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National Health and Environmental
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Corvallis, OR 97333

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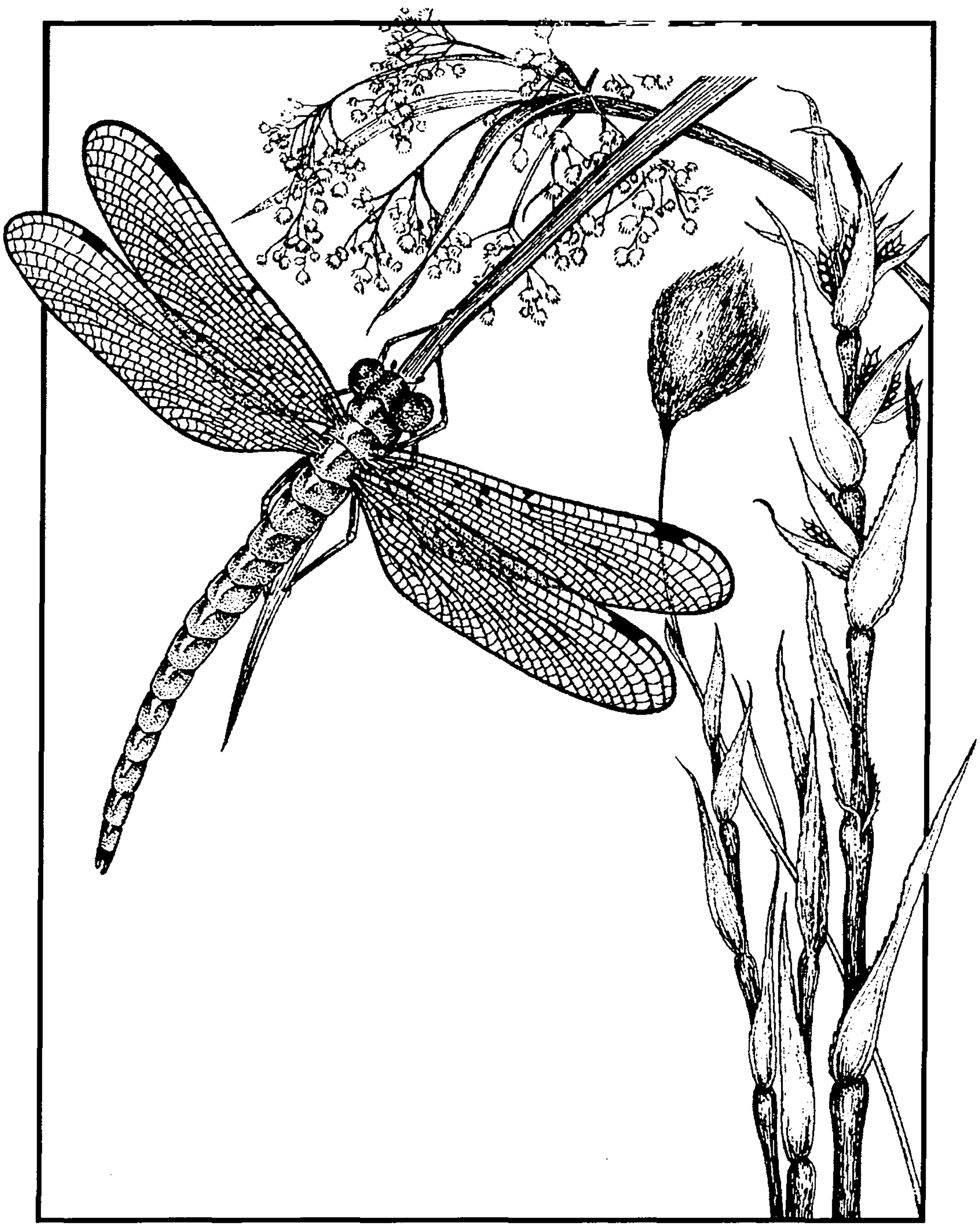
Development and Application of Assessment Protocols for Determining the Ecological Condition of Wetlands in the Juniata River Watershed



Environmental Monitoring and
Assessment Program

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Development and Application of Assessment Protocols for Determining the Ecological Condition of Wetlands in the Juniata River Watershed

by:

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This study will contribute to the development of a means to accurately, efficiently, and fairly assess a wetland's condition in the context of the surrounding watershed that can then be used to implement protective and restorative strategies that are appropriate for both the individual wetland and the watershed. This has been one of the primary goals of research and outreach efforts conducted by the Penn State Cooperative Wetlands Center (CWC) since 1993, and will guide their approach to monitoring and assessing wetlands in the Juniata watershed in central Pennsylvania. The objectives for the study are:

1) To determine and report on the ecological condition of wetlands in the Juniata River watershed using a series of assessment tools.
   a) Develop a preliminary assessment of wetland abundance on two sub-watersheds in the Juniata River watershed. Our experience with applying NWI digital data and other remotely-sensed data for inventorying wetlands in the unglaciated portion of Pennsylvania has shown that these sources do not include the majority of wetlands occurring in the watershed. To effectively sample wetlands in the Juniata, a better estimate of their abundance and general location is necessary (i.e., a Level 1 inventory is not adequate). To help remedy this situation, we are developing a process for deriving a best estimate of wetland acreage from a combined set of GIS databases and a series of decision rules (Level 2 inventory). Acreage will be expressed as an estimate of total wetland acreage in each subwatershed, with zones of high, moderate, and low probability of significant wetland acreage identified on a map

   b) Verify and calibrate the inventory process on two subwatersheds in the Juniata, before the process is applied to the entire watershed, including ground reconnaissance. During the reconnaissance, a cursory inspection of wetland stressors will be performed, resulting in a preliminary indication of condition (Level 2 assessment).

   c) Conduct an inventory of wetland acreage and an assessment of condition for the entire Juniata River watershed. The inventory of the entire watershed will be based on the results of the work done to accomplish Objectives 1a and 1b. Condition will be expressed in terms of HGM functions and HGM type. For example, condition might be expressed as: "Thirty percent of depressional wetlands in the Juniata watershed are exhibiting only a moderate degradation of the long-term storage of surface water function." Condition will be assessed by applying the HGM functional assessment models at a set of wetlands selected by probability-based sampling. The verified inventory and map of acreage zones, and application of HGM functional assessment models constitute a Level 3 assessment.

2) Evaluate the feasibility of integrating a series of bioindicators into the wetland condition assessments for the two sub-watersheds.

3) Evaluate the feasibility of using citizen volunteers to apply the wetland monitoring protocols throughout the Juniata River watershed.

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BACKGROUND

All wetlands are not equal in their ecological functions or societal values, thus, we should not treat them as such. If we do, the result will be mediocrity in the way we protect wetland resources overall. A means is needed to accurately, efficiently, and fairly assess a wetland's condition in the context of the surrounding watershed, and then use that assessment to implement protective and restorative strategies that are appropriate for both the individual wetland and the watershed. This has been one of the primary goals of research and outreach efforts conducted by the Penn State Cooperative Wetlands Center (CWC) since 1993, and will guide our approach to monitoring and assessing wetlands in the Juniata watershed.

