



United States Environmental
Protection Agency

Office of Water
Washington, DC 20460

EPA-822-R-02-018
March 2002

METHODS FOR EVALUATING WETLAND CONDITION
**#8 Volunteers and Wetland
Biomonitoring**





United States Environmental
Protection Agency

Office of Water
Washington, DC 20460

EPA-822-R-02-018
March 2002

METHODS FOR EVALUATING WETLAND CONDITION
**#8 Volunteers and Wetland
Biomonitoring**

Principal Contributor

University of Massachusetts
Anna L. Hicks

Prepared jointly by:

The U.S. Environmental Protection Agency
Health and Ecological Criteria Division (Office of Science and Technology)

and

Wetlands Division (Office of Wetlands, Oceans, and Watersheds)

NOTICE

The material in this document has been subjected to U.S. Environmental Protection Agency (EPA) technical review and has been approved for publication as an EPA document. The information contained herein is offered to the reader as a review of the “state of the science” concerning wetland bioassessment and nutrient enrichment and is not intended to be prescriptive guidance or firm advice. Mention of trade names, products or services does not convey, and should not be interpreted as conveying official EPA approval, endorsement, or recommendation.

APPROPRIATE CITATION

U.S. EPA. 2002. *Methods for Evaluating Wetland Condition: Volunteers and Wetland Biomonitoring*. Office of Water, U.S. Environmental Protection Agency, Washington, DC. EPA-822-R-02-018.

This entire document can be downloaded from the following U.S. EPA websites:

<http://www.epa.gov/ost/standards>

<http://www.epa.gov/owow/wetlands/bawwg>

CONTENTS

| | |
|--|----|
| FOREWORD..... | v |
| LIST OF “METHODS FOR EVALUATING WETLAND CONDITION” MODULES..... | vi |
| SUMMARY..... | 1 |
| PURPOSE | 1 |
| INTRODUCTION..... | 1 |
| VOLUNTEERS BIOMONITORING WETLANDS..... | 1 |
| WORKING WITH VOLUNTEERS..... | 2 |
| VOLUNTEER TRAINING AND PROTOCOLS | 8 |
| BIOLOGICAL COMMUNITIES AND VOLUNTEER MONITORING..... | 10 |
| STUDY PLANS AND QAPPS | 11 |
| DATA GENERATION, ANALYSIS, AND REPORTING | 12 |
| RECOMMENDATIONS..... | 13 |
| CASE STUDIES | 13 |
| REFERENCES..... | 18 |

LIST OF TABLES

| | |
|---|----|
| TABLE 1: USES AND USERS OF VOLUNTEER DATA..... | 4 |
| TABLE 2: EXISTING VOLUNTEER BIOMONITORING AT THE FEDERAL AND STATE AGENCY LEVELS | 15 |
| TABLE 3: ROLES OF VOLUNTEERS AND PROFESSIONAL SCIENTISTS IN A COOPERATIVE MONITORING PROGRAM | 16 |

FOREWORD

In 1999, the U.S. Environmental Protection Agency (EPA) began work on this series of reports entitled *Methods for Evaluating Wetland Condition*. The purpose of these reports is to help States and Tribes develop methods to evaluate (1) the overall ecological condition of wetlands using biological assessments and (2) nutrient enrichment of wetlands, which is one of the primary stressors damaging wetlands in many parts of the country. This information is intended to serve as a starting point for States and Tribes to eventually establish biological and nutrient water quality criteria specifically refined for wetland waterbodies.

This purpose was to be accomplished by providing a series of “state of the science” modules concerning wetland bioassessment as well as the nutrient enrichment of wetlands. The individual module format was used instead of one large publication to facilitate the addition of other reports as wetland science progresses and wetlands are further incorporated into water quality programs. Also, this modular approach allows EPA to revise reports without having to reprint them all. A list of the inaugural set of 20 modules can be found at the end of this section.

This series of reports is the product of a collaborative effort between EPA’s Health and Ecological Criteria Division of the Office of Science and Technology (OST) and the Wetlands Division of the Office of Wetlands, Oceans and Watersheds (OWOW). The reports were initiated with the support and oversight of Thomas J. Danielson (OWOW), Amanda K. Parker and Susan K. Jackson (OST), and seen to completion by Douglas G. Hoskins (OWOW) and Ifeyinwa F. Davis (OST). EPA relied heavily on the input, recommendations, and energy of three panels of experts, which unfortunately have too many members to list individually:

- Biological Assessment of Wetlands Workgroup
- New England Biological Assessment of Wetlands Workgroup
- Wetlands Nutrient Criteria Workgroup

More information about biological and nutrient criteria is available at the following EPA website:

<http://www.epa.gov/ost/standards>

More information about wetland biological assessments is available at the following EPA website:

<http://www.epa.gov/owow/wetlands/bawwg>

LIST OF “METHODS FOR EVALUATING WETLAND CONDITION” MODULES

| MODULE # | MODULE TITLE |
|----------|---|
| 1 | INTRODUCTION TO WETLAND BIOLOGICAL ASSESSMENT |
| 2 | INTRODUCTION TO WETLAND NUTRIENT ASSESSMENT |
| 3 | THE STATE OF WETLAND SCIENCE |
| 4 | STUDY DESIGN FOR MONITORING WETLANDS |
| 5 | ADMINISTRATIVE FRAMEWORK FOR THE IMPLEMENTATION OF A WETLAND BIOASSESSMENT PROGRAM |
| 6 | DEVELOPING METRICS AND INDEXES OF BIOLOGICAL INTEGRITY |
| 7 | WETLANDS CLASSIFICATION |
| 8 | VOLUNTEERS AND WETLAND BIOMONITORING |
| 9 | DEVELOPING AN INVERTEBRATE INDEX OF BIOLOGICAL INTEGRITY FOR WETLANDS |
| 10 | USING VEGETATION TO ASSESS ENVIRONMENTAL CONDITIONS IN WETLANDS |
| 11 | USING ALGAE TO ASSESS ENVIRONMENTAL CONDITIONS IN WETLANDS |
| 12 | USING AMPHIBIANS IN BIOASSESSMENTS OF WETLANDS |
| 13 | BIOLOGICAL ASSESSMENT METHODS FOR BIRDS |
| 14 | WETLAND BIOASSESSMENT CASE STUDIES |
| 15 | BIOASSESSMENT METHODS FOR FISH |
| 16 | VEGETATION-BASED INDICATORS OF WETLAND NUTRIENT ENRICHMENT |
| 17 | LAND-USE CHARACTERIZATION FOR NUTRIENT AND SEDIMENT RISK ASSESSMENT |
| 18 | BIOGEOCHEMICAL INDICATORS |
| 19 | NUTRIENT LOAD ESTIMATION |
| 20 | SUSTAINABLE NUTRIENT LOADING |

