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Office of Wetlands, Oceans
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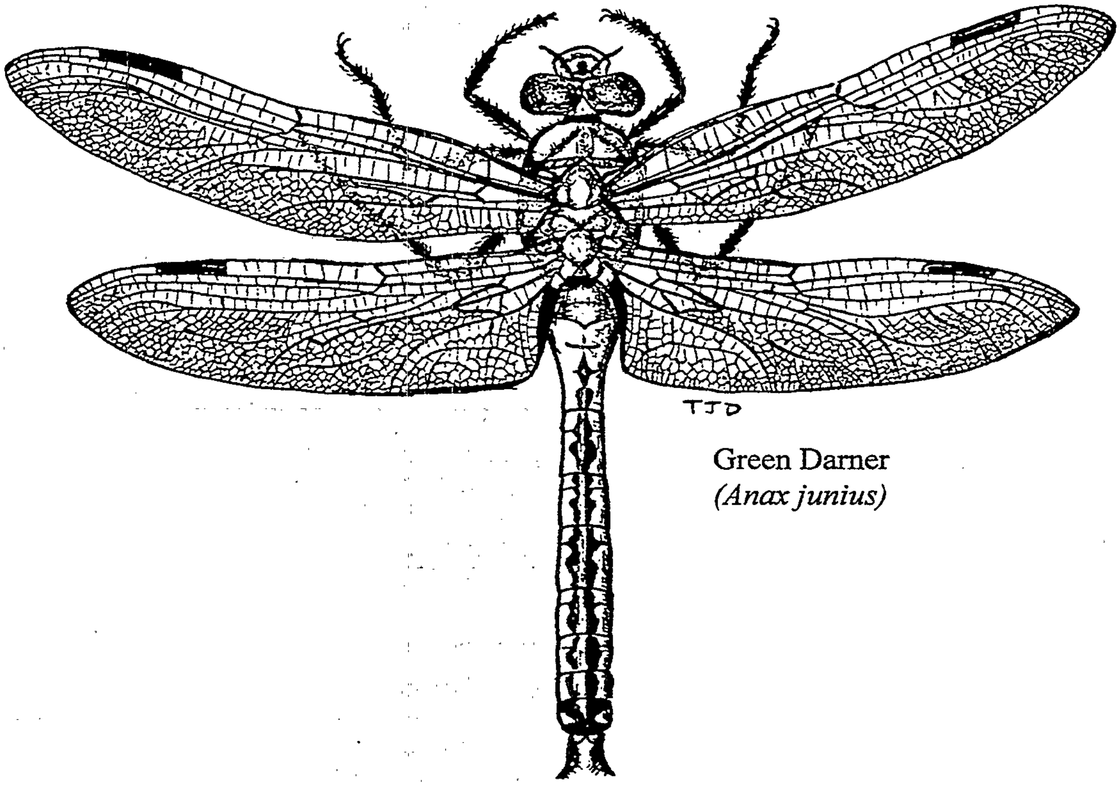
Wetland Bioassessment Fact Sheets



Green Darner
(Anax junius)

NOTICE

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Wetland Bioassessment Fact Sheets

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Cover art by Tom Danielson

ACKNOWLEDGMENTS

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Wetland Bioassessment Fact Sheet 1

Assessing Biological Integrity of Surface Waters

The objective of the Clean Water Act is to "maintain and restore the chemical, physical, and biological integrity of our Nation's waters." When the Clean Water Act was passed in 1972, the discharge of chemicals was commonly viewed as the primary threat to the health of our Nation's waterbodies. To track progress in reducing this threat, the Nation focused on developing chemical criteria which set numerical limits for safe levels of chemicals in waterbodies. During the past 25 years, the Nation has been largely successful in reducing the number and quantity of chemicals discharged into waterbodies by factories, wastewater treatment plants, and other point sources. During this same period of time, it has become increasingly clear that aquatic ecosystems are impacted by more than just chemicals. Aquatic ecosystems are altered by nonpoint source runoff, habitat alteration and fragmentation, introduced species, changes in the quantity and flow of water, and land use within a watershed. Traditional chemical criteria alone are unable to measure the impacts caused by these stressors. The EPA is now focusing on developing biological criteria in addition to chemical criteria to help track progress in maintaining and restoring the health of our waters. In most cases, the most direct and effective way to assess the "health" or biological condition of waterbodies is to: (1) directly measure the condition of their biological communities, and (2) support those data when necessary by measuring the physical and chemical condition of waterbodies and their watersheds.

Biological integrity is "the ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region."

Karr, J. R. and D. R. Dudley. 1981. Ecological perspective on water quality goals. *Environmental Management* 5:55-68.

As human activities degrade the condition of a waterbody, the changes are reflected by the characteristics of the plant and animal assemblages living in the waterbody. Biological communities are sensitive to chemical, physical, and biological stressors and will reflect any changes to their environment. For example, the diversity of plant and animal assemblages will typically decrease when impacted by acidification. The composition of assemblages will also change as (1) species that are sensitive to acidic conditions decline in numbers and (2) species that can tolerate acidic conditions increase in abundance. For other stressors, such as nutrient enrichment, taxa richness may initially increase and then decrease. The challenge facing water quality agencies is to develop biological assessment methods to quickly and accurately evaluate the integrity of aquatic ecosystems.

Biological Assessments Can Detect the Effects of the following Stressors

- ✔ Toxic levels of metals and other chemicals
- ✔ Changes to physical and chemical characteristics of water (e.g., pH, temperature, dissolved oxygen)
- ✔ Enrichment of nutrients
- ✔ Physical changes to habitat
- ✔ Alteration of the flow and quantity of water
- ✔ Impacts from introduced plants and animals
- ✔ Effects of changes in land use within watershed such as fragmentation of natural habitats within a watershed or increased runoff from logging or impervious surfaces
- ✔ Cumulative impacts of multiple stressors
- ✔ Effects of intermittent stressors (*e.g.*, stormwater runoff)
- ✔ Long-term effects of chronic stressors

CONDUCTING A BIOLOGICAL ASSESSMENT

The process of conducting a biological assessment is similar to a doctor performing an annual physical on a human patient. A simplified three step process is described below.

① Collect Supporting Information:
Collect background information and try to identify potential threats to the waterbody's condition. What type of wetland is it? Where is it located in its watershed? Was it ever drained or altered? What are the surrounding land uses that might influence it?

② Perform Standard Tests and Measurements:
Directly measure biological attributes of the waterbody. Attributes that are good indicators of biological integrity are called **metrics.** The medical profession has already established a series of indicators, such as body temperature, to quickly assess the health of human patients. The challenge facing water quality agencies is to identify metrics that they can use to quickly assess the biological integrity of waterbodies (See Fact Sheet ❺). During this screening process, conduct standard observations and measurements of the chemical and physical characteristics (*e.g.*, temp, pH) of the wetland and its surrounding landscape. These data help a scientist accurately diagnose what is damaging the wetland and to prescribe remedies.

③ Compare to Reference Conditions:
When a doctor takes a patients pulse or temperature, she compares the readings to the conditions of healthy people. The doctor uses the measurements from the healthy people as reference conditions. Similarly, a scientist compares the environmental conditions of a waterbody to minimally-impacted reference sites of the same type and region of the country. The reference sites provide a range of biological and environmental conditions that should be expected in that type of waterbody and region in the absence of human disturbances.

After comparing the measurements to the reference conditions, the scientist may give the waterbody a clean bill of health or may spot a warning sign. If the scientist spots a measurement that falls outside of the normal range, then the the scientist may decide to take more detailed biological measurements to determine if there really is a problem. At this point the scientist may also conduct more complex chemical and physical tests to help diagnose the source(s) of the impairment. The background information and supporting chemical and physical data will help the doctor identify stressors and potential risks to the wetland.

Using the Framework of a Patient's Annual Physical to Compare Biological and Chemical Assessments

How a Patient's Annual Physical Would Proceed Using the Framework of a Biological Assessment

A patient schedules an appointment with a doctor for an annual physical. The doctor starts the physical by collecting background information by asking a series of questions to identify any risks to the patient's health. The doctor then performs a series of standard tests (pulse rate, blood pressure, etc.) that are indicators of the patient's health. The doctor compares the measurements to reference conditions of healthy people. If the doctor spots any warning signs or conflicting signals during this screening process, the doctor will ask more questions and perform more advanced (and expensive) tests to determine if the problem really exists and to help identify what is causing the problem.