From 1993 to the present, the CWC has studied representative wetlands across the Commonwealth of Pennsylvania (Table 1). The goal of the original research project was to develop and evaluate a series of tools to be used by regulatory and non-regulatory staff to assess wetlands by characterizing their current conditions, potential functions, and restoration potential in a watershed context. This was accomplished and the results are briefly summarized below. The work from 1993-1996 was conducted primarily under Service Purchase Contract #275178 from the Pennsylvania Department of Environmental Protection (PADEP) and Federal Contract #CD993282-01 from the U.S. Environmental Protection Agency (USEPA), Region III. The work on reference wetlands is continuing under a Water and Watersheds contract through NSF/USEPA and a State Wetlands Protection Grant through PADEP and USEPA-Region III. These assessment tools have direct applications to this study of the Juniata River watershed. A list of the assessment tools relevant to the proposed project is provided below. Their integration with new approaches that will be developed during the current work is outlined later in this research plan:

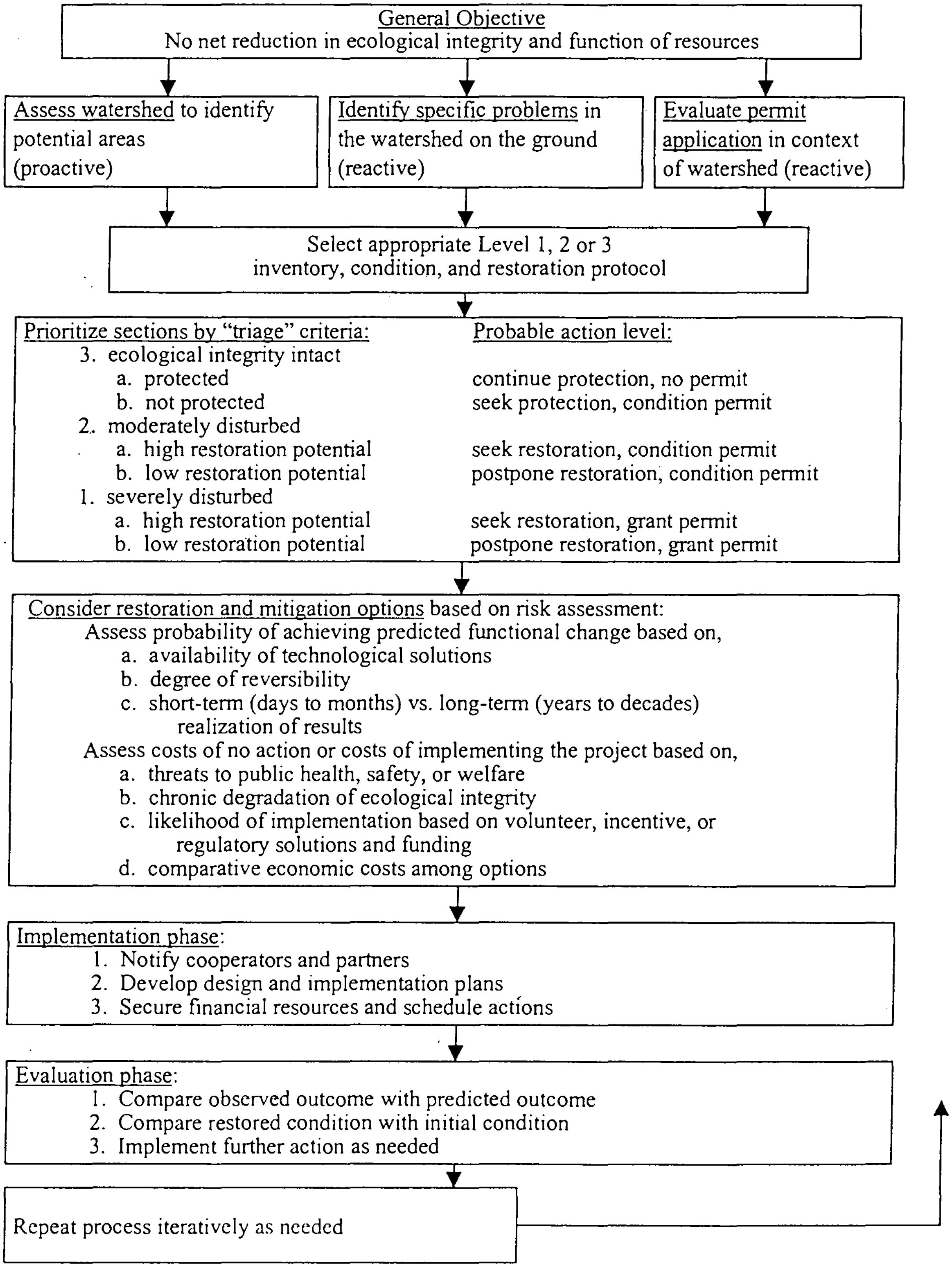
- Developed **W^{3}ATER**, a watershed assessment approach for application throughout Pennsylvania and surrounding states (Figure 1).
- Developed a **Hydrogeomorphic (HGM) Classification Key** for Pennsylvania's inland freshwater wetlands (Figure 2, Cole et al. 1997).

Table 1. Reference wetlands sampled in 1993 (1-22), 1994 (23-38), 1995 (39-51), 1997 (52-63), and 1998 (64-70).

SITE #	SITE NAME	SITE #	SITE NAME
1	BESP - PFO	36	Decker Pond
2	BESP - PEM	37	Peck's Pond
3	Bald Eagle Creek	38	Twin Ponds-PGC
4	LFC Dam	39	Little Sewickley Creek
5	McCall Dam	40	Little Sewickley Creek 2
6	Sand Spring	41	North Park
7*	Canoe Creek	42	Baran Estates
8	Duncansville	43	I-80 SS
9	PSU Airport	44	Black Forest
10*	Whipple Dam SP	45	Spruce Swamp
11	Toftrees	46	Long Pond PFO
12*	Mothersbaugh	47	Long Pond PEM
13	Clark's Trail	48	Mid State Upper
14	LFC - PFO	49	Brandywine Flood Plain
15	CPA Lumber	50	Mid State Middle
16	Old Greentown Rd	51	Donut Hole
17	Lakeville Hunt Clb	52	Tadpole
18	Buffalo Run	53	Nittany B&B Headwater Floodplain
19*	Rothrock St. For	54	Wardrop's
20	Black Moshannon	55*	Swamp White Oak
21	Marsh Creek-PEM	56	Farm 12
22	Marsh Creek-PFO	57	Thompson Run
23*	Shaver's Creek	58	Lock Haven
24*	McGuire Rd.	59	Nittany B&B Riparian Depression
25	Windy Hill Farms	60*	Laurel Run
26	Water Authority	61	Schneider Farm
27	WDC - Gaging Sta.	62	Flatbrookville
28	Millbrook Marsh	63	Shimer's Run
29	Colyer Lake	64	State College High School
30	PFBC - Spr. Creek	65*	Juniata Valley High School
31	Cedar Run	66	Tyrone Area High School
32	Fravel	67	Cumberland Valley High School
33	Lee's Gap	68	Nine Mile Run - Trailer
34*	Stone Valley	69	Nine Mile Run - Slope
35*	Davis	70	Bald Eagle Area High School

* = Reference wetland located in Juniata Watershed

Figure 1. W[3]ATER–Wetlands, Wildlife, and Watershed Assessment Techniques for Evaluation and Restoration



- Established a set of **70 naturally occurring reference wetlands** (Table 1) for long-term studies and intensively monitored the set for use as a benchmark for wetland mitigation designs and impact analyses (Brooks et al. 1996 and unpublished data). Reference wetlands, as defined by the CWC, do not consist only of wetlands in a pristine or unimpacted condition. Their use a benchmark in various types of studies has dictated that they span a range of condition, ranging from pristine to heavily impacted. At this time, 11 reference wetlands from this set are located in the Juniata watershed.
- Completed the development of **HGM Functional Assessment Models** for four wetland subclasses in the Ridge and Valley Province - headwater floodplain, mainstem floodplain, riparian depression, slope - which are typical of the Juniata River watershed. Models were peer-reviewed during a workshop in 1997 and are currently in the process of being calibrated. Calibration of models for depressions, slopes, headwater and mainstem floodplains will be completed by the end of 1999. It should be noted that calibration requires characterizing wetlands across a condition gradient, i.e., both the best condition and the worst condition must be sampled to determine the non-impacted and impacted endpoints of any variable value. Table 2 provides a list of functions and their associated variables for the HGM models. Development and calibration of models for remaining HGM types of importance will be completed by 2000.
- Developed a **standard monitoring protocol** for wetland studies (Brooks et al. 1996). Recently, the protocol was modified into a **Rapid Assessment Protocol** suitable for use by diverse groups such as agency personnel and high school students.
- Completed **Synoptic Watershed Maps** and landscape analyses for four sample watersheds in Pennsylvania, including Shaver's Creek within the Juniata watershed. Comparable work will be done on at least two sub-basins in the Juniata watershed during 1999; one in cooperation with PADEP wetland biologists, and one as part of a ecological/socioeconomic impact and restoration study of acid mine drainage affected watershed (Aughwick Creek, Huntingdon Co.).