SUMMARY

Agency staff and other professional wetland managers are called upon to achieve too much with too few resources. Well-trained volunteers have the potential to fill manpower needs and provide the assistance that will lead to scientifically sound data that are so urgently needed to protect the integrity of the nation's wetlands and to uphold the principles of the Clean Water Act. Recruitment and management guidelines, sound volunteer monitoring protocols, outreach and education programs, training workshops, volunteer service providers, and many other resources including a pool of motivated and often experienced volunteers, are currently available for wetland managers and State agency personnel to draw upon. The time is ripe for the formation of committed partnerships between volunteers and professional agency staff that will further the common goal of wetland protection.

PURPOSE

The purpose of this module is to address the concerns held by many agency personnel, whether national, State, or regional, in relationship to volunteer participation in wetland biomonitoring and the accomplishment of the goals of the Clean Water Act.

INTRODUCTION

Environmental managers are faced with the need to accurately portray the types and integrity of local wetlands to assist them in their goal of sound management, yet they have decreasing resources to spend on data collection and analysis. Citizen volunteers can help to bridge this gap, especially with the application of biomonitoring. There are many advantages in combining the technical expertise of State and Federal environmental agen-

cies with the local knowledge, personal involvement, and energy of volunteers. This partnership helps to build the capacity of citizens to become part of the planning process at the community level, changes the way volunteers think about wetland resources, and strengthens local stewardship. Using their newly acquired knowledge and tools, volunteers get involved in local planning and decisions to improve water quality, aquatic habitat, and biological communities. Agencies, in turn, are able to monitor more projects and obtain more data than would otherwise be possible. This partnership also breaks down some of the old barriers of mistrust and lack of cooperation.

VOLUNTEERS BIOMONITORING WETLANDS

COMMUNITY-BASED ENVIRONMENTAL PROTECTION

At some point the will to conserve our natural resources has to rise up from the heart and soul of the people—citizens themselves taking conservation into their own hands, and along with the support of their government, making it happen. Mollie H. Beattie, former Director, U.S. Fish and Wildlife Service

A growing sector of the public appreciates the important functions and values provided by wetlands and is concerned about their continuing loss and degradation in the face of ever-increasing development. Many citizens motivated to *do something* become involved as volunteers. The pool of volunteers – trained scientists, retired professionals, schoolteachers and students, conservation commissioners, environmental consultants and lawyers, as well as professional nonprofit volunteer organizations acting as service providers to willing citizens from all walks of life – is a growing source of

willing assistants. Many of these people and groups already have valuable skills, knowledge, and infrastructure that could be applied in a cost-effective manner to assist State and Federal agencies working to implement wetland conservation.

BRIDGING THE GAP

Agencies, on the other hand, are being directed to fulfill the requirements of the Clean Water Act and provide comprehensive monitoring data under the various sections of the act. This task conflicts with the reality of dwindling funding and manpower resources. A number of agencies are exploring volunteer participation in government monitoring programs. There are many issues yet to be resolved, and mechanisms to be put into place, before the partnership between volunteers and agencies can operate smoothly. This module aims to bridge the gap between the partners by providing a set of guidelines to facilitate volunteer participation in wetland bioassessment programs.

From the onset, a cooperative wetland biomonitoring program needs a framework of realistic expectations of respective responsibilities, roles, and tasks, together with a clear understanding of the required endpoints.

WORKING WITH VOLUNTEERS

ADVANTAGES

Education and environmental stewardship

Government agencies, watershed associations, and nonprofit organizations promote volunteerism to motivate people to change their attitudes and become involved in preventing pollution and restoring water quality. Volunteers usually become involved through a personal concern for water quality or the wildlife of a local wetland. By working with scientists and other concerned citizens and attending

workshops or taking academic courses, volunteers can receive hands-on education about wetland plants and animals, food chains, ecological principles, watershed management issues, regulations, and legislation. This experience provides citizens with valuable tools to use in a nonregulatory approach to protecting local wetland acreage, functions, and values.

Local knowledge

Citizens have intimate local knowledge of water resources and their environs and can provide an account of changes over time. Their familiarity with local land uses also helps to identify potential sources of point-source (dumpage, spills, unregulated discharges, etc.) and/or nonpoint-source pollution (flow alterations, habitat alterations, eutrophication, sedimentation, etc.). As members of the local community, volunteers can often gain access to privately owned or remote wetland sites.

Local-level assessments, management, and planning

Many local residents have a natural proclivity to learn about wetlands, habitats, and biota and are interested in monitoring water quality and the effectiveness of best management practices. They can act as public “watchdogs.” Public interest helps to shape planning policy in local communities. An involved public can advance both scientific research and good management practices.

Citizens do appreciate wetlands

Most citizens were first introduced to the wonders of aquatic flora and fauna on their first school outing to examine pond life. Many conservation-minded citizens view volunteering as an opportunity to use that fascination as a tool to become actively involved in wetland conservation. A proportionally very high number of listed threatened or endangered species are wetland dependent, and the connection between wetland health and biodiversity is already clearly established in the public arena.

Wetlands are also tied to a very personal interest. In addition, citizens have a financial interest in wetlands through the real estate value of their own property. A healthy wetland within or adjoining a private property raises the value of that property because of its aesthetic value and the associated privacy it provides. Citizens will become actively involved in protecting these vested interests.

