine and depressional wetland sites in the watershed. The sites chosen for study will be statistically chosen using EPA protocols to be representative of the entire watershed.

2. Use data from individual wetlands (Objective 1) to predict ecological conditions of non-tidal riverine and depressional wetlands in the watershed. Objective 2 will be accomplished by determining mathematical relationships between wetland conditions and GIS variables obtained in Objective 1. The mathematical relationships will be used in combination with GIS to predict wetland conditions over the entire watershed.

3. Objectives 1 and 2 are based on the important premise that the HGM approach accurately predicts ecological conditions in wetlands. The third objective will be to verify this premise by comparing results of HGM assessments at individual wetlands with measurements of ecological processes at the same sites. This part of the project will focus on denitrification, a specific component of the nitrogen cycle. The importance of denitrification in wetlands in the highly agricultural Nanticoke River watershed is described in more detail below.

4. A fourth objective of the project will be to use denitrification rates measured at individual wetlands (Objective 3) to predict rates of denitrification of all non-tidal riverine and depressional wetlands in the watershed. Objective 4 will be accomplished by determining mathematical relationships between denitrification rates and GIS variables obtained in Objective 1. The mathematical relationships will be used in combination with GIS to predict denitrification rates in all non-tidal riverine and depressional wetlands in the Nanticoke River watershed.

The Nanticoke River drains approximately 700,000 acres of four counties in Maryland and two counties in Delaware (Nature Conservancy 1994). Agriculture occupies about 42% of the watershed and less than 2% is urban or suburban lands. Forests cover approximately 45% of the watershed, but many are intensively managed (Bohlen and Friday 1997). Extensive agriculture and forest management have only been possible because of drainage, a practice that has had major impacts on wetlands in the watershed. Most of the losses of palustrine wetlands in Delaware, for example, has resulted from "agricultural conversion, drainage by channelization projects, and forestry practices" (Tiner 1985). Wetland losses in intertidal portions of the watershed are minimal, but considerable pressures exist for conversion of inland (non-tidal) wetlands (Tiner 1985, Tiner and Burke 1995). Water quality problems are common within the watershed and are thought to be a reflection of the intensive agriculture (Phillips et al. 1993, Maryland Department of the Environment 1994, Bohlen and Friday 1997, Jordan et al. 1997).

We anticipate that the greatest impacts to wetlands in the Nanticoke River watershed have been and will continue to be to riverine wetlands along small (1st and 2nd order) streams and to wetlands in the depressional and flats subclasses (*sensu* Brinson 1993). Accordingly, our efforts will focus on the assessment of wetland conditions in non-tidal riverine, primarily headwater areas, wetlands associated with 1st and 2nd order streams, and depressional wetlands. We will not assess ecological conditions in the more than 16,000 acres (@ 2% of the watershed) of intertidal wetlands associated with the Nanticoke River watershed (Tiner 1985, Tiner and Burke 1995). Our sampling of riverine wetlands will, however, not preclude the inclusion of forested riverine wetlands that are periodically influenced by tides. There is insufficient funding in the project to sample intertidal wetlands and, based on conversations with wetland experts from Delaware and Maryland, tidal wetlands are currently the least threatened wetland types in the watershed.

The approach that we will use to conduct the study, the timetable that we will follow, and expected products from the project are presented in the next four sections. The first year of the study will be the Developmental Phase consisting of three related components. First, we will produce a map of the distribution of HGM wetland subclasses in the watershed. Second, we will develop, test, and validate variables and models that will be used to assess wetlands in the watershed. The third component will be the testing of methods for measuring denitrification. The second year of the study will be the Assessment Phase when we will assess wetland conditions in the watershed, measure denitrification in a sub-set of wetlands chosen for assessment, analyze and interpret data, and produce reports and scientific publications.

SECTION I - HGM APPROACH TO WETLAND ASSESSMENT

We define ecological conditions to be the characteristics of individual wetlands. In the HGM approach to wetland assessment (e.g., Smith et al. 1995, Brinson 1996, Rheinhardt et al. 1997), wetland conditions are determined by quantifying variables chosen to characterize (e.g., assess) wetland functions. A variable is an attribute or characteristic of a wetland (e.g., plant species diversity) or the surrounding landscape (e.g., land-use in areas adjacent to the wetland) that influences the capacity of a wetland to perform a function. Functions are the normal activities or actions that occur in wetland ecosystems. For each wetland that is assessed, a numerical value for each variable is determined by observing the variable in the wetland or surrounding landscape then assigning a scaled value (Variable Subindex) based on comparison to predetermined reference standards. Reference standards are the conditions exhibited by a group of reference wetlands that correspond to a level of functioning that is both characteristic for the reference subclass (e.g., depressional or riverine non-tidal wetlands) in the reference domain (e.g., Nanticoke River watershed) and are sustainable over the long-term without human intervention. Once Variable Subindices have been assigned to each variable, functions are computed as Functional Capacity Index scores by mathematically combining variable Subindices (e.g., Rheinhardt et al. 1997).