Figure 2. Key for hydrogeomorphic classification of wetlands into classes and subclasses in Pennsylvania (Cole et al. 1997). Underlined items are HGM subclasses.

1. Wetland associated with a stream or river .... Floodplain or depression 2
1. Wetland not associated with a stream or river .... Fringing, slope, or depression 14

2. Wetland located within defined banks or channel of stream or river .... Floodplain in-stream
2. Wetland does not occur within defined banks or channel of stream or river) 3

3. Equivalent stream order is 1st or 2nd order ....Floodplain, headwater (H) 4
3. Equivalent stream order is 3rd or larger ....Floodplain, mainstem (M) 9

4. Wetland is impounded .... Headwater Impoundment (HI) 5
4. Wetland is not impounded 6

5. Wetland impounded by beaver activities .... Beaver, HI
5. Wetland impounded by human activities .... Human, HI

6. Wetland has evidence of recent flooding .... Headwater floodplain
6. Wetland has no evidence of recent flooding 7

7. Wetland located on a topographic slope with unidirectional flow of water... Slope
7. Wetland located in a topographic depression...... Depression, headwater (H) 8

8. Wetland located in a topographic depression with discernable inlets or outlets where primary source is groundwater.. Riparian depression (H)
8. Wetland located in a topographic depression with discernable inlets or outlets and with organic soil .... Organic depression (H)
8. Wetland located in a topographic depression with discernable inlets and outlets and where primary sources of water are overland flow or interflow .... Surface water depression (H)

9. Wetland is impounded.......................... Mainstem impoundment (MI) 10
9. Wetland is not impounded 11

10. Wetland impounded by beaver activities .... Beaver, MI
10. Wetland impounded by human activities .... Human, MI

11. Wetland has evidence of frequent flooding.............................. Mainstem floodplain
11. Wetland has no evidence of frequent flooding... 12

Figure 2 (cont.). Key for hydrogeomorphic classification of wetlands into classes and subclasses in Pennsylvania (Cole et al. 1997). Underlined items are HGM subclasses.

12. Wetland located on a topographic slope with unidirectional flow of water .... <u>Slope</u>
12. Wetland located in a topographic depression .... Depression, mainstem (M) 13

13. Wetland located in a topographic depression with discernable inlets or outlets and where primary source is ground-water .... <u>Riparian depression</u> (M)
13. Wetland located in a topographic depression with discernable inlets or outlets and with organic soil................ <u>Organic depression</u> (M)
13. Wetland located in a topographic depression with discernable inlets or outlets and where primary sources of water are overland or interflow .... <u>Surface water depression</u> (M)

14. Wetland associated with a lake, reservoir, or large pond .... <u>Fringing</u>
14. Wetland not associated with a lake, reservoir, or large pond 15

15. Wetland located on a topographic slope with unidirectional flow of water .... <u>Slope</u>
15. Wetland located in a topographic depression without discernable surface water inlets or outlets .... <u>Isolated depression</u> (I) 16

16. Wetland located in a topographic depression without discernable surface water inlets or outlets and with organic soil .... <u>Organic depression</u> (I)
16. Wetland located in a topographic depression without discernable surface water inlets or outlets where primary sources of water are overland flow or interflow .... <u>Surface water depression</u> (I)

Table 2. Variable and Functional Assessment Models in Development

Variable	*Variable Acronym*	*HGM Model Function*
Site Characteristics		
Slope of wetland surface area	Vslope	F1b1,F6,F7
Macrotopographic relief	Vmacro	F2,F8b
Presence of outlets for macrotopographic depressions within floodplain	Vmacro-out	F8
Microtopographic complexity of wetland surface	Vmicro	F1a,F1b1,F6,F7,F8,F9a
% cover of bare ground surface per standard area	Vbaregnd	F9a
Manning's roughness	Vroughness	F1a,F1b1,F7,F8
Representation of the general shape and orientation of the wetland as it relates to the flow path	Vshape	F1b1
Estimated mean depth of standing water during storage event	Vdepth	F1b2
Wetland surface area available for short term storage	Vsurface area	F1a,F1b1,F1b2
Ponded surface area available for short term storage	Vpondedsurface area	F1b2
Above-ground volume available for storage	Vsurfacevolume	F1b2
Below-ground volume available for storage	Vsubsurface volume	F1b2
Depth of restricted area	Vdepthra	F1b2
% total wetland surface area affected by physical features such as culverts, ditches, etc.	Vdisturb	F9a
Presence of disturbance to groundwater flow or discharge	Vgndwater	F4
Plant Community		
Presence of each of four vertical strata: canopy, sapling, shrub, & herbaceous	Vstrata	F9a
Dominant species by subclass or plant community	Vspcomp	F9b
Distribution of sizeclass values for all strata	Vsizeclass	F9a
Presence of propagules of dominant species in each stratum	Vregen	F9b
Proportion of dominance of non-native species or aggressive/invasive native species	Vexotic	F9b
Herbaceous Vegetation		
% cover of persistent herbaceous vegetation per standard area	Vperherb	F1a,F1b1,F5,F7,F8
Woody Vegetation		
Basal area of standing wood per standard area	Vbtree	F1a,F1b1,F7,F8
Basal area of live standing wood per standard area	Vbtreelive	F5
Basal area of dead standing wood per standard area	Vsnags	F5,F8,F10
Density of standing wood per standard area	Vdtree	F1a,F1b1,F7,F8,F9a

Table 2 (cont.). **Variable and Functional Assessment Models in Development**

Variable	*Variable Acronym*	*HGM Model Function*
Woody Vegetation (cont.)		
Density and sizeclass distribution of saplings per standard area	Vsapling	F9a
Total volume of shrub cover per standard area	Vshrub	F1a,F1b1,F5,F7,F8
Amount of coarse woody debris per standard area	Vcwd	F1a,F1b1,F5,F7,F8,F10
Amount of fine woody debris per standard area	Vfwd	F5,F8,F10
Soil Characteristics		
Depth of OE and O1 horizons	Vdepthoe,O1	F10
Amount of soil organic matter	Vsorgm	F5,F6,F8
Presence of redoxymorphic concentrations in upper part of soil profile	Vredox	F5
Soil texture	Vtex	F6
Permeability of the most restrictive layer present in the upper meter	Vperm	F6,F7
Presence of evidence of anaerobic activity	Vanaerobic	F8
Landscape Characteristics		
Categorical ranking of landscape characteristics	Vlandscape	F12
Width of buffer zone surrounding wetland separating it from agricultural or developed land use	Vbuff	F12
% agricultural cover in 1-km radius circle	Vagcov	F12
Degree of aquatic connectivity in 1-km radius circle	Vaqcon	F12
% forest cover in 1-km radius circle	Vforcov	F12
% open water cover in 1-km radius circle	Vowcov	F12
% open urban cover in 1-km radius circle	Vurbcov	F12