How a Patient's Annual Physical Would Proceed Using the Framework of a Chemical Assessment

A doctor visits a patient's house to assess the environmental conditions in the house. The doctor measures the amount of chemicals in air and on the floor, tables, and other surfaces. If the doctor finds a lot of toxic chemicals in the house, such as mercury, then the doctor could say that there is a high probability that the patient is not completely healthy, even without directly examining the patient. But if the doctor does not find a lot of chemicals, then the doctor could reach an erroneous conclusion by relying only on the chemical data. By extrapolating from chemical exposure to the patient's health, the doctor could overlook many other factors that can influence the patient's health. The patient may be unhealthy even though there are no chemicals in the house. The patient may be exposed to chemicals outside of the home or chemicals for which the doctor did not conduct tests. The patient could be affected the combination of many different chemicals. More importantly, the patient could be harmed by a variety of physical and biological stressors, which are overlooked by standard chemical tests. The only way to know for sure if the patient is ill, is to directly examine the patient. By combining the chemical data with direct measurements of the patient's condition, the doctor can make a more accurate assessment of the patient's health and can then determine the most appropriate course of action.

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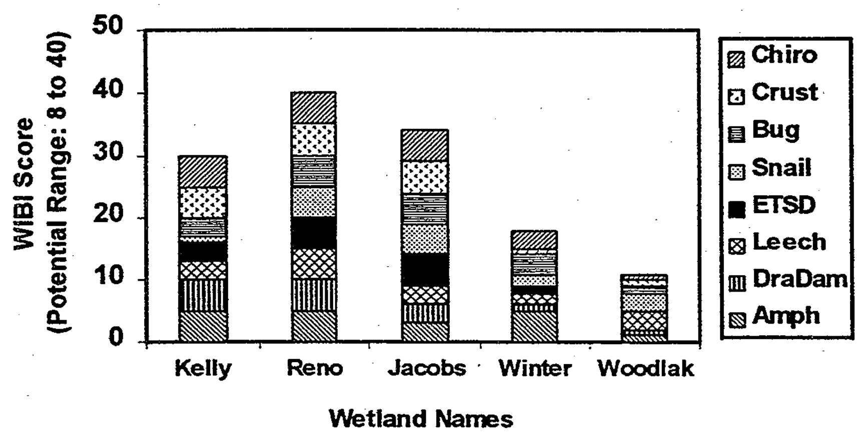
Applications of Biological Assessments in Wetlands

In most cases, the most direct and effective way of evaluating the ecological "health" or condition of a wetland is (1) to directly measure the condition of a wetland's biological community and (2) to observe and measure the chemical and physical characteristics of a wetland and its surrounding landscape. After developing and testing bioassessment methods, states, tribes, and federal agencies can use them for the following activities.

① Assess wetland condition.

Scientists can use bioassessment methods to directly measure biological integrity of wetlands and quickly screen wetlands for signs of impairment. For example, Minnesota Pollution and Control Agency is developing a Wetland Index of Biological Integrity (WIBI) based on wetland macroinvertebrates. While it is still under development, they can use WIBI to identify wetlands impacted by stormwater and agricultural runoff. In Figure 1, the three wetlands on the left are reference wetlands and the two wetlands on the right show signs of biological impairment. If a state or tribe detects a warning signal during this screening process, it can then conduct a more detailed and thorough assessment. Many states using bioassessments in streams are finding that they save time and resources by screening a large number of sites rapidly and then following up with more detailed (and expensive) biological studies and chemical and physical assessments when appropriate.

FIGURE 1: Wetland Index of Biological Integrity (WIBI) Scores of Five Minnesota Wetlands



② Diagnose the type of stressor damaging the biota.

An index of biological integrity (IBI) is composed of multiple metrics that each respond to the effects of a human activity. Some metrics are more sensitive to chemical alterations (*e.g.*, nutrient enrichment) while other metrics are more sensitive to physical (*e.g.*, hydromodification) or biological (*e.g.*, exotic species) alterations. By observing which metrics show signs of impairment and which do not, scientists can identify what type of stressor is damaging the biota. Scientists can increase their ability to diagnose what is damaging the biota by developing two or more IBIs. For example, the Montana Department of Environmental Quality has found that macroinvertebrate metrics are more sensitive to physical changes to wetlands while algal metrics are more sensitive to nutrient enrichment.

Developing methods and programs to assess the biological integrity of wetlands is a priority for the EPA because:

- The objective of the **Clean Water Act** is to "restore and maintain the chemical, physical, and biological integrity of our Nation's waters," including wetlands.
- As our nation draws closer to meeting the **Clinton Administration Wetlands Plan's** short-term goal of achieving a no overall net loss of wetlands, we must focus on the long-term goal of increasing the overall quantity and quality of our Nation's wetlands.

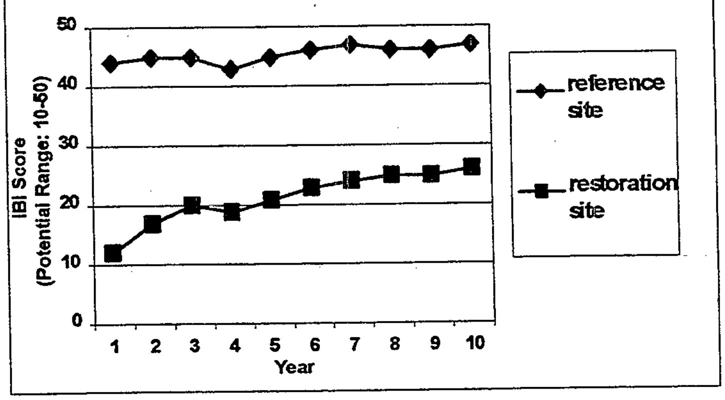
③ Define management approaches to maintain and restore wetland condition.

The information provided by biological assessments can help states prioritize and target activities to protect and restore wetlands. For example, by identifying the type of stressors damaging wetlands, states can develop site-specific management plans to maintain or restore the biological condition of wetlands. States can save time and resources by tailoring management plans to focus on the stressors which damage the wetlands the most. When conducting biological assessments, states can also identify and prioritize high quality wetlands for protection or acquisition.

④ Evaluate performance of protection and restoration activities.

States can evaluate the success of management activities by including follow-up assessments as a component of management plans (See Fact Sheet ❸). By periodically conducting bioassessments, states can track the condition of wetlands and learn which management activities work as planned and which do not work. With this knowledge, states can improve future management plans and save time and money by avoiding marginal activities. Figure 2 provides a hypothetical example of how a state can track the biological recovery of a wetland following restoration activities by tracking the IBI scores and comparing them to the conditions found in reference wetlands. It is important to compare the IBI scores from the same year to identify regional trends that may effect all wetlands in an area. For example, there may have been a drought in Year 4, which would account for the dip in the two curves on Figure 2.

FIGURE 2: Hypothetical IBI Scores of Reference and Restoration Sites



⑤ Develop and support water quality standards.

The objective of the Clean Water Act (CWA) is to "maintain and restore the chemical, physical, and biological integrity of our Nation's waters," including wetlands (CWA Section 101 (a)). Under CWA Section 303, states and eligible tribes develop water quality standards to ensure that their waters support beneficial uses such as aquatic life support, drinking water supply, fish consumption, swimming, and boating (See Fact Sheet ❼). States can use bioassessment methods to establish standards and criteria that are specifically appropriate for conditions found in wetlands. Criteria are the narrative or numeric descriptions of the conditions found in minimally impacted reference sites. By comparing the condition of a wetland to appropriate criteria, states can determine if the wetland is supporting its designated uses. In the absence of wetland-specific standards and criteria, states must rely on standards developed for lakes, streams, or other waterbodies that have different ecological conditions. In 1990, the EPA published guidance to help states create water quality standards for wetlands
(*Water Quality Standards for Wetlands*, EPA/440/S-90-011).

⑥ Certify that permits maintain water quality.

Under CWA Section 401, states have the authority to grant or deny "certification" for federally permitted or licensed activities that may result in a discharge to wetlands or other waterbodies. The certification decision is based on whether the proposed activity will comply with state water quality standards. Under this process, a state can use information from biological assessments to determine if a proposed activity would degrade water quality of a wetland or other waterbodies in a watershed. If a state grants certification, it is essentially saying that the proposed activity will comply with state water quality standards. Likewise, a state can deny certification if the project would harm the chemical, physical, or biological integrity of a wetland as defined by water quality standards. A state's Section 401 certification process is only as good as its underlying water quality standards. States can use bioassessments to refine narrative and numeric criteria to make them more suitable for conditions found in wetlands and subsequently improve the Section 401 certification process.

⑦ Track water quality condition in wetlands.

Under CWA Section 305 (b), states submit water quality reports every other year that summarize the quality of waters within their boundaries. In past years, few states have reported the quality of their wetlands. In the future, states can use bioassessment methods and wetland-specific standards and criteria to determine if wetlands are meeting their designated uses. States can then report the results in the Section 305 (b) reports.