Functions assessed using the HGM approach fall into three categories (hydrological, biogeochemical, biological/habitat) and they are conceptually representative of ecological conditions of a wetland at the time it was sampled. Functional Capacity Index scores and Variable Subindices are useful not only in determining existing wetland conditions but also in wetland restoration and mitigation.

One of the strengths of the HGM approach is that it not only can be used to assess overall wetland conditions but the data can be analyzed to determine which variables differ from reference conditions in each wetland or groups of wetlands. We will use matrices of Functional Capacity Index scores and Variable Subindex values to provide a detailed analysis of conditions for depressional and riverine subclasses of wetlands in the watershed. For example, wetland functions for depressional wetlands in the watershed might score high for a hydrology function (e.g., the quantitative score for the function would be near the maximum value of 1.0). The same wetlands, however, might score low for one of the biological/habitat functions (e.g., the quantitative scores for the function would be near the minimum value of 0.0). The Variable Subindex values can be analyzed to determine why the Functional Capacity Index score was low. Continuing with the same example, it might be found that the wetlands which scored low for a biological/habitat function had all been converted from forested wetlands to wetlands dominated by weedy herbaceous species and they all also had low Variable Subindex values for microtopography (i.e., the wetlands had been smoothed mechanically by farming activities). This approach will allow us to provide a detailed analysis of conditions in the watershed from the perspective of both variables and functions. Further descriptions of the application of HGM and examples of its application can be found in Rheinhardt et al. (1997), Ainslie et al.(In press) and Rheinhardt et al. (In review).

SECTION II - RESEARCH APPROACH

The primary goal of this study is to assess the ecological conditions of wetlands in the Nanticoke River watershed. It is not the intention of this study to focus on delineation of wetland boundaries in the watershed nor to perform a trends analysis on wetlands in the Nanticoke. We propose to reach the primary objective by conducting the following procedures during the Developmental and Assessment phases of this study.

Developmental Phase

1. National Wetland Inventory (NWI) maps and state wetland maps from Delaware and Maryland will be used to identify existing wetlands in the Nanticoke River watershed. Wetlands mapped by NWI and by Maryland and Delaware are categorized using the national classification system developed by Cowardin et al. (1979).

2. The Smithsonian Environmental Research Center (SERC) will convert NWI designations for wetlands into hydrogeomorphic classes as described by Brinson (1993). We anticipate that there will be four dominant HGM wetland subclasses in the Nanticoke River watershed: riverine, fringe (both tidal freshwater and tidal brackish-estuarine), depressional and flats. As stated in **Section I**, the scope of this project will only include non-tidal riverine and depressional wetlands. For simplicity, only non-tidal and depressional wetlands will be discussed below as it is uncertain at this time how flats will be handled.

   NWI designations for wetlands will be converted to HGM classes through a series of discussions with NWI and EPA experts and with field testing. We recommend that EPA engage Ralph Tiner to assist with this activity. Tiner is an employee of the US Fish and Wildlife Service, and is an expert in NWI and has experience in converting NWI designations to HGM classes. We also assume that EPA personnel (e.g., Mary Kentula, Charles Rhodes) and members of the research team from the parallel study in the Juniata watershed in Pennsylvania (Robert Brooks and Denice Heller Wardrop of Penn State University) will be available to assist with this activity.

   Once a protocol has been developed to convert NWI categories to HGM classes, SERC will prepare a map of the distribution of HGM wetland classes in the Nanticoke River watershed. The HGM watershed map and the associated GIS database will be made available to the EMAP Design Team for the purpose of assisting SERC in identifying wetland sites that will be sampled in the Assessment Phase.

3. SERC will coordinate with EMAP personnel to develop a sampling strategy, based on their probability-based (random) sample survey approach, to locate potential non-tidal riverine and depressional wetland study sites in the Nanticoke River watershed.

4. Access to wetland study sites and sampling of wetlands will be done by field crews organized and directed by the Wetland Coordinator who has been contracted by EPA to direct these activities. As much as possible, SERC staff we will evaluate each site identified by EMAP to determine its suitability for inclusion in this project. SERC will be responsible for training the Wetland Coordinator who, in turn, will train and supervise the field crews. SERC will assist in training field crews and will develop manuals containing procedures that will be used by the field crews.

5. SERC will develop a list of variables and HGM functional models that will be used to assess wetland conditions. There will be separate lists of variables and functions for non-tidal riverine and depressional wetlands. The initial list of variables and functions will be

based on existing draft HGM models for riverine and depressional wetlands in the Chesapeake Bay region. When appropriate, we will also utilize draft variables and functions that have been developed for wetland flats in the southeast (Rheinhardt et al. In review).