Support and enhance agency efforts

Agency staff can engage volunteers in a variety of ways, as described below:

- An established volunteer organization with fully trained team leaders and volunteer crews can take on some of the monitoring load and associated responsibilities from agency staff and can produce scientifically acceptable data. In addition, community volunteer activities attract positive press coverage.
- Volunteer-generated data are valuable as they act as a diagnostic “screen” to pinpoint wetland health problems.
- Several teams of volunteers can be sent into the field at one point in time, which achieves widespread sampling within the same period. This is normally very difficult to achieve under normal circumstances owing to a lack of personnel.
- Data collected by volunteers can be used by agencies to support their analysis of biological or ecological functioning of wetlands, not only in a utilitarian sense but in a broader context of wetland condition. Volunteers can be helpful in tracking whether key indicators of function are present from year to year. They can record presence/absence of birds, mammals, plants, and other biota associated with wetlands. Seasonal and annual changes can be recorded.
- Volunteers provide additional assistance in the field, in the laboratory, or on the computer keyboard.

- The time and money saved through volunteer participation can be spent in increasing the number of sites to be monitored and the amount of data to be collected.
- Many samples retrieved from wetlands are notoriously difficult and time-consuming to sort. With relatively little training and professional supervision, volunteers can complete this task immediately after sampling.
- Today’s volunteers often include people, especially retirees, with a high degree of professional expertise in fields associated with both biomonitoring and wetlands.

Appropriate use of volunteers by government agencies

Volunteer monitoring can be applied at three levels:

1. *Increase awareness and knowledge of resource values and conditions.* Awareness of water resource values and conditions is a prerequisite for public support to restore, protect, and maintain water resources. Such awareness does not require rigorous sampling or complex analytical methods, so volunteer monitoring programs can meet this goal.
2. *Assist with the assessment and management of wetlands at the community or watershed level.* Decisions at the community or watershed level typically involve municipal and privately owned land. Many volunteer organizations already participate at this level and provide reliable data based on sound Quality Assurance Project Plans (QAPPs) that are geared toward identifying gross problems and measuring changes over time. This form of volunteer involvement is most important if there is a need for the continuous monitoring of many wetlands. It can also provide information on wetland status that would not otherwise be obtainable, such as the presence of rare or invasive species.

3. *Contribute toward the evaluation and assessment programs of State and Federal agencies.* Volunteer monitoring can be used for many of the Federal and State wetland regulatory programs covered in Module 5: Administrative Framework for the Implementation of a Wetland Bioassessment Program. A typical example would be measuring the success over time of compensatory mitigation projects. Concerns about quality assurance/quality control (QA/QC) issues and data generated by volunteers can be avoided if the roles of volunteers are restricted to field assistance and, in the case of invertebrate biomonitoring, to sorting samples from debris, and possibly to identify to order level. The delegation of simple tasks can be of great assistance to professionals (modified from Dates et al. 1997).

Unless volunteers are highly trained specialists with a professional record in biomonitoring of particular community groups, it is strongly recommended that volunteers not be used when the quality of data has to meet legal, regulatory, and scientific peer review requirements.

4. *Other applications of volunteer monitors.* Many opportunities for volunteer participation exist apart from assisting agencies with data collection (Table 1). The National Directory of

Volunteer Environmental Monitoring Programs (1998) lists 772 water resources monitoring groups with a wide range in program types. Of these, 52% monitor macroinvertebrates to assess water quality.

HIGH SCHOOL STUDENTS AS VOLUNTEERS

There is an understandable reluctance among agency scientists to involve students in rigorous biomonitoring programs that require a high degree of quality control to be coupled with accurate biota identification. However, there are agency programs in which students can act in a volunteer capacity, particularly under the supervision of teachers who have attended “train the trainer” workshops. A number of agencies are developing their own high school manuals, training videos, and other support materials to encourage school participation in conservation programs.

One of the most encouraging case studies of school participation in wetland conservation is student involvement in the vernal pool certification program in Massachusetts. Colburn (1997), an aquatic ecologist working with Massachusetts Audubon, developed a manual, *Certified: A Citizen's Step-by-Step Guide to Protecting Vernal Pools*. Clear

TABLE 1: USES AND USERS OF VOLUNTEER DATA

| USE OF INFORMATION | TYPES OF USERS |
|--------------------------------------|--|
| Education | Individual citizen programs |
| Establish baseline conditions | Community organizations and watershed associations |
| Screen for problems | University scientists |
| Research | Local government |
| Advocacy and "watchdog" role | State government |
| Community organizing | Federal Government |
| Nonpoint Source Pollution Assessment | Nonprofit foundations and trusts |
| Watershed planning | Schools and nontraditional education programs |
| Restoration projects | |
| Land-use decisions | |
| BMP evaluation | |
| Enforcement | |
| Legislation | |
| State 305(b) reports | |
| Shellfish bed closures | |

and simple instructions guide citizens through the steps necessary to officially certify vernal pools with the Division of Fisheries and Wildlife. Once certified, the pool is then protected. Teachers throughout the State were quick to use this manual and now integrate vernal pool studies into their curricula. Reading Memorial High School, under the leadership of one teacher, Leo Kenney, has certified more than 200 local vernal pools. (See *Volunteer Monitor*, Spring 1998, "Defending the Underdog: Volunteers Protect Vernal Pools.") To assist with accurate identification of fauna, an excellent field guide has been developed under sponsorship of the Executive Office of Environmental Affairs (Kenney and Burne 2000).

As agency involvement in wetland restoration and creation grows, there is an excellent opportunity to engage teachers and students in habitat enrichment programs such as removal of invasive species, planting of indigenous species, and monitoring the success of the improvements. Students in turn learn more about wetland flora and fauna and their importance in wetland ecology and conservation. Martin (1999), of the Center for Science Education at Portland University, stresses the need to link student fieldwork with the more theoretical principles of science. In other words, an integrated educational approach of fieldwork and classroom instruction will provide students with a background in the scientific approach, as well as build sound ecological attitudes that students will carry into the future as adults. Students enjoy sharing their experiences with family and friends, thus increasing stewardship and helping to build trust between agencies and the public.

ADDRESSING CONCERNS

The reluctance of government agents to involve volunteers with their programs arises from a number of concerns, including:

- Fear of management pressure to substitute technical staff with volunteers

- Cost of volunteer monitoring programs
- Difficulty in recruiting and keeping effective volunteers
- Finding the time to train, coordinate, and supervise volunteers
- Professional distrust of data collected by volunteers (is it credible? how was it obtained? how stringent was QA/QC? etc.)
- Volunteers are unreliable in meeting schedules and deadlines
- Safety and liability issues

The following sections of this module attempt to address some of these concerns.