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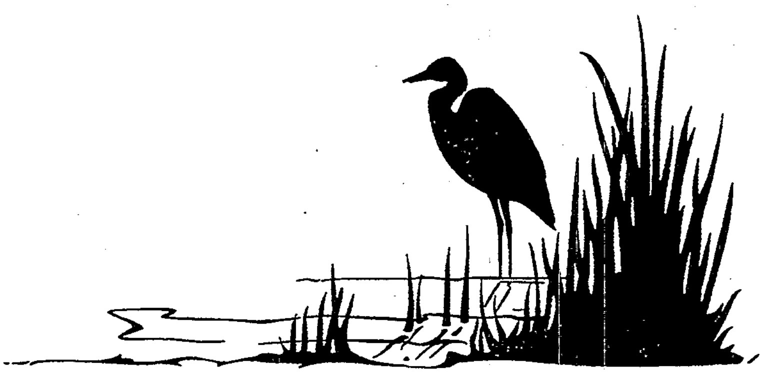
Biological Assessment of Wetlands Workgroup (BAWWG)

The Biological Assessment of Wetlands Workgroup (BAWWG, pronounced "bog") was formed in 1997 with the objective of improving methods and programs to assess the biological integrity of wetlands. The workgroup consists of wetland scientists from federal agencies, states, and universities and is coordinated by the EPA Office of Wetlands, Oceans, and Watersheds in partnership with the EPA Office of Science and Technology. BAWWG provides a forum for wetland scientists and professionals to:

- interact with peers and share expertise in developing wetland biological assessment methods
- form partnerships and collaborative projects
- develop consistency in terminology and sampling methods
- coordinate the development of biological and functional assessment methods (See Fact Sheet ❻)
- improve methods of managing and presenting data

ACTIVITIES AND PRODUCTS

BAWWG holds periodic conference calls in addition to periodic conferences and technical meetings to examine topics related to developing wetland biological assessment methods and programs (Box 1). The workgroup will prepare guidance and technical papers on some of these topics to help other states and federal agencies develop biological assessment capabilities. BAWWG also intends to develop a peer review process for reviewing project designs for wetland biological assessment projects.



Box 1: Recurring Workgroup Topics

- Selecting and testing metrics.
- Scoring metrics.
- Combining metrics into a multimetric Index of Biological Integrity.
- Selecting study design (*e.g.*, targeted vs. random sampling).
- Classifying wetlands and ecoregions.
- Defining reference conditions.
- Developing and testing sampling methods.
- Analyzing data.
- Communicating results.
- Defining terms.
- Exploring relationship with the hydrogeomorphic (HGM) approach to assessing wetland functions

BAWWG PARTICIPANTS

As of January 1998, the workgroup includes participants from six states, six federal agencies, and seven universities. See Fact Sheet ❹for a summary of existing wetland biological assessment projects.

STATES	Florida Maine Minnesota Montana North Dakota Ohio
FEDERAL	Smithsonian Environmental Research Center U.S. Environmental Protection Agency U.S. Fish and Wildlife Service U.S. Geological Survey U.S. Natural Resources Conservation Service U.S. Army Corps of Engineers
UNIVERSITY	Montana State University North Dakota State University Oregon State University Pennsylvania State University University of Florida University of Louisville University of Washington

FOCUS GROUPS

BAWWG has focus groups for five taxanomic assemblages:

① macroinvertebrates
② vascular plants
③ amphibians
④ algae
⑤ birds

These focus groups are identifying potential metrics and are examining topics, such as when and how to sample each assemblage. BAWWG has a sixth focus group examining the relationship between assessing wetland biological integrity and the hydrogeomorphic (HGM) approach to assessing wetland functions.

FOR MORE INFORMATION

More information about wetland bioassessments and BAWWG is available through the following sources:

- The "Wetlands and Water Quality" section of the Wetland Division's internet site (http://www.epa.gov/OWOW/wetlands)

- The EPA Wetlands Information Hotline (contractor operated) - 1 (800) 832-7828

- U.S. EPA Wetlands Division (4502F), 401 M Street, Washington, DC, 20460
  Phone: (202) 260-1799 Fax: (202) 260-8000

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Wetland Bioassessment Projects

Below is a list of some wetland biological assessment projects conducted by members of the Biological Assessment of Wetlands Workgroup (BAWWG) (See Fact Sheet ❸) in wetlands . In general, individual BAWWG members are still in the preliminary stages of identifying and testing potential metrics, particularly for birds, amphibians, plants, and algae. Most current research is being conducted on macroinvertebrates and vascular plants in depressional wetlands with emergent and submerged vegetation. Further research is needed in other wetland types, especially in wetlands that have saturated soils but lack standing water for most of the year.

AGENCY	ANALYTICAL METHODS	SPECIES ASSEMBLAGES	PROJECT PURPOSE	WETLAND TYPE	STRESSORS AFFECTING WETLANDS
Minnesota	Index of Biological Integrity (IBI) (See Fact Sheet ❺)	Vascular Plants Macroinvertebrates Amphibians	Water quality standards	Depressional semipermanent with emergent vegetation	Agriculture Storm water runoff
Montana	Attempting to develop bioassessment protocols using both multimetric and multivariate approaches	Macroinvertebrates Algae (diatoms) Vascular Plants	Water quality standards	Depressional Riparian/fen Closed basins Open lakes	Agriculture Mining Others
Ohio	* Floristic Quality Assessment Index (FQAI) for vascular plants * IBIs for both amphibians and macroinvertebrates	Vascular Plants Macroinvertebrates Amphibians	Water quality standards	Depressional Riparian	Agriculture Development Others
North Dakota	IBI	Macroinvertebrates Algae Vascular Plants	Water quality standards	Depressional (prairie potholes)	Agriculture

AGENCY	ANALYTICAL METHODS	SPECIES ASSEMBLAGES	PROJECT PURPOSE	WETLAND TYPE	STRESSORS AFFECTING WETLANDS
Patuxent Wildlife Research Center (USGS and NRCS)	Investigating use of each assemblage for bioassessments	Macroinvertebrates Vascular Plants Birds Fish Amphibians	Evaluating performance of wetland restoration	Depressional (Delmarva Bays) in various stages of succession	Restored wetlands on agricultural land compared to minimally disturbed wetlands
U.S. EPA Duluth Lab	IBI	Macroinvertebrates Vascular Plants Algae	Water quality standards	Depressional (prairie potholes)	Agriculture
U.S. EPA Corvallis Lab	Analyzing survey design and reporting methods	N/A	Evaluating wetland program effectiveness	Various wetlands located in mid-Atlantic region	Mixed land use
USGS Northern Prairie Science Center	Has collected some macroinvertebrate data in conjunction with HGM* project	Macroinvertebrates	Supplementing HGM* project	Depressional (prairie potholes)	Agriculture Others

HGM* = Hydrogeomorphic approach, which is a functional assessment method.

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Developing an Index of Biological Integrity

One method to assess biological integrity of wetlands is to develop an index of biological integrity (IBI) for an assemblage of wetland plants or animals. An IBI is made by combining several biological indicators, called metrics, into a summary index. A well-constructed IBI that can allow scientists to: (1) measure condition, (2) diagnose the type of stressors damaging a wetland's biota, (3) define management approaches to protect and restore biological condition, and (4) evaluate performance of protection and restoration activities.

FOUR STEPS TO CREATE AN IBI

① Select an Assemblage

② Test and Evaluate Metrics

③ Combine Metrics into an IBI

④ Test and Validate IBI

① Select an Assemblage

An assemblage is a group of plant and animals that are combined to form a larger group. Common wetland assemblages include:

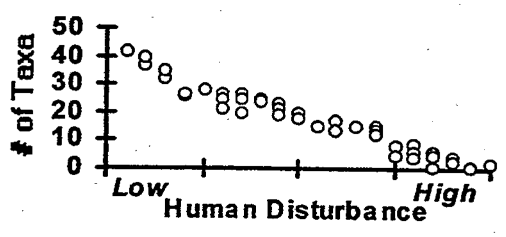
- VASCULAR PLANTS
- BIRDS
- MACROINVERTEBRATES (snails, insects, clams, crayfish, etc.)
- AMPHIBIANS
- ALGAE

② Test and Evaluate Metrics

Scientists can measure many biological attributes of wetlands such as the diversity of amphibians or the number of pollution-tolerant insects. Some of these attributes will provide valuable information about biological integrity and other attributes will not. The goal is to identify **metrics**, which are attributes that show an empirical and predictable change in value along a gradient of human disturbance. The gradient of human disturbance can represent the amount of logging, agriculture, development, impervious surfaces, or other land use or activity in a watershed, or some combination of land use, depending on the purpose of the bioassessment. An example of a metric is taxa richness of macroinvertebrates (the number of taxa of insects, snails, clams, crayfish, etc.). Several states have found that macroinvertebrate richness decreases as a wetland is degraded by human activities (Figure 1). For illustrative purposes, Figures 1-5 were developed using hypothetical data, but are based on figures that were provided by Dr. James Karr (University of Washington). As Figure 1 shows, there is a clear response to increasing human disturbance and this attribute could be used as a metric.