6. A group of experts familiar with the two wetland classes and with HGM procedures will be asked to review the list of variables and functions selected for the wetland sub-classes. The list of variables will be revised based on comments and suggestions from the experts. We recommend that EPA enlist Mark Brinson and Rick Rheinhardt (East Carolina University), Leander Brown (Natural Resource Conservation Service) and Lyndon Lee (L.C. Lee & Associates, Inc.) in this effort. SERC also anticipates that this effort will benefit by interactions with EPA staff (Mary Kentula, Charles Rhodes and Art Spingarn) and scientists (Rob Brooks and Denice Heller Wardrop) involved in the Juniata River assessment study.

7. Procedures for sampling wetlands developed by SERC will be used by the Wetland Coordinator and field crews to sample 25 non-tidal riverine and 25 depressional wetlands. The 50 wetlands will be sampled for purposes of testing, scaling, and revising the preliminary lists of HGM variables. In HGM terminology, the 50 wetlands that will be sampled are called Reference Wetlands and they will be selected, in conjunction with EMAP, to represent the range of ecological conditions that are present in the watershed. If possible, the range of ecological conditions will be represented by selecting Reference Wetlands that are relatively un-impacted by human activities, wetlands that have been impacted by natural and anthropogenic activities, wetlands that have been restored and wetlands that have been converted to agricultural purposes. Data compiled from the 50 Reference Wetlands will be used to scale variables for the two subclasses of wetlands. In addition, feed-back from the field crews will be used to revise protocols for field sampling.

8. The revised list of variables and revised protocols for field sampling will be further evaluated and tested by sampling a second set of 25 randomly chosen wetlands in each subclass. The goals of this test will be: (1.) Continued refinement of the variables and protocols used for sampling wetlands in the Nanticoke River watershed in 2000, (2.) Determine if the protocols that have been developed effectively quantify differences between wetlands. Wetlands that will be used in this test will be identified by the EMAP Design Team, and selected by SERC and the Wetland Coordinator.

Assessement Phase

<u>Site-Level Condition</u> The EMAP Design Team will assist SERC in locating wetlands in the two subclasses for sampling in the spring, summer, and autumn of 2000. The goal of this part of the study will be to use the HGM procedures developed in the 1999 Developmental Phase to determine the ecological conditions of wetlands in the Nanticoke River watershed in 2000 during the Assessment Phase. The number of sites selected and eventually sampled will depend on the number of field crews and number of individuals in the field crews. At minimum, we hope to

sample 100-350 wetlands in each subclass.

Role of Denitrification As noted above, water quality issues are of major concern in the Nanticoke River watershed. Agriculture has greatly increased discharges of nitrogen from the Nanticoke and other coastal plain watersheds of Chesapeake Bay (Jordan et al. 1997). Atmospheric deposition also adds significant nitrogen loads to non-agricultural lands as well as agricultural lands in the Chesapeake watershed (Fisher and Oppenheimer 1991, Jordan et al. 1995). Wetlands can remove nitrogen through denitrification (the conversion of nitrate to nitrous oxide and dinitrogen gases) and improve water quality (Peterjohn and Correll 1984, 1986, Lowrance et al. 1984, Brinson et al. 1984, Bowden 1987, Brodrick et al. 1988, Weller et al. 1994, Hill 1996, Jordan et al. in press). However, it is difficult to extrapolate denitrification rates to large spatial scales because of the high spatial variability of denitrification (Tiedje et al. 1989).

The objectives of this part of the study are to: (1.) Measure denitrification rates in non-tidal riverine and depressional wetlands, (2.) Determine the correlation between denitrification rates and HGM variables that will be used to assess wetland conditions and with other landscape variables represented in digital spatial data sets. These correlations will be used to predict denitrification rates of non-tidal riverine and depressional wetlands in the Nanticoke River watershed.

We will measure denitrification in surface soils *in situ* using chambers placed over the soil to trap emitted nitrous oxide (Yoshinari et al 1977). With this widely-used acetylene inhibition technique (Tiedje et al. 1989), we will infer total denitrification and the proportion of dinitrogen produced by comparing the nitrous oxide release with and without acetylene present. We will also evaluate potential denitrification in response to nitrate loading, the dominant form of nitrogen discharged from agricultural watersheds.

We will also examine correlations between denitrification and related variables such as pH, Eh (Platinum electrode), temperature, organic carbon, total nitrogen, nitrate, and ammonium in the soil; and with dissolved nitrate, ammonium, and organic nitrogen in groundwater and in overlying water (if present).