Table 2 (cont.). Variable and Functional Assessment Models in Development

F1a - ENERGY DISSIPATION/SHORT-TERM SURFACE WATER DETENTION	
Applicable Subclasses:	Headwater floodplain and mainstem floodplain
F1b1 - ENERGY DISSIPATION	
Applicable Subclasses:	Slope wetlands
F1b2 - SHORT-TERM SURFACE WATER DETENTION/STORAGE	
Applicable Subclasses:	Slope wetlands
F2 - LONG-TERM SURFACE WATER STORAGE	
Applicable Subclasses:	Headwater floodplain, mainstem floodplain, and alluvial riparian depression (slope subclass)
F4 - INTERCEPTION OF GROUNDWATER FLOW OR DISCHARGE	
Applicable Subclasses:	Depressions and slopes (see discussion)
F5 - CYCLING OF REDOX-SENSITIVE COMPOUNDS	
Applicable Subclasses:	Depressions, headwater floodplain and mainstem floodplain, slope, and impoundments
F6 - SOLUTE ADSORPTION CAPACITY	
Applicable Subclasses:	Depressions, headwater floodplain and mainstem floodplain, slopes, and impoundments
F7- RETENTION OF INORGANIC PARTICULATES (assumes retention of organic matter considered elsewhere)	
Applicable Subclasses:	Depressions, headwater floodplain and mainstem floodplain, slopes, and impoundments
F8a - EXPORT OF ORGANIC PARTICULATES F8b - EXPORT OF DISSOLVED ORGANIC MATTER	
Applicable Subclasses:	Depressions, headwater floodplain and mainstem floodplain, slopes, and impoundments
F9-F12 BIODIVERSITY/HABITAT FUNCTIONS	
Applicable Subclasses:	Depressions, headwater floodplain and mainstem floodplain, slopes, and impoundments
F9 PLANT COMMUNITY STRUCTURE AND COMPOSITION	
F10 DETRITUS	
F11 VERTEBRATE COMMUNITY STRUCTURE AND COMPOSITION	
F12 MAINTENANCE OF LANDSCAPE SCALE BIODIVERSITY	

- Derived a set of **Performance Criteria Matrices** (PCMs) from studies of reference wetlands for establishing reference standards on hydrology, soils, sediments, vegetation, and wildlife habitat for mitigation projects and for assessing wetland condition. The PCMs describe standard conditions in wetlands both by HGM type and by level of condition. The matrix structure is illustrated in Table 3.
- Developed a **Wildlife Community Habitat Profile** to facilitate wildlife assessments among different wetland types based on habitat potential (Brooks and Prosser 1995).

PROJECT DESCRIPTION

For decades, a great deal of attention has been focused on the Chesapeake Bay ecosystem and the threats to the ecological health of this valuable natural resource. The emphasis, however, has been on the portions of the watershed nearest the estuary proper. Only recently have major projects included the headwater regions of the ecosystem, such as the Juniata River watershed.

Much of the CWC's work over the last five years has been to develop a cost-effective approach to gathering and synthesizing information needed in wetland decision making. The approach involves the integration of information to support three aspects of decision making--inventory, assessment of condition, and determination of restoration potential (if applicable). Inventory and assessment will be employed in this study and are described below. The entire approach is illustrated in Figure 3. The aspects of decision making are considered sequentially, and each step in the process involves a series of tools developed by the CWC that have been tested in wetlands and watersheds across the state. Each step requires a different level of effort. Whether one goes on to the next step in the process and to a greater level of effort depends on the outcome of the previous effort and the quality of information required.

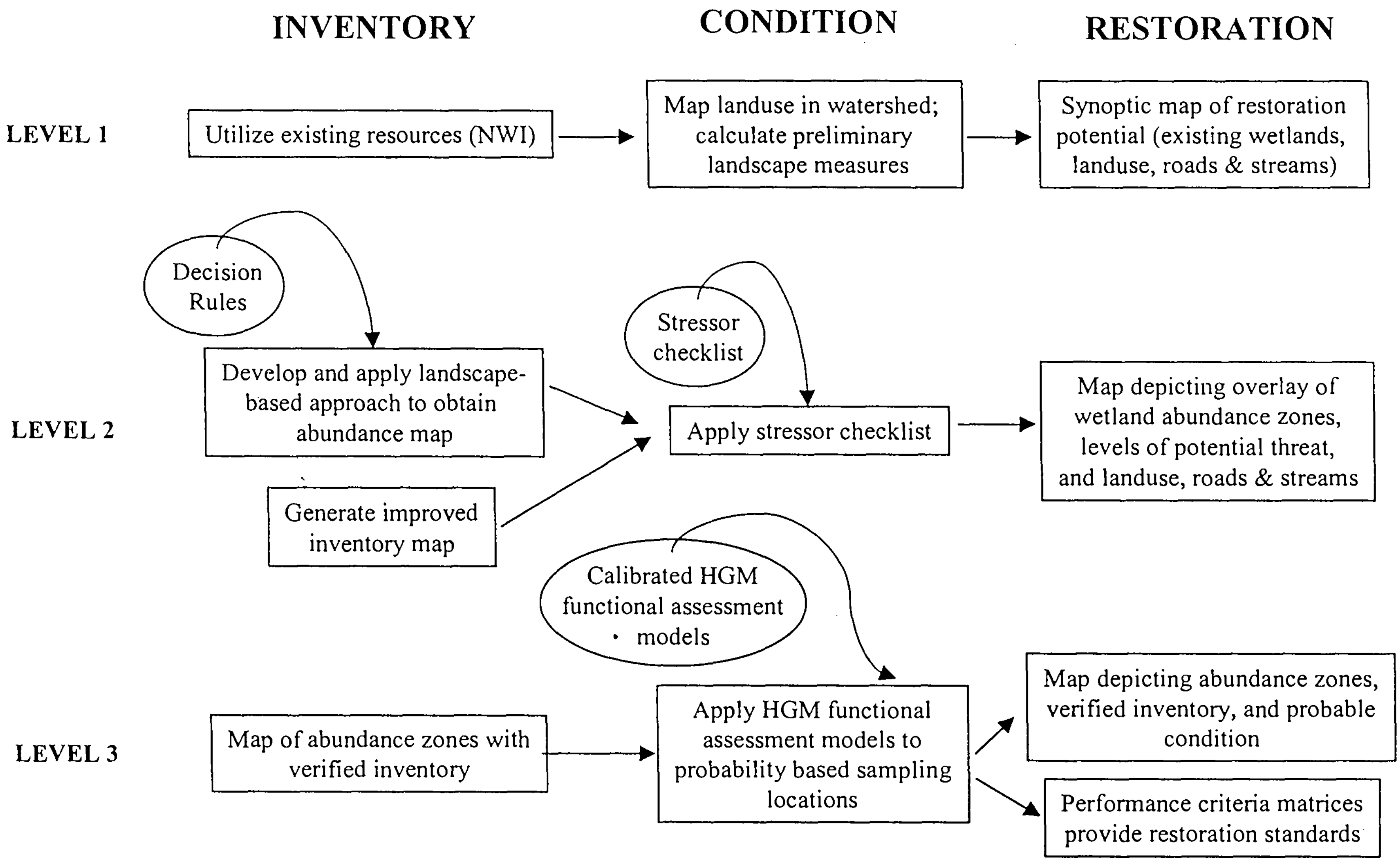
WETLAND INVENTORY

Assessment of watershed condition, based on wetland abundance and condition, in a majority of the watersheds in the Northeast is impossible or inaccurate without a reliable

Table 3. PCM Structure.