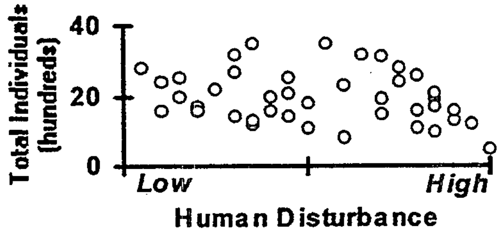
A metric is a measurable component of a biological system with an empirical change in value along a gradient of human disturbance

Figure 1: Macroinvertebrate Taxa Richness of 40 Wetlands



In contrast, total abundance of macroinvertebrates is often more dependent on natural environmental variability of wetlands and does not show a reliable change in response to human disturbance (Figure 2). As Figure 2 shows, there is no clear response to increasing human disturbance and this attribute would not be useful as a metric. In these two examples, total taxa richness of macroinvertebrates could serve as a metric and total abundance could not.

Figure 2: Total Macroinvertebrate Abundance of 40 Wetlands



③ Combine Metrics into an IBI

Typically, an IBI is formed by combining at least 7 metrics from one biological assemblage. One approach of combining metrics into an IBI is to assign scores of 1, 3, or 5 to the metrics according to how they respond to human disturbances. For example, the diversity and richness of macroinvertebrate taxa may consistently decrease with increasing human disturbance (Figure 3). In this case, we could assign a score 1 to indicate poor conditions, 3 to indicate moderate conditions, and 5 to indicate minimally impacted conditions (Figure 3). Another metric, the relative abundance of tolerant taxa [(number of tolerant individuals in sample) / (total number of individuals in sample) x 100], may increase with increasing human disturbance (Figure 4). In this case, a wetland dominated by tolerant taxa would receive a low score and a wetland with a small percentage of tolerant taxa would receive a high score.

If 10 metrics were scored in this manner, then the scores could be added together to form the index of biological integrity (IBI) with potential scores ranging from 10 (maximally impacted) to 50 (minimally impacted). The IBI scores should form a relatively straight line when plotted against the gradient of human disturbance (Figure 5). Sometimes there will be scores that are far from the line which should be investigated. More often than not, an outlier is either the result of (1) misclassifying the wetland or (2) a stressor, such as acid mine drainage, that is damaging the wetland biota and was not captured by the gradient of human disturbance.

Figure 3: Macroinvertebrate Taxa Richness of 40 Wetlands

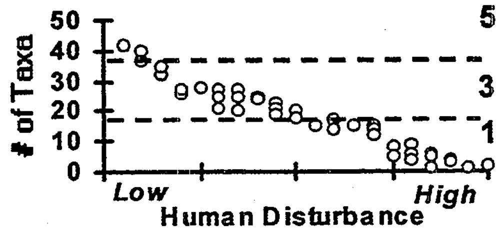
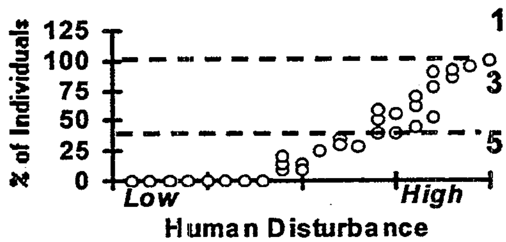


Figure 4: Percent Macroinvertebrate Tolerant Taxa of 40 Wetlands

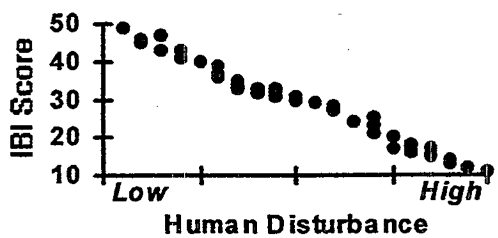


④ Test and Validate IBI

After developing the IBI, the scientists would then test the IBI to see if it accurately detects the effects of human disturbances on the biological assemblage. One approach is to (1) randomly split the data into two halves, (2) develop the IBI on one half of the data, and (3) test the IBI on the other half of the data. The results should be similar.

Scientists can also test the IBI on more than one gradient of human disturbance. For example, the scientists may first develop the IBI with a gradient such as the percent of a watershed that is logged. During subsequent years, they could test the same IBI across another gradient of human disturbance, such as percent of watershed with impervious surfaces or distance of wetlands to nearest road or farm field. Some metrics will consistently show clear patterns regardless of the type of human disturbance used on the X axis.

Figure 5: Index of Biological Integrity Scores of 40 Wetlands



After testing and validating the index, they could directly measure the health of similar wetlands without having to measure every attribute. They would only have to measure the ten metrics and some basic chemical and physical characteristics of the wetlands to help diagnose the type of stressor(s) damaging wetlands and to develop plans to reduce the impacts. When reporting results of a bioassessment, the IBI score should always be accompanied by a narrative description of the overall site condition, scores of the individual metrics, and a narrative descriptions of each metric as compared to conditions found in reference wetlands of the same type and region.

United States Environmental Protection Agency | Office of Water Office of Wetlands, Oceans and Watersheds (4502-F) | EPA843-F-98-001f July 1998

EPA

Wetland Bioassessment Fact Sheet ❻
Wetland Biological Assessments and HGM Functional Assessment

The purpose of this fact sheet is to provide a comparison of a functional assessment method, the Hydrogeomorphic (HGM) Approach, and biological assessments based on an index of biological integrity (IBI). Our intention is not to advocate one particular approach, because each was developed for a different purpose and has many strengths. Rather, our intention is to identify their similarities and differences and to identify ways that the two approaches can be supportive of each other. The functional assessment column was written primarily by Mark Brinson (East Carolina University).

	Biological Assessment [Index of Biological Integrity (IBI)]	**Functional Assessment [Hydrogeomorphic (HGM) Approach]**
Purpose of Assessment	To evaluate a wetland's ability to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable with that of minimally disturbed wetlands within a region. The condition of the biota will show if a wetland is degraded by any chemical, physical, or biological stressors and will help scientists diagnose the stressor(s) causing the damage. Biological assessments (bioassessments) also detect intermittent stressors or the cumulative effect of multiple stressors.	To evaluate current wetland functions and predict potential changes to a wetland's functions that may result from proposed activities. A wetland is compared to similar wetlands that are relatively unaltered. The approach is based on combining variables that are typically structural measures or indicators that are associated with one or more ecosystem functions. Functions normally fall into one of three major categories: (1) hydrologic (*e.g.*, storage of surface water), (2) biogeochemical (*e.g.*, removal of elements and compounds), and (3) physical habitat (*e.g.*, topography, depth of water, number and size of trees).
	COMMENTS: Both approaches evaluate the condition of individual wetlands by comparing them to the conditions found in an established set of reference wetlands. The goal of both approaches is to maintain wetlands in their minimally disturbed conditions and wetlands are only compared to other wetlands of the same type. The definition of reference wetlands is discussed on the last page of this fact sheet.	
Primary Means of Estimating Conditions	Direct, quantitative measurements of certain attributes of a wetland assemblage (*e.g.*, taxa richness of macroinvertebrates) that show clear, empirical changes in value along a gradient of human influence. Typically, between 8 and 12 of these attributes, called metrics, are combined into an Index of Biological Integrity (IBI) for an assemblage (See Fact Sheet ❺). The biological data are related to corresponding physical and chemical data.	Estimates and some measurements of variables related to wetland functions in comparison to reference standard conditions characteristic of relatively unaltered sites of the same wetland type. Available technical literature, ongoing research, and best professional judgement are used in the development of the assessment method and in its application.
	COMMENTS: Biological assessments can be used to: (1) determine if HGM's field indicators and variables accurately reflect the biotic condition of wetlands, (2) determine the level of spatial and temporal variation in HGM's biotic field indicators and variables, (3) validate or invalidate how HGM model variables are scaled and combined as they relate to ecosystem functions, and (4) detect if selected animal and plant community functions have changed from HGM reference standard conditions.	