ROLE OF AGENCY PROFESSIONALS

Volunteers should not replace the work responsibilities of trained agency technicians and scientists. Agency staff need to generate the study design and QAPP, conduct training at the appropriate level, set required level of rigor, supervise volunteer involvement, perform the data analysis, and follow through with reports and recommendations for management.

FUNDING

Volunteer monitoring programs produce cost-effective wetland biomonitoring data, but they are not free. A quality volunteer monitoring program requires funding, either from an agency or an outside source. At least one salaried person is required to act as a volunteer coordinator to recruit volunteers; to organize and coordinate monitoring; to purchase, distribute, and maintain equipment; to organize meetings and training sessions; to provide support services; to receive records and monitoring data; to enter and analyze data and possibly write study designs, QAPPs, and reports; and finally, to provide general administrative assistance. Other consider-

ations include costs related to equipment purchase, transportation, office overhead, photocopying, film development, and last but not least, “rewards” such as refreshments to maintain volunteer morale (Millet et al. 1996). Volunteers will provide free labor, but should not be asked to carry the burden of other related expenses.

RECRUITMENT

One strategy for recruiting effective, committed volunteers is to contact established volunteer resources, including community watershed groups and local environmental organizations already involved in water resource protection, natural history societies such as Audubon, academic groups (high schools, colleges, and universities), land trust organizations, and fishing and hunting clubs. Unaffiliated members of the public can be recruited at community meetings and through newsletters, posted flyers, list servers’ e-mail lists, or announcements on cable television or radio and in newspapers. A discussion of benefits and drawbacks of each of these potential pools is provided by Miller et al. (1996). It is important to make the volunteer project attractive and of relevance to the community.

ORGANIZATION AND LEADERSHIP

Agency staff already feel taxed with work requirements and are reluctant to take on the additional responsibilities of recruiting, organizing, training, and leading a team of volunteers, even though they recognize the long-term benefits. The best solution to this dilemma is to work through an established volunteer group, usually a watershed association, and a service provider such as River Watch Network, Adopt-A-Stream Foundation, New England Region Monitoring Consortium, or Massachusetts Water Watch Partnership, that provides training programs, manuals, and support services, and understands the QA/QC requirements associated with the CWA monitoring and data quality. A trained and experienced volunteer or volunteer team can

be more quickly incorporated into an agency program and reduce the time required of agency staff.

MAINTAINING CONTINUITY AND COMMITMENT

Volunteers come and go. Attrition is high. The Spring 1996 issue of *Volunteer* is devoted to managing a volunteer monitoring program and discusses why people volunteer, why volunteers leave, and what can be done to correct the situation. Florida Lakewatch offers the following action plan:

Improve feedback

- Hold more meetings – at least one general meeting. These meetings will:
 - Give volunteers a sense of connection to a group or project
 - Offer opportunities for staff to deal firsthand with volunteers’ questions
- Speed turnaround time between data collection and feedback; improve data report formatting (volunteers want simply expressed results, not statistical rationale)
- Produce a variety of types of feedback (videos, brochures, in-person-presentations, newsletters, Web pages)
- Use regional coordinators to maintain closer touch with volunteers

Improve screening

- Enroll new volunteers selectively, with long-term commitment as the primary criterion.
- Hold an initial interview that will:
 - Emphasize the benefits of having a long-term database
 - Caution volunteers not to expect that data alone can solve any particular problem
 - Warn volunteers about possible delays in receiving feedback

- Identify and discourage mismatched volunteers

Add new challenges

- Offer veteran volunteers training in new monitoring skills
- Use veteran volunteers in a mentoring/training capacity with new recruits
- Involve volunteers in the planning stages of a monitoring program

Provide positive feedback

- Treat volunteers as if they were paid staff
- Respect their opinions and local knowledge
- Provide words of encouragement
- Thank volunteers for their efforts
- Provide rewards—social gatherings with free refreshments, an outing such as a canoe trip, tee shirts, caps, mugs, certificates of appreciation, or free copies of photographs showing their involvement

And finally, conduct regular workshops and refresher courses, because they play an important role in maintaining a pool of qualified volunteers (Miller et al. 1996).

SAFETY/LIABILITY

Wetlands can be hazardous, and biomonitoring requires intimate contact with potentially dangerous environs such as contaminants; unconsolidated muddy substrates; sometimes concealed glass, fishing hooks, and tins; allergic reactions from poison ivy, stinging nettle, poison sumac, or insects; scratches and cuts from thorned plants and fish spines; and Lyme disease carried by ticks. A volunteer should always work with another field technician or companion. Issues such as vaccinations, suitability of clothing, first-aid measures, safety of

sampling sites, training in sampling techniques, and the handling of equipment must be resolved prior to taking volunteers into the field. Each team should have a first-aid kit. Remember, volunteer safety is always more important than data, and volunteers should never be put at unreasonable risk to obtain a measurement or a sample (Dohner et al. 1997).

Dangers associated with preservation solutions and reagents must also be considered. The team/laboratory leader should outline any hazards associated with particular preservatives, and the precautionary measures that can be taken prior to the volunteers handling the solutions.

Insurance coverage for volunteer workers has been highly variable. Laws differ markedly from State to State. Very few volunteer organizations have formal liability insurance coverage, and the legal strength of volunteers signing waivers of responsibility is questionable. Few State and Federal agencies had policies until the Federal Volunteer Protection Act of 1997 was enacted.

The act's primary purpose is to assist nonprofit organizations in recruiting and maintaining volunteer support by limiting their exposure to lawsuits arising from the volunteer activity. The act applies only for "qualifying organizations," i.e., an organization formed for charitable, civic, educational, religious, welfare, or health purposes; or a tax-exempt organization; or a State or its subdivisions. The protected party must qualify as a "volunteer," i.e., the party may not receive compensation for services (other than reasonable reimbursement or allowance for expenses actually incurred) or receive any gift in lieu of compensation exceeding \$500. A volunteer will enjoy protection only if he or she: (1) was acting within the volunteer's scope of responsibility; (2) was properly licensed or certified if licensing or certification is required; (3) did not engage in willful, criminal, reckless, or grossly negligent conduct;

or (4) did not cause an injury while operating a motor vehicle, vessel, aircraft, or other vehicle requiring a license (Riverways Newsletter, Fall 1999).