Landscape-Level Condition We will statistically evaluate relationships between HGM variables and ecological conditions in non-tidal riverine and depressional wetlands in the Nanticoke River watershed. SERC will use appropriate variables and statistics to project data from sites sampled in the field to the entire watershed. We will use ARC/INFO GIS software already in use at SERC to organize and analyze the spatial data on ecological conditions and landscape characteristics.

SERC has extensive experience in GIS technology in our ongoing studies of nutrient discharge from Chesapeake Bay and Patuxent River watersheds. We already hold considerable GIS data on the Nanticoke watershed, including data on NWI wetlands (to be updated with revised NWI maps provided by EPA), stream maps from EPA's Reach Files 1 and 3, USGS digital elevation models, USGS hydrologic unit boundaries, land cover as estimated by remote sensing, soils maps, geologic maps, and other data sets.

SECTION III - SCHEDULE OF ACTIVITIES

Oct.-Dec., 1998

a. Initial discussions with EPA and revision of study plan based on reviewer comments.

b. Meetings with MD and DE stakeholders and EPA staff to evaluate goals and objectives of the project.

Jan.-May, 1999

a. Hire technicians.

b. Draft QAPP plan.

c. Compile NWI maps for watershed into SERC GIS database.

d. Discussions and meetings with NWI and HGM experts to convert NWI maps for Nanticoke River watershed to HGM maps.

e. Discussions and meetings with EPA EMAP to begin coordination of efforts to select wetland sites that will be sampled in 1999.

f. Develop list of variables to be used in models of HGM functions for riverine and depressional wetland subclasses.

g. Develop protocols and field assessment sheets for sampling Reference Standard wetlands.

h. Discussions with Wetland Coordinator to develop protocols for selecting, organizing and training field crews.

i. Conduct GIS analysis of landscape variables for Reference Wetlands selected by SERC and Wetland Coordinator.

j. Conduct preliminary denitrification studies at a subset of Reference Wetlands.

k. Prepare SOP's and QAPP documentation for site selection, inventory, and data management.

Jun.-July, 1999

a. Analyze data from Reference Wetlands provided by Wetland Coordinator and data on landscape variables obtained by GIS procedures at SERC.

b. Revise list of variables and protocols for sampling wetlands.

c. Scale variables using data from Reference Wetlands.

d. Continue measurement of denitrification at a subset of Reference Wetlands.

e. Discussions with Wetland Coordinator and field crews to prepare for sampling second set of wetlands to test procedures.

Aug.-Oct., 1999

a. Wetland Coordinator and field crews sample second set of wetlands.

b. SERC measure denitrification in sub-set of second set of wetlands.

Nov.-March, 2000

a. SERC analyzes data from second set of wetlands to make adjustments needed to conduce watershed assessment in 2000.

b. SERC prepares SOP's and QA documentation for site selection, inventory, and data management for second year of project.

c. EPA EMAP, SERC, and Wetland Coordinator identify and select wetland sites that will be sampled in 2000.

d. SERC analyzes GIS data for wetlands selected for second year of project and prepare information for verification by field teams when they sample the sites.

e. SERC analyzes nitrogen and carbon content of stored soil samples form denitrification measurements.

f. SERC selects sub-set of wetlands that will be used for measurements of denitrification and related variables in 2000.

g. SERC and Wetland Coordinator train field crews for 2000 field season.

April-Oct. 2000

a. Wetland coordinator and field crews sample wetlands.

b. SERC conduct denitrification study at sub-set of wetlands.

Nov.-Sept., 2001

a. Wetland Coordinator provide corrected data, original field sheets, field notes and photographs of wetland sites to SERC.

b. SERC analyze data from wetland assessment and from denitrification study.

c. Prepare final report and prepare publications.

SECTION IV - LIST OF PRODUCTS

1. Semi-annual reports in the form of a memo to the Project Officer.

2. Final report, which may be in the form of a scientific publication (see #5 below)

3. Guidebook of procedures that can be used to assess wetland conditions at the level of an individual wetland and at the watershed scale.

4. Ecological profiles of riverine and depressional wetland subclasses in the Nanticoke River watershed. The profiles would include: (1.) descriptions of the wetland subclass based on results from the project and an analysis of relevant literature, (2.) Summaries and analysis of data collected during the project, (3.) Appendices of data or directions on how to obtain the raw data electronically.

5. Scientific publications based on 3 and 4 above.

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16. Introduction The overall objective of the study is to assess the ecological conditions of wetlands in the Nanticoke River watershed of Maryland and Delaware. It is one part of a multi-faceted effort coordinated by EPA's Environmental Monitoring and Assessment Program (EMAP), EPA Region III, Chesapeake Bay Program, and Commonwealths of Maryland and Delaware. The study plan is divided into four sections. Section I is a description of the Hydrogeomorphic (HGM) approach that we will use to assess the wetland conditions. Section II is a description of the proposed activities, Section III contains a preliminary schedule. Section IV is a projected list of products.

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