	Biological Assessment **[Index of Biological Integrity (IBI)]**	**Functional Assessment** **[Hydrogeomorphic (HGM) Approach]**
Relevant Sections (§) of the Clean Water Act **(CWA)**	**CWA §303** (water quality standards): Water quality standards are state or tribal laws or regulations that, at a minimum, define: (1) the water quality goals of a water body (designated uses), (2) the limits or conditions that, if met, will generally protect water quality goals (criteria), and (3) provisions to protect waterbodies (antidegradation provisions) [See Fact Sheet ❼]. States and tribes can use biological assessment methods to develop numeric biological criteria that quantitatively describe the condition of wetland plant or animal assemblages found in minimally disturbed wetlands. **CWA §401** (water quality certification): Under CWA §401, states and tribes have the authority to certify that federally permitted or licensed activities that may result in a discharge to a waterbody, such as those requiring CWA §404 permits, comply with their water quality standards. If proposed activities will violate their water quality standards, then states and tribes can deny or condition the permits.	**CWA §404** (dredge and fill permits): The U.S. Army Corps of Engineers and U.S. EPA administer a program for permitting the discharge of dredged or fill material in "waters of the U.S.," which, by definition, include wetlands. The HGM approach to functional assessment estimates the change in functioning induced by alteration of a wetland, either positive or negative. Negative effects (i.e, reductions in sustainable levels of functioning) are normally determined in association with dredge-and-fill permits. The permit review process could use output from an assessment as one tool to determine if the project results in significant degradation. Output from HGM models can be used to determine the amount of positive effects (i.e., increases in sustainable levels of functioning) associated with compensatory mitigation requirements, normally through restoration of previously altered wetlands of the same type. Although the HGM approach was designed initially for use in the CWA §404 program, the output of assessments is not constrained to any particular statutes, federal or otherwise.
	COMMENTS: HGM has direct applications for CWA §404 decisions and bioassessments have indirect applications to CWA §404 decisions through CWA §401 water quality certification programs.	
Applications (Also see Fact Sheets ❷, ❼, ❽)	• Establishing appropriate narrative and numeric biological criteria for wetlands as part of state water quality standards. • Assessing wetlands to determine if they are meeting water quality standards. • Evaluating performance of wetland restoration activities at improving the ability of wetlands to support and maintain wetland plant and animal assemblages. • Administering CWA §401 water quality certification programs. • Tracking condition of wetlands as part of CWA §305(b) water quality reports to Congress.	• Evaluating impacts of projects that degrade wetland ecosystems, including the comparison of project alternatives. Projects include those related to CWA §404 dredge-and-fill permits, the Swampbuster provision of the Food Security Act, or other relevant projects that seek to detect significant alterations of wetland ecosystems through an analysis of change in functions. • Evaluating restoration projects designed to improve wetland conditions by estimating changes in functioning over time.
	COMMENTS: Although designed for different purposes, both approaches are flexible and have multiple applications.	

<table>
<tr><th></th><th>Biological Assessment
[Index of Biological Integrity (IBI)]</th><th>Functional Assessment
[Hydrogeomorphic (HGM) Approach]</th></tr>
<tr><td rowspan="2">Key Steps in Developing Assessment Method</td><td>(1) Classify wetlands into biologically distinct classes. Can use a variety of classification techniques (e.g., ecoregions, HGM classification, Cowardin, etc.) or some combination.
(2) For each wetland class, select wetlands across a gradient of human disturbance from minimally impaired reference wetlands to severely degraded wetlands.
(3) Select one or more assemblages (e.g., macroinvertebrates, vascular plants) to monitor.
(4) Directly measure attributes of the selected assemblage (e.g., taxa richness, community composition) and corresponding chemical and physical data in the wetlands.
(5) Identify metrics, which are attributes which show an empirical and predictable change in value along the gradient of human disturbance (Fact Sheet ❺). Combine metrics into an Index of Biological Integrity (IBI). Test and validate IBI. If more than one assemblages are measured, then each should have its own IBI.
A properly constructed IBI will detect damage of a wetland caused by a variety of chemical, physical, or biological stressors. An IBI will also help diagnose the type of stressor(s) that caused the damage. After the IBI has been tested and validated, scientists can use the IBI to screen wetlands for signs of degradation without having to conduct expensive chemical and physical analyses. If signs of degradation are detected, then the scientists can conduct more extensive biological measurements and chemical and physical tests to determine the stressors impacting the wetland. By understanding how biological assemblages respond to increasing human disturbance, wetland managers can predict how the taxa richness and composition of assemblages may change following alternative development approaches, restoration activities, or conservation measures.</td><td>(1) Classify wetland by geomorphic setting for the purpose of partitioning natural variation, thus allowing variation by impacts to be more easily detected within a regional subclass.
(2) Develop a profile for the wetland subclass that characterizes it according to its geology, hydrology, biogeochemistry, plant and animal communities, and typical alterations that have occurred historically. This profile, in addition to identifying functions characteristic of the subclass, should be assembled by an interdisciplinary group of professionals (fields of hydrology, geomorphology, soil science, plant and animal community ecology, ecosystem ecology, etc.) familiar with the region and the technical literature.
(3) Identify reference standard wetlands from a subset of reference sites that are relatively unaltered or natural, and characterize these sites by estimating or measuring indicators and field variables that will be used to develop models which relate the measurements to functions.
(4) Develop scales for variables that distinguish the reference standard wetlands from those that are degraded.
(5) Combine variables into HGM models of functions. Test and validate HGM models. After models have been tested and validated, users will be able to quickly apply the models to wetlands that have been proposed for alteration or restoration.
(6) Properly constructed and tested HGM models of functions for a specific subclass will quantify differences and similarities between a wetland that is being sampled and reference standard wetlands. The models will also be useful in predicting changes that will result from proposed alterations to the site.</td></tr>
<tr><td colspan="2">COMMENTS: Both methods require the development or refinement of regionally appropriate assessment methods. Wetland ecosystems are the unit of assessment and comparison in both approaches, not individual functions. Under HGM, the score of a variable or function index can never exceed the score of a reference standard wetland.</td></tr>
<tr><td rowspan="2">Presentation of Assessment Results</td><td>• summary IBI score.
• narrative description of overall biotic condition in comparison to reference wetlands of the same region and wetland type.
• numerical value of each metric.
• narrative description of metric in comparison to reference wetlands of the same region and wetland type.</td><td>• no overall, summary score.
• index value of each function in comparison reference standard of wetlands in same reference domain and HGM class or subclass.
• index value of each variable with supporting narrative describing estimates and measurements.
(See last page for definitions of HGM reference terms)</td></tr>
<tr><td colspan="2">COMMENTS: HGM does not use an overall, summary score to compare wetlands. Both approaches use minimally impaired wetlands as their measuring sticks. Both approaches only compare wetlands to other wetlands of the same region and type. For example, both approaches would compare a New England bog only to other New England bogs and a minimally impacted bog would receive the highest score.</td></tr>
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<table>
<tr><th></th><th>Biological Assessment
[Index of Biological Integrity (IBI)]</th><th>Functional Assessment
[Hydrogeomorphic (HGM) Approach]</th></tr>
<tr><td rowspan="2">Method of Classifying Wetlands</td><td>Wetlands occur in many landscape positions with a variety climatic, hydrologic, and soil conditions. As a result, the community composition and diversity of an assemblage (e.g., amphibians) will naturally vary between wetland types. When examining how an assemblage is affected by a stressor, too much natural variation in the data can make it difficult or impossible to detect signs of impairment. Thus, in bioassessments, the purpose of classifying wetlands is to group wetlands with assemblages of similar diversity and composition, and separate those wetlands with assemblages that are not similar. The goal is to avoid comparing apples to oranges. By minimizing natural variation within classes and making sure that wetlands within a class respond similarly to human disturbances, it is much easier to identify signs of degradation. Current wetland bioassessment projects use a variety of classification systems, such as ecoregions and the HGM classification method (See Fact Sheet ❹). Researchers often start with a method or a combination of methods and then lump or split as needed based on biological data to end up with classes of biologically distinct wetlands.</td><td>The HGM approach identifies 7 geomorphic settings of wetlands as guidance for the identification of regional subclasses that function similarly (i.e, riverine, depressional, slope, mineral soil flat, organic soil flat, estuarine fringe, lacustrine fringe). Settings differ by dominant sources of water and hydrodynamics (e.g., flow rates and fluctuations of water within the wetland). Local vernacular is preferred in naming regional subclasses as long as it is recognized that vegetation cover types may not vary between some subclasses that are functionally distinct.</td></tr>
<tr><td colspan="2">COMMENTS: The HGM classification system can provide a good starting point for biological assessment programs. For bioassessment projects, one option is to classify first by ecoregion and then by HGM class or subclass. Then lump or split these classes as needed based on preliminary bioassessment data.</td></tr>
<tr><td rowspan="2">Definition of Reference Terms</td><td>In biological assessments, the terminology for <u>reference conditions</u> is based on the protocols that have been developed for assessing the condition of streams, lakes, and estuaries. From this heritage, a <u>reference site</u> or <u>reference wetland</u> is a minimally impaired wetland that is representative of the expected ecological conditions of a wetland of a particular type and region. The reference sites serve as the measuring stick to determine the integrity of other wetlands. Each biologically distinct class of wetlands has its own set of reference sites. For example, bogs are only compared to other minimally impaired bogs and prairie potholes are only compared to other minimally impaired prairie potholes.