For further assistance contact the advisory body, *The Nonprofit Risk Management Center*, 1001 Connecticut Ave. NW, Suite 900, Washington DC 20036, phone 202-785-3891, fax 202-833-5747 (Ely 1996).

VOLUNTEER TRAINING AND PROTOCOLS

A good deal of the skepticism about volunteer-collected data stems from the feeling that data collected by “nonscientists” or “nonprofessionals” cannot be trusted. The best defense against such objections is to make sure you give your volunteers the most comprehensive training possible, then follow up by testing the volunteers at intervals to document the fact that they are performing procedures correctly. (Ely 1992)

From the onset, the volunteer wetland biomonitoring project needs clearly stated goals and endpoints. Related to these is the level of involvement of volunteers and the intensity or rigor of their sampling and data collection. If the volunteers do not have the required skills at the onset, they will need training.

WHO WILL PROVIDE THAT TRAINING?

Training can be provided by an agency, a biomonitoring scientist, a volunteer service provider, a land grant university with a volunteer training extension education program, or even private training organizations such as the Izaak Walton Foundation and the Institute for Wetland & Environmental Education & Research.

Throughout the New England region there is a comprehensive infrastructure of interconnected volunteer training organizations that are now providing training in freshwater wetlands and estuarine salt marshes. Coordination of the many training organizations is provided by the New England Region Monitoring Collaborative (NERMC). Members of NERMC include representatives from EPA NEBAWWG, New England Interstate Water Pollution Control Commission (NEIWPC), River Network, Massachusetts Water Watch Partnership (MWWP), and Massachusetts Executive Office of Environmental Affairs (EOEA), as well as extension educators from the region’s State universities. Working as a team the members of NERMC write standardized training protocols, produce training videos, run training workshops, provide advisory services for volunteer organizations, conduct surveys on volunteer needs, and work towards filling the gaps identified. This is an excellent example of cooperation and coordination among agencies, educators, and volunteer organizations.

WHAT PROTOCOLS SHOULD BE CONSIDERED?

Training manuals, protocols, and teaching materials vary greatly in approach and levels of intensity. There are two approaches to the selection of protocols: (1) manuals and training protocols should be selected on the basis of their compatibility with the goals of the study or (2) nationally standardized protocols with accompanying training programs that all volunteers working with government agencies, regardless of their knowledge or previous experience, should attend. If agencies are not providing training in their own methods, they need to ensure that their volunteers have had training that will provide monitoring expertise equivalent to their own, and if not, to be prepared to fill in the gap. To date there is no EPA standardized Rapid Bioassessment Protocol suitable for volunteers working in wetlands. EPA’s streams and rivers manual (Dohner et al. 1997) is an excellent resource for trainers and volunteers engaged in lotic systems biomonitoring.

There are some volunteer training protocols developed by the Biological Assessment of Wetlands Workshop Group (BAWWG) members. As a number of these protocols are not published, the names, phone numbers, and e-mail address of contacts are included.

Freshwater invertebrates

Minnesota Pollution Control Agency. Draft Guidance on Sampling and Identifications of Wetland Invertebrates for Training Citizen Team
Contact: Judy Helgen, (651) 296-7240, judy.helgen@pca.state.mn.us.

Hicks AL, Nedeau E. 2000. New England Freshwater Wetlands Invertebrate Biomonitoring Protocol. Communications Center UMass Extension, University of Massachusetts, Amherst, MA.

Contact: Anna Hicks, (413) 253-3180, anna.hicks@verizon.net.

Saltmarsh invertebrates

Hicks AL. 2001. Draft New England Estuaries Invertebrate Biomonitoring Protocol. Massachusetts Coastal Zone Management. Boston, MA.

Contact: Anna Hicks, (413) 253-3180, anna.hicks@verizon.net

Freshwater plants

Minnesota Pollution Control Agency. Draft Guidance on Sampling, Biological Metrics, and Identification of Wetland Vegetation for Citizen Teams.

Contact: Mark Gernes, (651) 297-3363, mark.gernes@pca.state.mn.us.

Birds

Firehock K, Graff L, Middleton JV, Starinchak KD, Williams C. 1998. Handbook for Wetlands Conservation and Sustainability. Izaak Walton League of America, Gaithersburg, MD.

Marine algae

Contact: Sherwood Hall, Washington Seafood Laboratory, Office of Seafood HFS-426, U.S. FDA, 200 C St. SW, Washington, DC. (202) 205-4818, shall@bangate.fda.gov. Has a training video, color pictures of phytoplankton and additional materials, and provides technical advice.

Amphibians

King County Department of Natural Resources. Amphibian Survey Protocols for the King County Water and Land Resources Volunteer Amphibian Monitoring Program.

Contact: Klaus Richter, (206) 205-5622, klaus.richter@metrokc.gov.

Massachusetts Calling Amphibian Survey: North American Amphibian Monitoring Program: Procedures and Protocols.

Contact: Scott Jackson, (413) 545-4743, sjackson@umext.umass.edu.

Fish

Firehock K, Graff L, Middleton JV, Starinchak KD, Williams C. 1998. Handbook for Wetlands Conservation and Sustainability. Izaak Walton League of America, Gaithersburg, MD.

TESTING COMPETENCY

Once volunteers have finished training and are in the field sampling, it is essential to make sure they are collecting and analyzing samples correctly. The two basic approaches to testing the soundness of volunteers' techniques are to (1) bring the volunteers to a central location for periodic QC sessions and (2) send a professional expert into the field with the volunteers and perform parallel testing (Ely 1992). Parallel, or side-by-side, testing of data collected by volunteers versus data collected at the same sampling stations by professionals is conducted for two primary reasons: to assure government agencies that the quality of volunteers' data is sufficiently reliable for use by those agencies, and

to provide a volunteer program's staff and participating citizens with a measure of their ability to produce credible data (Ely 1997). Parallel testing also identifies study design problems, leads to improved training, and builds volunteers' confidence in their abilities.