HGM Class	Disturbance Level	%Organic Matter 5cm	%Silt 5cm
Isolated Depression	Pristine (n=5)	55.5+/-30.4%	16.3+/-7.1%
	Moderate (n=2)	38.2+/-4.8%	18.2+/-2.8%
	Severe (n=3)	8.2+/-2.8%	47.7+/-2.9%
Riparian Depression	Pristine (n=19)	25.4+/-15.6%	37.4+/-12.2%
	Moderate (n=5)	12.0+/-3.5%	52.9+/-13.6%
Headwater Floodplain	Pristine (n=2)	58.7+/-2.9%	32.4+/-11.4%
	Moderate (n=9)	8.7+/-2.3%	37.0+/-12.9%
	Severe (n=8)	8.2+/-3.1%	48.3+/-20.5%
Mainstem Floodplain	Pristine (n=5)	4.7+/-1.3%	27.1+/-14.3%
	Moderate (n=6)	6.9+/-0.6%	50.9+/-6.2%
	Severe (n=10)	8.8+/-5.3%	37.0+/-20.2%
Slope	Pristine (n=27)	27.2+/-23.5%	34.9+/-10.4%
	Moderate (n=16)	9.6+/-3.1%	35.6+/-9.1%
	Severe (n=5)	9.9+/-1.7%	63.3+/-4.9%
Headwater Impoundments	Pristine (n=23)	27.9+/-24.2%	37.9+/-13.4%
	Moderate (n=4)	10.8+/-3.4%	51.1+/-10.9%

Figure 3. Integration of wetland inventory, assessment, and restoration



inventory of wetland area. Wetlands in the unglaciated portion of Pennsylvania are believed to encompass only 3-5% of the landscape and they are relatively small in area. Our experience has shown that National Wetland Inventory (NWI) quads for Pennsylvania underestimate the occurrence of wetlands by nearly 100%, and any wetland assessment of an entire watershed will not include the majority of wetlands occurring in the watershed if based on NWI information. To help remedy this situation, we are developing a best estimate of wetland occurrence derived from a combined set of Geographic Information System (GIS) databases and a series of decision rules. The inventory methodology is composed of three levels of effort and is described below.

LEVEL 1 - Gather best available mapped information from NWI and other sources.

LEVEL 2 – If NWI-based information is deemed to be insufficient, landscape-based decision rules are developed to identify relative areas of high, moderate, and low probability of wetland acreage. This process ultimately requires ground reconnaissance to locate and classify wetlands from a probability-based sample, resulting in verification and calibration of the approach. Calibration provides an estimate of total acreage of wetland area associated with each zone (high, moderate, and low probability of wetland acreage), ultimately leading to an estimate of total wetland acreage in the watershed. It is important to note that this procedure results in zones of relative wetland acreage, with zones of high, moderate, and low probability of significant wetland acreage displayed on a map; it does not locate individual wetlands over the entire watershed. However, some specific wetlands are identified and mapped during the ground reconnaissance, although the numbers of such wetlands are limited. Level II results in a map with the following items: 1) all NWI wetlands, 2) zones of high, medium, and low probability of wetland acreage, and 3) all "new" wetlands (i.e., those not indicated on the NWI map) discovered during ground reconnaisance activities.

LEVEL 3 –Additional ground reconnaisance events may occur during a range of watershed-related activities, not necessarily related to the construction of an inventory per se. For example, during a condition assessment of the watershed, field activities may identify additional wetlands not present on the Level II map. Any additional wetlands (i.e., those not indicated on the Level II map) discovered during these ground reconnaisance activities are therefore added to the Level II map, and the resulting product is termed a Level III map. A Level III map may constantly evolve, as additional wetlands are encountered and verified during ongoing watershed assessment and planning activities.

ASSESSMENT OF CONDITION

A primary question is always, "What is the condition (eventually, level of impairment) of a wetland?" The CWC has developed a triage approach to wetland assessment (see description of **W^{3}ATER** in Figure 1), which utilizes three levels of condition, i.e., intact ecologically, moderately disturbed, and severely disturbed. These three levels of condition can be established with varying levels of certainty, i.e., confidence intervals of varying widths. Not all decision-making requires fine-scale information on wetland condition; the requirements of decision-making may dictate the level of condition assessment required. In order to provide a range of condition assessment options, the CWC has developed a three-tiered approach. Each tier in the process of assessing condition requires a different level of effort. Whether one goes on to the next step and a greater level of effort depends on the outcome of the previous effort and the quality of information required.

LEVEL 1 – As a screening tool, prepare a watershed map utilizing the synoptic approach and the best, available inventory information (provided by Level 1 of the inventory process, as described above). The synoptic approach is documented in USEPA, 1992, and uses readily-available GIS data layers to produce statewide maps that rank portions of the landscape according to a set of landscape variables, or indices. The maps and indices are intended to provide regulators with a measure of the landscape condition of an area and a relative rating of cumulative impacts between areas. The indices are determined by the user, and, thus, may reflect the user's priorities and needs. For example, if a map depicting the loss of flood storage function is desired, the synoptic approach would combine GIS layers containing information on wetland loss and hydrologic loading. At a minimum, a synoptic map should characterize land use patterns of broad areas of the watershed and present this information on a map of Level I inventory wetlands. It is anticipated that an update of GIS land cover data layers would occur about every five years. The map can then be used to see if significant or particularly sensitive wetland acreage is located in proximity to a land use considered to have a high potential for impact (i.e., with potential for impact on wetland functions). Areas of present impact, potential impact, and no probable impact can be approximated, and used to prioritize watershed activities.

LEVEL 2 – If the existing inventory is judged to be insufficient for the level of decision-making desired, landscape-based decision rules are developed and applied to provide an improved estimate of wetland acreage. This information is provided by Level 2 of the inventory process (as described above). Wetland acreage is expressed as an estimate of total wetland acreage in the watershed, with zones of high, moderate, and low probability of significant wetland acreage identified on a map. This process ultimately requires ground reconnaissance to locate and classify wetlands from a probability-based sample. During this ground reconnaissance, a preliminary assessment of condition is also performed, utilizing a simple checklist to identify probable stressors. This level of assessment provides both an estimate of wetland acreage and level of potential threat with wide confidence intervals.

LEVEL 3 - If assessments at Levels I or II detect potential problems, a more detailed ground-based assessment to assess condition and diagnose specific stressors (about one half day per wetland) can be performed. If HGM functional models are chosen to serve this purpose, condition can be expressed in terms of HGM functions and HGM types. For example, condition would be expressed as: "Thirty percent of depressional wetlands in the Juniata watershed are exhibiting moderate degradation of the long-term storage of surface water function."

OBJECTIVES

Our objectives for the study are:

1) To determine and report on the ecological condition of wetlands in the Juniata River watershed using a series of assessment tools.
   a) Develop a preliminary assessment of wetland abundance on two sub-watersheds in the Juniata River watershed. Our experience with applying NWI digital data and other remotely-sensed data for inventorying wetlands in the unglaciated portion of

Pennsylvania has shown that these sources do not include the majority of wetlands occurring in the watershed. To effectively sample wetlands in the Juniata, a better estimate of their abundance and general location is necessary (i.e., a Level 1 inventory is not adequate). To help remedy this situation, we are developing a process for deriving a best estimate of wetland acreage from a combined set of GIS databases and a series of decision rules (Level 2 inventory). Acreage will be expressed as an estimate of total wetland acreage in each subwatershed, with zones of high, moderate, and low probability of significant wetland acreage identified on a map.

b) Verify and calibrate the inventory process on two subwatersheds in the Juniata, before the process is applied to the entire watershed, including ground reconnaissance. During the reconnaissance, a cursory inspection of wetland stressors will be performed, resulting in a preliminary indication of condition (Level 2 assessment).

c) Conduct an inventory of wetland acreage and an assessment of condition for the entire Juniata River watershed. The inventory of the entire watershed will be based on the results of the work done to accomplish Objectives 1a and 1b. Condition will be expressed in terms of HGM functions and HGM type. For example, condition might be expressed as: "Thirty percent of depressional wetlands in the Juniata watershed are exhibiting only a moderate degradation of the long-term storage of surface water function." Condition will be assessed by applying the HGM functional assessment models at a set of wetlands selected by probability-based sampling. The verified inventory and map of acreage zones, and application of HGM functional assessment models constitute a Level 3 assessment.