When developing an IBI, however, researchers compare the condition of an assemblage (e.g., birds) in reference sites and impaired wetlands that represent a gradient of human disturbance. No term has been developed for the impaired wetlands or for the larger set of wetlands (reference and impaired wetlands).</td><td>The HGM approach identifies a suite of terms to facilitate assessments and recognize ambiguities that often develop in the regulatory environment if terminology is not defined. Only cryptic definitions are given here for expediency, and include:
(1) <u>reference domain</u> (the geographic extent of a wetland subclass),
(2) <u>reference wetlands</u> (all sites within the reference domain, regardless of their condition),
(3) <u>reference standard sites</u> (a subset of reference wetland sites that are judged to be least altered),
(4) <u>reference standards</u> (conditions exhibited by reference standard sites that are reflective of characteristic levels of functioning),
(5) <u>site potential</u> (the best conditions that can be achieved on a site within local constrains of land use, etc.),
(6) <u>project target</u> (level of functioning negotiated for enhancement, restoration, or creation),
(7) <u>project standards</u> (performance criteria or specifications to guide activities toward project target).</td></tr>
<tr><td colspan="2">COMMENTS:

IBI's <u>reference wetland</u> is equivalent to HGM's <u>reference standard sites</u>.

IBI's <u>reference conditions</u> is equivalent to HGM's <u>reference standards</u>.

Shared reference sites will enable better coordination of biological and functional assessments and will enhance both sets of objectives. Biological assessments can help determine if HGM reference domains and subclasses need to be split or altered by providing information about the geographic variation of biological communities</td></tr>
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United States Environmental Protection Agency
Office of Water
Office of Wetlands, Oceans and Watersheds (4502-F)
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Wetland Bioassessment Fact Sheet ❼
Water Quality Standards

The main objective of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical, and biological integrity of the Nation's water." To help meet these objectives, states must adopt water quality standards (WQS) for all "waters of the U.S." within their boundaries, including wetlands. Water quality standards, at a minimum, consist of three major components: ① designated beneficial uses, ② narrative and numeric water quality criteria for supporting each use, and ③ an antidegradation statement.

① Designated Uses

Designated uses establish the environmental goals for water resources. States and tribes assign designated uses for each water body, or segment of a body of water, within their boundaries. Typical uses include public water supply, primary contact recreation (such as swimming), and aquatic life support (including the propagation of fish and wildlife). States and tribes develop their own classification system and can designate other beneficial uses including fish consumption, shellfish harvesting, agriculture, wildlife habitat, and groundwater recharge.

Since designated uses can vary, states and tribes may develop unique water quality requirements or criteria for their designated uses. States and tribes can also designate uses to protect sensitive or valuable aquatic life or habitat, such as wetlands. When designating uses for wetlands, states may establish an entirely different format to reflect the unique functions and values of wetlands. At a minimum, designated uses must be attainable uses that can be achieved using best management practices and other methods to prevent degradation. States and tribes can also designate uses which have not yet been achieved or attained. Protecting and maintaining such uses may require the imposition of more stringent control programs.

② Water Quality Criteria

The Water Quality Standards Regulation requires states to adopt criteria sufficient to protect and maintain designated uses. Water quality criteria may include narrative statements or numeric limits. States and tribes can establish physical, chemical, and biological water quality criteria. Wetland biological monitoring and assessment programs can help states and tribes refine their narrative and numeric criteria to better reflect conditions found in wetlands.

Narrative water quality criteria define conditions that must be protected and maintained to support a designated use. States should write narrative criteria to protect designated uses and to support existing uses under State antidegradation policies. For example, a state or tribe may describe desired conditions in a water body as "waters must be free of substances that are toxic to humans, aquatic life, and wildlife." In addition, states and tribes can write narrative biological criteria to describe the characteristics of the aquatic plants and animals. For example, a state may specify that "ambient water quality shall be sufficient to support life stages of all native aquatic species."

Narrative criteria should be specific enough that states and tribes can translate them into numeric criteria, permit limits, and other control mechanisms including best management practices. Narrative criteria are particularly important for wetlands, since states and tribes cannot numerically describe many physical and biological impacts in wetlands by using current assessment methods.

Numeric water quality criteria are specific numeric limits for chemicals, physical parameters, or biological conditions that states and tribes use to protect and maintain designated uses. Numeric criteria establish minimum and maximum physical, chemical, and biological parameters for each designated use. Physical and chemical numeric criteria can include maximum concentrations of pollutants, acceptable ranges of physical parameters, minimum thresholds of biological condition, and minimum concentrations of desirable parameters, such as dissolved oxygen.

States and tribes can adopt numeric criteria to protect both human health and aquatic life support. For example, numeric human health criteria include maximum levels of pollutants in water that are not expected to pose significant risk to human health. The risk to human health is based on the toxicity of and level of exposure to a contaminant. States and tribes can apply numeric human health criteria (such as for drinking water) to all types of water bodies, including wetlands.

Numeric chemical or physical criteria for aquatic life, however, depend on the characteristics within a water body. Since characteristics of wetlands (such as hydrology, pH, and dissolved oxygen) can be substantially different from other water bodies, states and tribes may need to develop some physical and chemical criteria specifically for wetlands.

Numeric biological criteria can describe the expected attributes and establish values based on measures of taxa richness, presence or absence of indicator taxa, and distribution of classes of organisms. Many states have developed biological assessment methods for streams, lakes, and rivers, but few states and tribes have developed methods for wetlands. Several states, including **Florida**, **Maine**, **Minnesota**, **Montana**, **North Dakota**, and **Ohio** are currently developing biological assessment methods for monitoring the "health" of wetland plant and animal communities. Wetland biological assessment methods are essential to establish criteria that accurately reflect conditions found in wetlands.

③ Antidegradation Policy

All state standards must contain an ***antidegradation policy***, which declares that the existing uses of a water body must be maintained and protected. Through an antidegradation policy, states must protect existing uses and prevent water bodies from deteriorating, even if water quality is better than the minimum level established by the state or tribal water quality standards. States and tribes can use antidegradation statements to protect waters from impacts that water quality criteria cannot fully address, such as physical and hydrologic changes.

States and tribes can protect exceptionally significant waters as outstanding national resource waters (ONRW). ONRWs can include waters, such as some wetlands, with special environmental, recreational, or ecological attributes. No degradation is allowed in waters designated as ONRW. States can designate waters that need special protection as ONRWs regardless of how they ecologically compare to other waters. For example, although the water of a swamp may not support as much aquatic life as a marsh, the swamp is still ecologically important. A state or tribe could still designate the swamp as an ONRW because of its ecological importance.

Applications of WQS

WQS provide the foundation for a broad range of management activities. WQS can serve as the basis to:

- Assess the impacts of nonpoint source discharges on waterbodies under CWA §319,
- Assess the impacts of point source discharges on waterbodies under CWA §402,
- Determine if federally permitted or licensed activities maintain WQS under CWA §401 water quality certification, and
- Track and report if waterbodies are supporting their designated uses under CWA §305(b).