BIOLOGICAL COMMUNITIES AND VOLUNTEER MONITORING

Volunteers performing biomonitoring in wetlands are encouraged to wear appropriate footwear (sneakers or waders depending upon the situation and safety issues) and should always be accompanied by at least one other team member. Every effort should be made to avoid damage to the wetlands, wetland habitats, and biota. Identification of amphibian or reptile eggs, for example, should be done without disturbing them. Typical skills required of volunteers in addition to data recording are listed below.

Vegetation

- Experience with establishing transects or sampling plots
- Ability to use taxonomic keys
- Ability to identify the local common wetland plants at least to genus
- Experience with collecting and preserving specimens

Refer to Module 10: Using Vegetation to Assess Environmental Conditions in Wetlands, and Module 16: Vegetation-Based Indicators of Wetland Nutrient Enrichment.

Algae

- Experience with sampling, preserving, and diluting procedures

- Ability to use taxonomic keys to species level
- Use of microscope
- Identify specimens to species level

Refer to Module 11: Using Algae to Assess Environmental Conditions in Wetlands.

Invertebrates

- Experience with sampling and preserving procedures
- Ability to use taxonomic keys to family level
- Use of dissecting microscope
- Identify local macroinvertebrates to family level

Refer to Module 9: Developing an Invertebrate Index of Biological Integrity for Wetlands.

Amphibians

- Knowledge of appropriate seasons for the different organisms
- Identify local frog calls
- Identify egg masses of local frogs, salamanders, and other amphibians to species level
- Experience in trapping techniques

Refer to Module 12: Using Amphibians in Bioassessments of Wetlands.

Fish

- Experience in sampling techniques appropriate to different types of fish
- Ability to use taxonomic keys to species level
- Identify local fish to species level

Birds

- Understanding of appropriate monitoring seasons and times of day

- Identify bird calls
- Ability to use bird identification keys
- Identify local birds to species level

Refer to “Birds as Indicators”

Reptiles

- Understanding of appropriate monitoring season and habitat
 - Identify eggs to species level
 - Experience in trapping methods
 - Ability to use identification keys
 - Identify reptiles to species level

Not all volunteers will be proficient in identifying some of these biological groups to species level, even with careful training. Supervision by a specialist will be necessary for the rigor that will produce reliable, consistent data among volunteer teams. When it is not possible to train all volunteers to the desirable level of skill, volunteers can still accompany experts and act as assistants and recorders.

STUDY PLANS AND QAPPS

One of the most difficult issues facing volunteer environmental monitoring programs today is data credibility. Potential data users are often skeptical about volunteer data — they may have doubts about the goals and objectives of the project, about how volunteers were trained, about how samples were collected, handled and stored, or about how data were analyzed and reports written. A key tool in breaking down this barrier of skepticism is the quality assurance project plan. Geoffrey H. Grubbs, Director, Office of Science and Technology, U.S. EPA

Refer to Module 4: Study Design for Monitoring Wetlands.

WHO IS RESPONSIBLE?

If volunteers are to work under the supervision of agency biomonitorers, the agency itself is responsible for the study design and the preparation of the QAPP. The QAPP must include the measures that will be taken to train, supervise, and control the quality of work performed by volunteers.

If, however, a volunteer organization such as a watershed association has been awarded a grant to perform biomonitoring aimed at producing data suitable for agency use, designing the study and preparing the written QAPP is the responsibility of that organization. No biomonitoring is to be done until the funding agency has reviewed the submitted QAPP.

RESOURCES TO ASSIST VOLUNTEERS

Volunteer organizations often feel they do not have the expertise to produce a study design and QAPP that will meet the rigorous standards of their funding agency. USEPA has provided a set of guidelines for producing a volunteer monitor’s QAPP that meets their requirements (Hunt et al. 1996). This guide is available free from EPA on request. Unfortunately, State agencies frequently have QAPP standards and formatting requirements that vary from EPA’s, and rarely have these agencies produced similar guidelines for volunteers.

The Fall 1992 issue of *The Volunteer Monitor* covers the topics of volunteer study design and QAPP preparation. Many volunteer organizations have also structured their own guidelines. The Volunteer Environmental Monitoring Network (VEMN), with assistance from River Watch Network, produced a Study Design Workbook (Dates et al. 1997). VEMN holds workshops for volun-

teers and the participants leave with a draft study design for their specific project. They are advised to seek assistance from their funding agency, whether Federal or State, in the construction of the required QAPP.

During the process of writing the QAPP, specific protocols should be specified, e.g., the degree of precision in identification of organisms—order, family, genus, or species—must be established. Plants, fish, amphibians, and birds are usually identified to species level. Invertebrates and algae are more difficult to identify to the species level and a fully trained and experienced taxonomic expert is usually assigned that task. Volunteers can be trained to identify to order level, and even to family level with appropriate and simple keys. However, the accuracy of their work does need to be tested. This can be done in a number of ways: through a voucher collection that can be verified by an expert taxonomist; or having an expert taxonomist randomly select 10%–20% of the archived samples to verify the accuracy of the identification and enumeration.

Design and maintain a volunteer database for every biomonitoring project to include name, mailing address, phone contact, e-mail address, allocated tasks, and allocated sites, and hold a sample signature on record. Ensure every volunteer has full contact details for their project leader/s, and advise them of any alterations. These precautionary measures will provide a means of quick exchange if any serious questions arise or scheduling needs to be altered.

DATA GENERATION, ANALYSIS, AND REPORTING

Agency specialists frequently conduct parallel testing to identify problems and ensure data is sufficiently reliable for regulatory uses.

Of prime importance is the level of accuracy required for the goals of the project. For example, a group that is monitoring for educational purposes or performing the first screening assessment of wetland condition does not need as high a level of data quality as a group that is generating data for a state 305(b) assessment report (Dilley 1991, Ely 1997, Hannaford and Resh 1995, Penrose 1995, Setzer 1997).