2) Evaluate the feasibility of integrating a series of bioindicators into the wetland condition assessments for the two sub-watersheds.

3) Evaluate the feasibility of using citizen volunteers to apply the wetland monitoring protocols throughout the Juniata River watershed.

APPROACH AND METHODS

USE OF REFERENCE WETLANDS

As stated previously, the CWC has intensively studied 70 reference wetlands in Pennsylvania spanning both a variety of HGM subclasses and a disturbance gradient. The majority of these sites are located in the Ridge and Valley Province. Eleven reference wetlands from the set are located in the Juniata River watershed, including one wetland being monitored in cooperation with the Juniata Valley High School in Alexandria. It is important to reiterate that the use of the term "reference" applies to the entire collection of wetlands that span a disturbance gradient, while other investigators may use the term "reference" to imply only pristine conditions. The characterization of wetlands across a disturbance gradient is an intentional characteristic of the reference collection's architecture. We must know not only the level of function a wetland of a given type may achieve (assumed to be in a pristine, unimpacted landscape), but also the level of functioning that is attainable in an impacted landscape. The data from the reference collection provides two major products: Performance Criteria Matrices (PCMs) and a means to calibrate the HGM functional assessment models. PCMs establish reference standards on hydrology, soils, sediments, vegetation, and wildlife habitat for mitigation projects and for assessing wetland condition. The PCMs describe standard conditions in wetlands both by HGM type and level of condition. The matrix structure is illustrated in Table 3. The original PCMs (Bishel-Machung et al. 1996, Brooks et al. 1996) are being continuously updated as new data become available. Calibration of the HGM functional assessment models utilized some of the PCM data, although some variables contained in the models were never measured during the initial characterization of the reference set. To address this deficiency, many of the reference wetlands were re-sampled during 1998 using our Rapid Assessment Procedures (RAPs) to ensure that all members of the reference set were assessed for all potential functions as described by the HGM models for the Ridge and Valley. These data are being used to calibrate the HGM functional models for the Ridge and Valley Province.

OBJECTIVE 1A. DEVELOP PRELIMINARY ESTIMATE OF WETLAND ABUNDANCE ON TWO SUB-WATERSHEDS USING GIS.

Wetlands in the unglaciated portion of Pennsylvania are believed to encompass only 3-5% of the landscape and they are relatively small in area. Based on our experience, National Wetlands Inventory (NWI) quads for Pennsylvania underestimate the total acreage of wetlands by nearly 100%. Any wetland trends assessment of the entire watershed will not include the majority of wetlands occurring in the watershed. To help remedy this situation, we will develop a best estimate of wetland abundance derived from a combined set of GIS databases and a series of decision rules.

Two sub-watersheds in the Juniata River watershed will be selected for detailed investigations. Although we have some candidate watersheds in mind (e.g., portions of the Spruce Creek sub-watershed), the selection of these watersheds will be made in consultation with USEPA, PADEP, and local community leaders. The intent will be to select two watersheds that are typical of the geologic and land use diversity found in the Juniata River watershed.

Each of the sub-watersheds selected will be portrayed with digital data from satellite imagery that characterize land cover and land use. For example, USEPA's Multi-Resolution Land Cover (MRLC) and classified satellite imagery for Pennsylvania (Terrabyte from the Pennsylvania GAP Project) are both at 30-m pixel resolution with overlays of 1:24,000 scale stream and road data digitized by the Pennsylvania Department of Transportation (PennDOT). Again, in our experience, wetlands are poorly recognized in this database. We have tried using on-screen identification of known wetlands in an effort to identify appropriate spectral signatures. However, the lack of unique vegetation patterns in most wetland types of the unglaciated portions of the Commonwealth make this task difficult for all sites except those with significant amounts of open water and/or aquatic beds, i.e., the wetter sites. Thus, we will use other relevant data such as stream data, watershed boundaries, surficial geology (Pennsylvania Geologic Survey, Map 51), elevation/slope/aspect, soils, the Federal Emergency management Agency's (FEMA) floodplain maps, within a GIS to develop decision rules. The rules will then be used to predict the probability of wetland abundance in three categorical zones: high, moderate, and low.

OBJECTIVE 1B. VERIFY AND CALIBRATE THE PRELIMINARY ESTIMATE OF WETLAND ABUNDANCE FOR THE TWO SUB-WATERSHEDS.

We will use an EMAP-style probability-based sampling approach to verify and calibrate our preliminary wetland abundance estimate in the targeted two sub-watersheds (Stevens, 1997). The EMAP sampling points will be randomly stratified into high, moderate and low probability of being associated with wetlands. Initially, the EMAP sampling points located in the moderate and low probability areas will be identified on aerial photographs. DEP staff and interns will summarize the wetland area within a 1-km strip on the photo that is centered on the sampling point and oriented on a randomly-selected compass direction. If it is determined that not all wetlands or wetland area can be identified using the aerial photographs, the sampling point will be visited in the field by DEP staff and interns. At the sampling point, the DEP staff and interns will inventory wetlands within the 1-km strip previously identified on the aerial photos to obtain an estimate of wetland abundance. They will also perform a cursory inspection of stressors to the wetland. CWC staff and volunteers will visit each sampling point located in the high probability area and inventory the wetlands within the 1-km strip. The results of the inventory process (estimates of abundance) in all three categories will be used to verify the GIS probability map and to calibrate the decision rules.

In addition, a stressor checklist (Level 2 condition assessment) will be completed for each wetland identified in the field. The checklist is composed of a set of indicators used to identify probable stressors, such as sedimentation, hydrologic modifications, habitat fragmentation, and acidification (Adamus and Brandt 1990). The purpose of the indicators is to allow agency biologists and trained volunteers to rapidly identify the stressors affecting individual wetlands, stream reaches, and the surrounding landscape. Wherever feasible, there will be both field and landscape versions of each indicator. Some stressors, such as habitat fragmentation and sedimentation, must be assessed both from the synoptic watershed maps and from ground reconnaissance. An example of one field indicator for one stressor - sedimentation - might be observations of potential pathways for sediments such culverts, ditches, or exposed earth around the edge of a wetland. For hydrologic modification one field indicator might be evidence of dying trees in a flooded wetland.

OBJECTIVE 1C. CONDUCT AN ASSESSMENT OF WETLAND ABUNDANCE AND CONDITION IN THE ENTIRE JUNIATA WATERSHED.

We will use the EMAP-style probability-based sampling approach (Stevens 1997), tested in Objective 1b, to characterize the wetland abundance and condition in the entire Juniata. For this objective, the EMAP sampling points will be randomly located in only areas of high probability of wetland occurrence. Since, at this time, it is not known how many points should be sampled, we will assume about 150 will be sufficient (and probably a maximum number). The inventory process described in Objective 1b will be performed at the sampling points to obtain an estimate of wetland abundance.

Once wetland area at each sampling point has been inventoried, the wetlands will be weighted by their area, and then one wetland within the 1-km strip will be randomly selected to perform the condition assessment. At each selected wetland, the Rapid Assessment Procedures (RAPs) and an alternative protocol, which requires less plant identification, will be performed. The Rapid Assessment Procedures (RAPs) were developed for the Adopt-a-Wetland Program of Pennsylvania's High Schools and for collecting calibration data for our HGM models (Brooks and Wardrop in prep.). The results of both the RAPs and alternative protocol will be compared to see if the alternative protocol provides adequate information for decision making.

Assuming about 150 points will be sampled, we estimate that each site can be monitored with our Rapid Assessment Procedures (RAPs) (Level 3 condition assessment) in about 3 hours in the field with a two-person team, for a total of about 600 hours of actual sampling time. Where access to a site is not allowed, an alternative point will be selected and assessed.