Additional Information

The following EPA publications provide more information about WQS for wetlands and other surface waters:

- "Water Quality Standards for Wetlands: National Guidance" (EPA/440/S-90-011)
- "Biological Criteria: National Program Guidance for Surface Waters" (EPA/440/5-90-004)
- "Procedures for Initiating Narrative Biological Criteria" (EPA/822/B-92-002)
- "The Quality of Our Nation's Water: 1994" (EPA/841/S-94-002)

(Some of these are available on http://www.epa.gov/OWOW/wetlands/wqual.html)

United States
Environmental Protection
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Office of Water
Office of Wetlands, Oceans
and Watersheds (4502-F)

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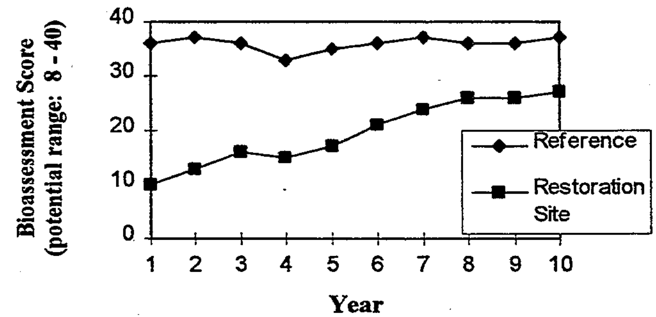
Wetland Bioassessment Fact Sheet ❽
Evaluating Performance of Wetland Restoration Activities

Perhaps the most commonly neglected component of wetland restoration projects is a clearly defined approach to evaluate the success of the restoration activities. How well do current wetland restoration techniques work? Are they effective at restoring a balanced, adaptive community of plants and animals? How do the conditions in restoration sites compare to conditions in minimally impaired sites?

One way to tell if a wetland is recovering properly is to periodically assess the condition of one or more biological assemblages, such as plants, amphibians, or macroinvertebrates. Wetland managers can rapidly assess the condition of an assemblage using biological assessment methods based on a regionally appropriate index of biological integrity (IBI). An IBI is constructed by combining at least eight attributes of an assemblage that each show an empirical and predictable responses across a gradient of anthropogenic disturbance (See Fact Sheet ❸). When applying an existing IBI to a new region or wetland type, make sure to validate the metrics and calibrate the IBI scores to regional conditions. Below are some helpful suggestions to keep in mind when using an IBI to track the recovery of a wetland.

- Compare restoration site to reference wetlands - Reference wetlands are minimally impaired sites that are representative of the expected ecological conditions and integrity of other wetlands of the same type and region. By comparing a biological assemblage (*e.g.*, macroinvertebrates) of a restoration site to a similar assemblage found reference sites, wetland managers can determine the relative condition of the wetland. Figure 1 shows a hypothetical example of comparing the IBI scores of a restoration site to average IBI scores of reference wetlands over ten years.

Figure 1: Hypothetical Bioassessment Scores of a Restoration Site and Reference Wetlands



- Track both reference wetlands and restoration sites - It is important to compare the IBI scores of the restoration site and reference sites from the same year to identify regional trends that may effect all wetlands in an area. For example, there may have been a drought in Year 4, which would account for the dip in the curves on Figure 1.

- Sample during proper time of year - Bioassessment protocols typically require that sampling be conducted within a certain time of the year, which is often called an index period. The diversity and composition of an assemblage can vary considerably at different times of the year. Sampling at the wrong time of year will provide data that can not be used. In addition, some assemblages can only be sampled at certain times of the year because of their seasonal life cycles. For example, the best time to sample adult frogs is during the breeding season when many species congregate in ponds and vernal pools.

For further information, contact the EPA Wetlands Information Hotline (contractor operated) at 1-800-832-7828 or visit the Wetlands Division home page at http://www.epa.gov/OWOW/wetlands. **Printed on Recycled Paper**

CASE STUDY: *USGS, Biological Resources Division, Patuxent Wildlife Research Center*
USDA Natural Resources Conservation Service, Wetlands Science Institute

The interdisciplinary team of researchers is developing a biological assessment method to evaluate the success of wetland restoration activities. They are conducting research in Delmarva Bays, which are depressional, freshwater wetlands that are common on the Eastern Shore of Maryland. The wetlands in this study fall into two groups. The first group includes 24 wetlands which were previously used for agriculture and been restored during the past 10 years. The second group includes 10 minimally impaired wetlands, which they are using for reference wetlands. The reference wetlands are at different successional stages to help understand how the biological communities may change over time. Some of the reference wetlands have open water and emergent vegetation while others are only seasonally inundated and have trees.

For each of the restoration and reference sites, the team or researchers is taking measurements of the following components of the wetland ecosystems:

- Hydrology and Soil
- Water Chemistry
- Vascular Plants
- Macroinvertebrates
- Amphibians
- Birds
- Mammals

Their goal is to identify reliable indicators of wetland condition. For each component, they are testing a variety of attributes to identify metrics that show clear, empirical changes in value across a gradient of disturbance, from the minimally impaired wetlands to the most severely degraded wetlands. They intend to develop standardized methods for gathering and analyzing these metrics. Eventually, they intend to develop IBIs for one or more assemblages (See Fact Sheet ❺). After developing the IBIs, they will be able to determine the condition of other restored, depressional wetlands in the region. They will also gain valuable information about the effectiveness of different wetland restoration methods.

BENEFITS OF EVALUATING PERFORMANCE

In the long run, the cost of periodically conducting biological assessments will probably be small compared to benefits that come from such assessments. Wetland managers will benefit by:

- Determining the effectiveness of their methods and learning how to improve methods,
- Learning how to avoid common mistakes,
- Improving investment of restoration money and increasing ecological return of investments,
- Avoiding the substantial financial and ecological costs of spending money on ineffective restoration techniques and having to make second attempts at restoring sites,
- Recording the effects of extraneous events (*e.g.*, drought, beaver activity) that may hinder recovery,
- Incorporating unexpected results into an adaptive management process or simply re-evaluating restoration objectives,
- Acquiring reliable, quantitative data that can help (1) communicate results to managers and the public, (2) resolve disputes, and (3) support grant applications to fund future projects.

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Wetland Bioassessment Fact Sheet 9

Involvement of Volunteers in Wetland Monitoring

The involvement of volunteers in ecological monitoring programs is a realistic, cost-effective, and beneficial way to obtain important information which might otherwise be unavailable due to lack of resources at government agencies. Initiatives such as Riverwatch, Adopt-a-Stream, and the Izaak Walton League's Save-Our-Streams program have been highly successful in maintaining groups of interested volunteers as well as in yielding data useful to scientists, planners, and concerned citizens. Although many programs aim to assess the health of streams and lakes, relatively few volunteer programs have attempted to monitor and document the biological condition or functional values of wetlands. The diversity of wetland types can also complicate efforts to monitor wetlands. It is nevertheless feasible to use volunteers to help collect valuable data on wetlands, such as water levels, vegetation types, water quality, and composition of plant and animal assemblages. It is also feasible for volunteers to monitor specific plants or animals, such as non-native weeds or amphibians.

Facts About Volunteer, Water Quality Monitoring Programs

- There are more than 500 volunteer monitoring programs nationwide evaluating the water quality of wetlands, rivers, lakes, estuaries, and other waterbodies.
- More than 340,000 volunteers of all ages and backgrounds participate.

Volunteer Monitoring Fosters a Sense of Stewardship

Volunteer monitoring programs empower citizens to become more active stewards of wetlands in their communities. Volunteer programs provide an opportunity for land owners, children, and other community members to become more familiar with the functions and values of wetlands in their watershed as well as the pressures placed on these resources. Informed citizens can play a key role in encouraging land and water stewardship in all sectors of society, from industry to private homeowners, and from housing developers to municipal sewage treatment managers.

Volunteer Monitoring Provides Valuable Data

Volunteer monitoring programs can provide data for federal, state, tribal, and local water quality agencies and private organizations. Although these data are generally not as rigorous as data collected by trained professionals, organizations can use these data to screen areas that otherwise may not be assessed. If the volunteers spot warning signs, they can alert professionals to the problem, and the professionals can follow up with more detailed assessments.

EPA Volunteer Monitoring Web Site

http://www.epa.gov/OWOW/monitoring/vol.html

EPA Wetland Volunteer Monitoring Site

http://www.epa.gov/OWOW/wetlands/wqual.html

In 1995, elementary school students in Minnesota discovered frogs with malformations. They captured the Nation's attention and professionals and other volunteers have subsequently found malformed amphibians across the Great Lakes region and northern New England.

Volunteers can monitor wetlands for a variety of objectives. The following four case studies illustrate different objectives for volunteer monitoring.

Keys to a Successful Program

- Strong links between volunteers, government agencies, private organizations, and technical experts.
- Standardized methods.
- Simple instructions.
- Quality assurance protocols.
- Monitoring plan based on answering specific questions and objectives.
- Adequate trainer/volunteer ratios.
- Permission to access wetlands.