In general, agency staffs use the raw data provided by volunteer monitors to generate a thorough data analysis for incorporation into government reports. However volunteers are not automatically eliminated from these processes, and several volunteer manuals provide suitable guidelines for data analysis and report writing (Schoen et al. 1999, Laughlin and Rosselli 1994). Analytical methods for use by volunteers should be designed to reflect state-of-the-art science (e.g., the multimetric approach), but still be applicable at the nonprofessional level. Volunteer monitoring program managers should carefully assess the information needs of the agencies and/or individuals who will use the data. Only volunteers capable of data analysis and report writing should be selected to perform these demanding tasks, and they should work in close coordination with the agency staff member in charge of the project.

All environmental data measurements and analysis procedures should be well documented and be covered by the QAPP.

RECOMMENDATIONS

The following summarized recommendations have been drawn from a large number of sources, particularly Miller et al. 1996, and the quarterly EPA journal *Volunteer Monitor*. Many volunteer coordinators and Agency scientists provided valuable comments at conferences based on their

personal experiences in training and supervising volunteers.

- Develop a selection process for volunteer recruiting. An application process tied to the study plan will help ensure volunteers meet relevant requirements. This may take the form of proficiency testing upon the completion of training.
- Outline the study objectives and design to the volunteers, and explain their role in achieving overall study goals.
- Match volunteers with the types of tasks for which they are best suited.
- Try to meet the scheduling needs of the volunteers as closely as possible.
- When there is a mismatch between a project and a volunteer, it is OK to advise that particular volunteer their assistance will not be required in the future.
- State short-term volunteer goals, outline responsibilities, and specify time requirements at the onset of a program.
- Set realistic expectations for fieldwork and other activities. Ensure these expectations are outlined to all involved and adhered to throughout a project.
- Establish safety guidelines and legal liability requirements at the outset of a volunteer program.
- Provide regular training programs using appropriate protocols.
- Use piloted and peer-reviewed volunteer manuals and ensure that the protocol will relate to the goals of the project.
- Apply the appropriate level of training for the desired rigor of data (QA/QC and testing).
- Have clearly written instructions on procedures to be conducted in the field, laboratory, data entry, etc., and be explicit when giving instructions.

- Conduct routine and comprehensive monitoring overview.
- Have a system of collecting data in a set reasonable time frame.
- Validate volunteer data through technical assessments and parallel studies.
- Provide feedback, updates, and rewards to volunteers.
- Give volunteers the same respect as proficient paid staff.

CASE STUDIES

The case study summarized below provides an illustration of the application of many of the principles covered by this module. The table that follows lists, with a brief description, a number of other existing volunteer biomonitoring programs being conducted at the Federal and State agency level. The EPA journal *Volunteer Monitor* reports on many case studies of volunteer biomonitoring programs, many of which provide data useful to government agencies.

WHAT (WETLAND HEALTH ASSESSMENT TOOLBOX) PROJECT

Also reported by Eleanor Ely (2000). *Volunteer Monitor* 12(2):14-15.

Under the sponsorship of EPA's Wetlands Division, a pilot volunteer program for estuarine salt marsh health assessment was developed and implemented on the North Shore of Massachusetts in 1999. This involved formation of a partnership among Massachusetts Coastal Zone Management, Mass Bays Program, University of Massachusetts Cooperative Extension Service, and two citizens' water protection nonprofit organizations, Salem Sound 2000 and Eight Towns and the Bay.

The major goals of the project were to establish an estuarine salt marsh assessment training program for volunteers, and implement volunteer monitoring programs throughout New England that would:

- Provide high-quality data for assessing estuarine salt marsh health
- Evaluate the success of restoration/creation projects
- Improve local wetland protection efforts and stewardship
- Assist with state program efforts for salt marsh management and protection

This project contains six components of salt marsh assessment—the nonbiological tools of water chemistry, land use, and tidal influence; and the biological tools of vegetation, invertebrates, and birds. The training protocols were developed by the specialist scientists, Bruce Carlisle (MCZM), Jan Smith (MBP), and Anna Hicks (UMass Extension). A coordinator/technician, Vivian Kooken, was hired to administer the training program; to purchase equipment; to roster, facilitate, and supervise volunteer activities; and to manage volunteer data.

In the first year, 46 volunteers and volunteer leaders participated in the training program, which consisted of 6 individual workshops, one for each of the assessment procedures. The workshops were held at different times so that volunteers could choose to attend more than one, and the respective specialist scientists provided instruction. On completion of their training the volunteers monitored four estuarine marsh sites, three of which were impacted by tidal restrictions and the fourth by intensive urban development. Each of the four project sites had a corresponding reference site that represented the “best obtainable” condition for the area.

A parallel test (comparing volunteer results with scientists’ results) was conducted during the monitoring season to help evaluate the success of the

training program and to help the scientists improve their training protocols. Issues arising from the parallel testing and the volunteer evaluation sheets were mostly centered on difficulties the volunteers had with identification of invertebrates and birds. Another problem was the lower number of organisms sampled by volunteers compared with the scientists, possibly because of their less rigorous sampling techniques. Nevertheless, when the metrics arising from volunteer data were compared with those arising from the scientists’ data, there was encouraging similarity.

A followup meeting with the volunteers and the scientists was arranged after the monitoring was concluded and the data had been analyzed. The agenda was mostly social. The volunteers were presented with certificates of achievement, T-shirts, and a pizza dinner. A part of the meeting was set aside for a report on the results of the volunteer monitoring, and an open discussion session to share experiences and generate suggestions for improvements.

The lessons learned in 1999 were transferred to a successful repeat of the whole program in 2000. The Department of Environmental Management has since modified some of the tidal restrictions. The volunteers are now collecting data to measure the effect over time of the mitigation efforts. Based on the WHAT project’s successful history, funding has been established through the Jessie B. Cox Charitable Trust for 2 more years. The training protocols for each of the assessment tools are currently being revised in readiness for publication in 2001.

For further information on the WHAT program, contact Vivian Kooken at Salem Sound 2000, 201 Washington Street, Suite 9, Salem, MA 01970, phone 978-741-7900, e-mail vivian.kooken@salemsound.org.

Table 2 lists Federal and State agencies involved in volunteer biomonitoring.

Table 3 categorizes the various tasks for an integrated biomonitoring project, with the recommended suitable roles of volunteers and supervising professional scientists. The foundations for this table were

laid during the pilot phase of two programs, the WHAT Toolbox outlined in the case study, and the Wells National Estuarine Research Reserve project reported by Neckles and Dionne (2000).