The data collected in the field on wetland condition will be used to develop an index of wetland condition. The final form of the index is not known at this time. A potential model, however, can be found in US EPA's "Surf-Your-Watershed" web site (www.epa.gov/surf/iwi) where an "Index of Watershed Integrity" (IWI) can be generated. There are two categories for the IWI, one of <u>condition</u> and one of <u>vulnerability</u>. The former consists of characteristics, much like those measured by the RAPs for individual wetlands. The latter represent stressors similar to the ones measured by during the landscape assessments. So perhaps, a similar index to wetland integrity for an entire watershed might be created and displayed on the same web page with the IWI.

OBJECTIVE 2. EVALUATE THE FEASIBILITY OF USING BIOINDICATORS IN ASSESSING CONDITION.

The CWC has extensive experience in the development and testing of biological, chemical, and physical indicators for use in assessing wetland condition, e.g., plants (Goslee et al. 1997), soils (Bishel-Machung et al. 1996, Stauffer and Brooks 1997), sediments (Wardrop and Brooks 1998), hydrology (Cole et al. 1997, CWC unpublished data), water quality (Babb et al. 1997, CWC unpublished data), birds (Croonquist and Brooks 1993, O'Connell et al. 1998, Gaudette 1998), amphibians (Brooks et al. 1996, CWC unpublished data), and macroinvertebrates (Bennett, CWC in progress). Also, work has been conducted on a watershed basis at the landscape scale (Brooks et al. 1996, Miller et al. 1997, Wardrop 1997, O'Connell et al. 1998). Brooks and Wardrop are participants in US EPA's Biological Assessment of Wetlands Working Group (BAWWG), so the principals in the Juniata study will remain current with regard to recommended bioindicators and methods.

For this project, we plan to test the use of several bioindicators in conjunction with the RAPs. This work will be conducted during the work in the field to verify and calibrate the estimates of wetland abundance in the two sub-watersheds (objective 2a). At this time, we plan to collect plant (dominant species) data, at a minimum, which can be easily collected by trained volunteers. Pending the results of our work in progress on birds, wetland macroinvertebrates and streamside salamanders, we may add these components. A brief discussion of the approach used for each of these indicators presented below.

Plant Community Assessment

Indicators can generally be thought of as measurable variables that are directly or indirectly related to parameters of interest. When indicators are intended to infer a measure of biological function, they are termed bioindicators. Attempts to compile exhaustive lists of potential bioindicators have been attempted elsewhere, and a short list has been prepared by the USEPA (Adamus and Brandt 1990). Potential responses of a wetland to stressors are many, and involve plant, animal, and microbial communities. While not all plant species are highly sensitive to disturbance, the immobility of the plant community, its amenity to remote sensing techniques, and easily recognized signs of stress make it preferable for an initial study of disturbance effects.

Previous work at the CWC studied the impact of one stressor (sedimentation) on the plant community, and investigated the potential utility of plant community measures as indicators of wetland disturbance (Wardrop and Brooks, 1998). Responses did occur at the level of individual species, and species can be categorized as sediment tolerant, moderately tolerant, slightly tolerant, and sediment intolerant based on their association with environments of varying magnitudes of sedimentation. In general, species that were categorized as sediment tolerant or moderately intolerant increased in percent cover (dominance) over a gradient of increasing sediment accumulation. Mean percent cover, when plotted versus sediment accumulation, provides a stressor-impact curve for an individual species.

The RAP developed by the CWC contains a comprehensive plant community sampling methodology, which has been used in a variety of project types. Three sizes of plots are used to record various measures of the plant community: a 1 m^2 plot, a circular plot with a radius of 3 m, and a circular plot with a radius of 11.6 m. The activities in each plot are:

1 m^2 Plot

- Percent cover to the nearest 5% for dominant species (up to 5 herbaceous species).

3 m-radius Plot

- Species richness (i.e., number of species present)
- Percent aerial cover of downed leaf and small woody material (less than 1 cm in diameter)
- Height and circular projection of cover (crown) for all shrubs

11.6 m-radius Plot

- Basal area, by species of trees and estimates of crown closure
- Estimates of percent herbaceous cover
- Number of occurrences of downed woody material

This protocol has been used with a variety of sampling personnel, including high school students, and has been shown to be fairly robust if the sampling team is properly trained.

Avian Community and Landscape Pattern Assessment

Additional indicators of landscape condition are useful and relevant to this study because of the relationship between watershed-wide landscape condition and the condition of wetlands in the Juniata. Bird communities provide one type of regional indicator of landscape condition, and their use is easily justified. Due to their mobility, birds may respond to a wide range of stressors affecting both terrestrial and aquatic habitats. Predictions regarding bird community responses to changes in land cover and connectivity are based on readily-available life history information, and have proven to be reliable (e.g., Croonquist and Brooks 1991). Although census data are usually site-specific, they can be aggregated at least to a landscape scale (multiple $km^{2)}$, and perhaps to an ecoregion. Trends in songbird populations are reported both regionally and nationally, and their suitability as a regional indicator is currently being tested (O'Connell et al. 1998).

We are engaged in a separate project to examine changes in bird communities across landscapes in the Mid-Atlantic Highlands Area (MAHA)(O'Connell et al. 1998). A Bird Community Index (BCI) that is responsive to changing landscape patterns has been developed. Data were collected in 58 plots during 1995 and for 68 plots in 1996 centered on random points of the EMAP hexagonal grid. In addition, we have bird data from 34 reference wetlands and associated upland plots in the Ridge and Valley Province from 1994, and a similar set of data from 60 other wetlands collected in 1995 (Gaudette 1998). Numerous points from both of these studies were located in the Juniata watershed. These data are being correlated with landscape metrics developed from 1-km diameter circles. Results from these studies show that response guilds of the bird community vary predictably as the landscape matrix shifts from predominantly forest to a mixed mosaic of patches (Gaudette 1998, O'Connell et al. 1998). At least five categories of landscape configuration have been identified, with corresponding responses by bird guilds.

Measurement of bird communities is relatively simple, a volunteer data collection network is in place, and historic databases exist. This information could be used in conjunction with on-site avian censuses conducted by knowledgeable volunteers, as a coarse indicator of landscape condition within each watershed. The Juniata Audubon Chapter is quite active and competent, so at least a modest pool of potential volunteers is available. Avian communities will be assessed using standard 10-minute point counts (i.e., morning census period under suitable weather conditions). Point counts will be conducted three times during the breeding season at a minimum of 10 points per stream reach. Birds detected by sound or sight within a 50-m radius plot adjacent to the stream will be recorded. Plots will be at least 150 m apart. Habitat characteristics at point counts will follow those used by O'Connell et al. (1998) for plots the EMAP Bird Landscape Study. If avian community data becomes available for the Juniata, it could be applied to the existing BCI as a means of assessing landscape condition around selected wetlands. Data for wetland-dependent species could be applied to a wetland bird IBI (proposed for development in late 1999) to evaluate the condition of wetlands in the Juniata basin.

Macroinvertebrate Community Assessment

Aquatic invertebrate communities are known to change in response to a variety of stressors (Adamus and Brandt 1990, Brooks et al. 1991, Hicks 1995). A significant effort has been made to integrate chemical, biological, and physical parameters for assessing the ecological integrity of streams (e.g., USEPA 1991), resulting in satisfactory predictions of the health and condition. Considerably less effort has been directed towards wetlands. Use of macroinvertebrates as an indicator will depend on the level of taxonomic detail needed for the Invertebrate Community Index (ICI) being developed by Bennett and Brooks for wetlands under separate funding. If feasible, we will aggregate species into easily identifiable groups and response guilds to simplify the ICI.