CASE STUDY: MONITORING MITIGATION SITES

The Maryland Department of the Environment is implementing a citizen-based program to monitor nontidal mitigation wetlands. The project has developed a monitoring manual and training seminars. Volunteers are trained to collect baseline data on vegetation density and groundwater elevations on state-developed programmatic wetland mitigation sites. Information gathered from this study provides resource managers with quantitative, site-specific data for direct comparison with established performance standards. [Contact: Denise Clearwater, (410) 631-8094]

CASE STUDY: MONITORING COASTAL WETLANDS

In 1995-1996, Save-the-Bay, in partnership with the EPA Narragansett Bay Estuary Program, developed a method for characterizing the health of tidal and formerly tidal coastal marshes. Through Save-the-Bay's Habitat Protection and Restoration Program, over 100 trained volunteers have participated in the evaluation of marshes in Rhode Island and Massachusetts. Nearly 1,885 acres (or 60%) of Narragansett Bay's marshes have been evaluated by volunteers and reviewed by Save-the-Bay's staff. There is a standard QA/QC protocol for all such evaluations. Several of the monitoring sites are on golf courses, and cooperation with these golf courses has been a carefully orchestrated part of the marsh monitoring effort. [Contact: Andy Lipsky, (401) 272-3540.]

CASE STUDY: INCORPORATING MONITORING INTO EDUCATIONAL PROGRAMS

Caddo Lake Institute (Project WET Texas) uses Caddo Lake, a large, shallow, cypress-dominated wetland, as a living laboratory for wetland science training. The institute targets teachers in local colleges, universities, and public schools with the intention of getting students involved in a long-term commitment to environmental research. Groups from five different high schools and six colleges associated with the institute currently monitor 23 sites on Caddo Lake. Other sites in the upper watershed, including constructed wetlands, are monitored as well. [Contact: Sara Kneipp, (903) 938-3545]

CASE STUDY: TRAINING VOLUNTEERS TO CONDUCT BIOLOGICAL ASSESSMENTS

The Minnesota Pollution Control Agency is training volunteers to assess the biological integrity of wetlands in a pilot project. The volunteers learn sampling methods, quality assurance protocols, and how to identify plants, insects, and other animals living in the wetlands. Initial results indicate that the volunteer assessments, although not as rigorous as the professional assessments, provide repeatable results that are consistent with the more detailed, professional assessments. [Contact: Judy Helgen, (612) 296-7240]

EPA Wetland-Related Volunteer Monitoring Publications*

EPA. *The Volunteer Monitor's Guide to Quality Assurance Project Plans.* EPA 841-B-96-003

EPA. *Volunteer Lake Monitoring: A Methods Manual.* EPA 440/4-91-002

EPA Region 10 (Northwest). *Wetland Walk Manual: A Guidebook for Citizen Participation.* EPA 910/B-95-007

Miller, T., J. Martin, L. Storm, and C. Bertolotto. 1996. *Monitoring Wetlands: A Manual for Training Volunteers*
(Collaboration between EPA Region 10 and King County)
[Source: Adopt-a-Beach, 4649 Sunnyside Ave. N, Rm 305, Seattle, WA 98103. Cost: $15]

* Electronic versions of most EPA volunteer monitoring publications are available on either the EPA Volunteer Monitoring or Wetland Division web sites (*http://www.epa.gov/OWOW/monitoring/vol.html* or *http://www.epa.gov/OWOW/wetlands/wqual.html*)

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Wetland Bioassessment Fact Sheet ⑩
Glossary of Bioassessment Terms

Ambient Monitoring: Monitoring within natural systems (*e.g.*, lakes, rivers, estuaries, wetlands) to determine existing conditions.

Assemblage: An association of interacting populations of organisms in a given waterbody. Examples of assemblages used for biological assessments include : algae, amphibians, birds, fish, herps (reptiles and amphibians), macroinvertebrates (insects, crayfish, clams, snails, etc.), and vascular plants.

Attribute: A measurable component of a biological system. (Karr, J.R., and E.W. Chu. 1997. *Biological Monitoring and Assessment: Using Multimetric Indexes Effectively*. EPA 235-R97-001. University of Washington, Seattle)

Biological Assessment (bioassessment): Using biomonitoring data of samples of living organisms to evaluate the condition or health of a place (*e.g.*, a stream, wetland, or woodlot).

Biological Criteria (biocriteria): Numerical values or narrative expressions that describe the condition of aquatic, biological assemblages of reference sites of a given aquatic life use designation.

Biological Integrity: "...the ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region." (Karr, J. R. and D. R. Dudley. 1981. Ecological perspective on water quality goals. *Environmental Management* 5:55-68)

Biological Monitoring (biomonitoring): Sampling the biota of a place (*e.g.*, a stream, a woodlot, or a wetland)

Biota: The plants and animals living in a habitat.

Composition (structure): The composition of the taxanomic grouping such as fish, algae, or macroinvertebrates relating primarily to the kinds and number of organisms in the group.

Community: All the groups of organisms living together in the same area, usually interacting or depending on each other for existence.

Criteria (singular = criterion): Statements of the conditions presumed to support or protect the designated use or uses of a waterbody. Criteria may be narrative or numeric.

Designated Use: Classification designated in water quality standards for each waterbody or segment that defines the optimal purpose for that waterbody. Examples - drinking water use and aquatic life use.

Diatom: Microscopic algae with cell walls made of silicon and of two separating halves.

Diversity: A combination of the number of taxa (see taxa richness) and the relative abundance of those taxa. A variety of diversity indexes have been developed to calculate diversity.

Ecological Assessment: A detailed and comprehensive evaluation of the status of a water resource system designed to detect degradation and if possible, to identify causes of that degradation.

Ecological Integrity: The condition of an unimpaired ecosystem as measured by combined chemical, physical (including physical habitat), and biological attributes.

Ecoregion: Regions defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables.

Functions: The roles that wetlands serve, which are of value to society or environment.

Functional Groups: A means of dividing organisms into groups, often based on their method of feeding (*e.g.*, shredder, scraper, filterer, predator), type of food (*e.g.*, fruit, seeds, nectar, insects), or habits (*e.g.*, burrower, climber, clinger).

Habitat: The sum of the physical, chemical, and biological environment occupied by individuals of a particular species, population, or community.

Herpetiles: Reptiles and amphibians.

Hydrogeomorphic (HGM) Classification: A wetland classification system based on the position of a wetland in the landscape (geomorphic setting), dominant sources of water, and the flow and fluctuation of water once in the wetland. Hydrogeomorphic classes include riverine, depressional, slope, mineral soil flats, organic soil flats, estuarine fringe, and lacustrine fringe.

Hydrogeomorphic (HGM) Approach: A functional assessment method which compares a wetland's condition to similar wetland types (as defined by HGM classification) that are relatively unaltered. HGM functions normally fall into one of three major categories: (1) hydrologic (*e.g.*, storage of surface water), (2) biogeochemical (*e.g.*, removal of elements and compounds), and (3) habitat (*e.g.*, maintenance of plant and animal communities).

Hydrology: The science of dealing with the properties, distribution, and circulation of water both on the surface and under the earth.

Impact: A change in the chemical, physical (including habitat), or biological quality or condition of a waterbody caused by external forces.

Impairment: A detrimental effect on the biological integrity of a waterbody caused by an impact that prevents attainment of the designated use.

Index (plural = indices or indexes): An integrative expression of site condition across multiple metrics. An index of biological integrity is often composed of at least 7 metric. (Karr, J.R., and E.W. Chu. 1997. *Biological Monitoring and Assessment: Using Multimetric Indexes Effectively*. EPA 235-R97-001. University of Washington, Seattle)

Index of Biological Integrity: An integrative expression of the biological condition that is composed of multiple metrics. Similar to the Dow Jones Industrial index used for expressing the condition of the economy.

Macroinvertebrates: Animals without backbones that can be seen with the naked eye (caught with a 1 mm^2 mesh net). Includes insects, crayfish, snails, mussels, clams, fairy shrimp, etc.

Metric: An attribute with empirical change in value along a gradient of human influence. (Karr, J.R., and E.W. Chu. 1997. *Biological Monitoring and Assessment: Using Multimetric Indexes Effectively*. EPA 235-R97-001. University of Washington, Seattle)

Pollution: The Clean Water Act (§502.19) defines pollution as "the [hu]man-made or [hu]man-induced alteration of chemical, physical, biological, and radiological integrity of water."

Reference Condition: Set of selected measurements or conditions of minimally impaired waterbodies characteristic of a waterbody type in a region.

Reference Site: A minimally impaired site that is representative of the expected ecological conditions and integrity of other sites of the same type and region.

Taxa (singular = taxon): A grouping of organisms given a formal taxonomic name such as species, genus, family, etc.

Taxa Richness: The number of distinct species or taxa that are found in an assemblage, community, or sample.

Water Quality Standard: A legally established state regulation consisting of three parts: (1) designated uses, (2) criteria, and (3) antidegradation policy (See Fact Sheet ❼).

Wetland: Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, an similar areas. (Cowardin et al. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Department of the Interior. Fish and Wildlife Service. FWS/OBS-79/31)