There are no standard methods recommended for sampling macroinvertebrates in wetlands. In previous studies, we have investigated the utility of several techniques, including submergence traps, emergence traps, benthic grab samples, benthic cores, and sweep nets (Brooks et al. 1991, Brooks and Prosser, unpublished). In still waters having an open water column, submergents, or emergents, we will use a D-net, swept in a 1-m arc 10 times. Benthic cores (5-10 cm in diameter and depth) will be taken in wetlands with standing water, saturated soils, or seasonally saturated soils (Kentula et al. 1992, Hicks 1995). For sweeps and benthic cores, three samples will be taken in representative habitats and pooled for sorting and analysis.

All samples will be rinsed through a No. 35 mesh (500-micron) screen. The remaining material will be distributed evenly in a light-colored pan and the macroinvertebrates removed.

Specimens will be preserved in alcohol before being identified (or afterwards if sorting occurs immediately). The level of identification will generally be to order. Further identification to family, genus, and species may be required for some taxa. Voucher specimens will be kept for reference. The primary identification guides used will be Thorp and Covich (1991) and Merritt and Cummins (1996).

OBJECTIVE 3. EVALUATE THE FEASIBILITY OF WORKING WITH CITIZEN VOLUNTEERS.

We will contact leaders of the communities and conservation groups within the watershed to discuss the objectives of the proposed study, discuss opportunities for collaboration and sharing data, and request their assistance in the completion of this work. Four conservation organizations are identified in USEPA's "Surf Your Watershed" site for the Juniata, although others exist. In addition, we will request to work explicitly with the County Conservation Districts, County Cooperative Extension Offices, PADEP's Southcentral Regional Office, Pennsylvania Game Commission's Southcentral Regional Office (we have worked previously with Willis Sneath, the Regional Director), and other interested parties. These community outreach efforts will be organized by our Research Assistant - Jennifer Perot, and coordinated with the Juniata Monitoring Coordinator for the project. A web site should be established to communicate the progress of the study and to provide a location for displaying data and information. One possible location for summarized data and maps is USEPA's "Surf Your Watershed" site (www.epa.gov/surf/iwi). Our queries to this site have found it to be very useful for both passive and interactive inquiries about the watershed.

We will test the suitability of the condition assessment protocol for trained volunteers during the initial 1999 field season. Field team leaders from the Southern Alleghenies Conservancy (SAC) will accompany CWC personnel during condition assessments of at least 10 wetlands. The protocol will be open to evolution during that time, with input from the SAC personnel on its appropriateness for implementation by volunteers. In addition, a formal test of two versions of vegetation sampling will occur, and the results will be used to finalize the protocol for the year 2000 field season (with accompanying QA plans (USEPA, 1996)).

GENERAL PROJECT INFORMATION

PERSONNEL ASSIGNMENTS

Robert P. Brooks, Ph.D. -- Principal Investigator (PI): Dr. Brooks has over 20 years of experience as a wildlife biologist and wetland scientist. Currently, he is Professor of Wildlife and Wetlands Ecology and Director of the Penn State Cooperative Wetlands Center. He has experience in managing multi-scale projects. He recently completed a 3-year statewide study of reference wetlands, is the PI for the EMAP Bird Landscape study in the MAHA, and Co-PI for a multi-year Water and Watersheds study cooperatively funded through the National Science Foundation and USEPA . He has extensive expertise regarding the ecology and conservation of wetland, stream, and riparian components of watersheds, but is also familiar with terrestrial habitats, land use planning, and landscape analysis. Dr. Brooks will serve as Project Director, and in that role will oversee the work of others on the project, including the GIS analyses. He will also guide and participate in the development of the wetland trends analysis for the total watershed. He will work with the team members to compile, analyze, and interpret the project's data in preparation for submittal of reports.

Denice Heller Wardrop, PE, Ph.D. -- Co-PI and Project Manager : - Dr. Wardrop has over 20 years of experience in environmental sciences, the ecology of wetland and aquatic systems, risk assessment, and the fate and transport of sediment. She is currently a Research Associate with the Penn State Cooperative Wetlands Center. She has extensive experience in project management, both technical and administrative. She recently participated in a 3-yr statewide study of reference wetlands, and completed her dissertation on the occurrence and impact of sedimentation in central Pennsylvania wetlands. Dr. Wardrop will serve as Project Manager, and will be responsible for preparation of reports and submittals. She will also work with Dr. Brooks to compile, analyze, and interpret project data.

Jennifer K. Perot -- Research Assistant: Ms. Perot has over seven years of experience in aquatic ecology, use of GIS, and risk assessment. She is currently a Research Assistant with the Penn State Cooperative Wetlands Center. She has recently used GIS to classify watersheds in the Lower Peninsula of Michigan and the Illinois River Basin.

GIS Research Assistant - This staff person will be responsible for compiling databases and conducting landscape analyses using the GIS resources of Penn State's Office of Remote Sensing of Earth Resources (ORSER). This person will be supervised by Barry Evans of ORSER. He currently manages the GIS database and all task orders requested by state agencies in Pennsylvania.

TIMETABLE AND PRODUCTS FOR THE PROPOSED WORK:

January 1999 - Selection of subwatersheds and initiation of GIS assessments of subwatersheds. Finalization of decision rules for preliminary inventory.

Spring 1999- Submission of final Study Plan and Quality Assurance Project Plan (includes RAP and QA/QC procedures)

June 1999 - Reconnaissance of subwatersheds for both inventory verification and condition assessment protocol testing

September 1999 - Compilation of field data; refinement of inventory and condition protocol

January 2000 - Selection of watershed sites on final inventory map

June 2000 - Reconnaissance of randomly-selected wetlands in watershed

September 2000 - Compilation of field data

January 2001- Begin preparation of final report

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16. ABSTRACT: This study will contribute to the development of a means to accurately, efficiently, and fairly assess a wetland's condition in the context of the surrounding watershed that can then be used to implement protective and restorative strategies that are appropriate for both the individual wetland and the watershed. This has been one of the primary goals of research and outreach efforts conducted by the Penn State Cooperative Wetlands Center (CWC) since 1993, and will guide their approach to monitoring and assessing wetlands in the Juniata watershed in central Pennsylvania. The objectives of the study are:

1. To determine and report on the ecological condition of wetlands in the Juniata River watershed using a series of assessment tools.
   a. Develop a preliminary assessment of wetland abundance on two sub watersheds in the Juniata River Watershed. Our experience with applying NWI digital data and other remotely-sensed data for inventorying wetlands in the unglaciated portion of Pennsylvania has shown that these sources do not include the majority of wetlands occurring in the watershed. To effectively sample wetlands in the Juniata, a better estimate of their abundance and general location is necessary (i.e., a Level 1 inventory is not adequate). To help remedy this situation, we are developing a process for deriving a best estimate of wetland acreage from a combined set of GIS databases and a series of decision rules (Level 2 inventory). Acreage will be expressed as an estimate of total wetland acreage in each subwatershed, with zones of high, moderate, and low probability of significant wetland acreage identifies on a map.
   b. Verify and calibrate the inventory process on two subwatersheds in the Juniata, before the process is applied to the entire watershed, including ground reconnaissance. During the reconnaissance, a cursory inspection of wetland stressors will be performed, resulting in a preliminary indication of condition (Level 2 assessment).
   c. Conduct an inventory of wetland acreage and an assessment of condition for the entire Juniata River watershed. The inventory of the entire watershed will be based on the results of the work done to accomplish Objectives 1a and 1b. Condition will be expressed in terms of HGM functions and HGM type. For example, condition might be expressed as: "Thirty percent of depressional wetlands in the Juniata watershed are exhibiting only a moderate degradation of the long-term storage of surface water function." Condition will be assessed by applying the HGM functional assessment models at a set of wetlands selected by probability-based sampling. The verified inventory and map of acreage zones, and application of HGM functional assessment models constitute a Level 3 assessment.

2, Evaluate the feasibility of integrating a series of bioindicators into the wetland condition assessments for the two sub-watersheds.

3. Evaluate the feasibility of using citizens volunteers to apply the wetland monitoring protocols throughout the Juniata River watershed.

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