TABLE 2: EXISTING VOLUNTEER BIOMONITORING AT THE FEDERAL AND STATE AGENCY LEVELS

| AGENCY | PROJECT | VOLUNTEER INVOLVEMENT |
|---|--|--|
| Minnesota Pollution Control Agency Judy Helgen 651-296 -7240 judy.helgen@pca.state.mn.us Mark Gernes 651-297-3363 mark.gernes@pca.state.mn.us | Minnesota's Wetland Evaluation Project - Dakota County | Trained volunteers to sample, sort, identify, and complete metric data sheets for freshwater depressional wetlands invertebrates and plants |
| Massachusetts Coastal Zone Management and Mass Bays Program, University of Massachusetts Bruce Carlisle 617-626-1205 Bruce.Carlisle@state.ma.us Jan Smith 617-626-1231 Jan.Smith@state.ma.us Anna Hicks 413-545-1884 ahicks@umext.umass.edu | Wetland Health Assessment Toolbox -North Shore region of Massachusetts | Trained volunteers to monitor plants, birds, and invertebrates in estuarine salt marshes of the North Shore Region of Massachusetts |
| Massachusetts Audubon Society Elizabeth Colburn 781-259-9506 Leo Kenney 617-942-9135 vernalpool@whale.simmons.edu | Certified: A Citizen's Step-by-Step Guide to Protecting Vernal Pools | Reading Memorial High School Students sample for fairy shrimp and findings support the State certification of vernal pools |
| Illinois Department of Natural Resource's Eco Watch Network Michael Jeffords 217-333-5986 | EcoWatch Network | Statewide citizen volunteer monitoring program that includes wetland macroinvertebrates, vegetation, and wetland zones |
| Maryland Department of the Environment Chirsti Noble 410-631-8904 | Mitigation Banking | Program to train citizens to monitor mitigation sites. Their manual includes methods for monitoring vegetation density, hydrology, and soils |
| Georgia Environmental Protection Division Michele Droszcz 404-656-0099 | Adopt-A-Wetland | A pilot program for volunteers. Level 1 is simple observational monitoring 4 times a year; levels 2 and 3 are yet to be developed |
| U.S. EPA's Wetland Research Program Mary Kentula 541-754-4478 kentula@mail.cor.epa.gov | Citizen Science: The Oregon Wetlands Study | Science teachers participate in a large-scale monitoring effort paying particular attention to vegetation |
| King County Department of Natural Resources, Seattle, WA Klaus Richter 206-205-5622 klaus.richter@metrokc.gov Elissa Ostergaard 206-296-1911 elissa.ostergaard@metrokc.gov | King County Wetland-Breeding Amphibian Monitoring Program | Trained volunteers counted amphibian eggs, juveniles, and adults in freshwater palustrine wetland in King County, WA |

**TABLE 3: ROLES OF VOLUNTEERS AND PROFESSIONAL SCIENTISTS
IN A COOPERATIVE MONITORING PROGRAM**

| CATEGORY | VOLUNTEER | VOLUNTEER + PROFESSIONAL | PROFESSIONAL + VOLUNTEER |
|--|-----------|-----------------------------|-----------------------------|
| Land Use | | | |
| Preparation of base maps | | | X |
| Obtaining aerial photographs | | | X |
| Delineating zones of influence | | X | |
| Mapping land uses | | X | |
| Field works conducting Land Use Index of Rapid Assessment | X | | |
| Calculation of wetland evaluation area (WEA) | | X | |
| Calculation of land-use coefficients | | X | |
| Calculation of Land Use Index | | X | |
| Tidal Influence | | | |
| a. Reference mark technique | | | |
| Establishing benchmark | | X | |
| Recording readings | X | | |
| b. Staff gauge technique | | | |
| Installing gauges | | X | |
| Recording readings | X | | |
| Data analysis and tidal range ratio | | X | |
| Water Chemistry | | | |
| a. Ambient water quality for invertebrates with YSI multimeter calibration | | | X |
| Monitoring | | X | |
| Recording | X | | |
| b. Salinity | | | |
| Establishing transects | | X | |
| Constructing wells | | X | |
| Installation of wells | | X | |
| Monitoring and recording | X | | |
| Avifauna | | | |
| Species identification | | X | |
| Behavior observations | | X | |
| Recording | X | | |
| Data analysis to Avifauna Index | | X | |
| Vegetation | | | |
| Establishing transects | | X | |
| Selection of subunit transects | X | | |
| Laying of quadrates | X | | |
| Plant identification to genus & species | | X | |
| Abundance and cover estimates | X | | |
| Recording | X | | |
| Data Analysis to Index of Vegetation Integrity | | X | |

TABLE 3 (CONTINUED)

| CATEGORY | VOLUNTEER | VOLUNTEER +PROFESSIONAL | PROFESSIONAL +VOLUNTEER |
|---|-----------|----------------------------|----------------------------|
| Invertebrates | | | |
| Habitat assessment | | X | |
| Siting of sampling locations | | X | |
| Recording of field conditions | X | | |
| Sampling and preservation | | X | |
| Sorting | | X | |
| Identification to order level | | X | |
| Identification to family level | | | X |
| Counting and recording | X | | |
| Data Analysis to Invertebrate Community Index | | | X |

REFERENCES

- Bryne RR, Dionne M, Cook RA, Jones J. 1997. Maine Citizens Guide to Evaluating, Restoring, and Managing Tidal Marshes. Maine Audubon Society, Falmouth, ME.
- Colburn EA. 1997. Certified: A Citizen's Step-by-Step Guide to Protecting Vernal Pools. Massachusetts Audubon Society, Lincoln, MA.
- Dates G, Lehrer A, Schoen J, McVoy R. 1997. Merrimack River Watershed Study Design Workbook. The Volunteer Environmental Monitoring Network, C/- Merrimack River Watershed Council, Lawrence, MA.
- Dates GA, Schloss J. 1998. Data to Information: A Guide Book for Coastal Volunteer Water Quality Monitoring Groups in New Hampshire and Maine. University of Maine Cooperative Extension and University of Maine/New Hampshire Sea Grant Extension.
- Dilly MA. 1991. A Comparison of the Results of a Volunteer Stream Quality Monitoring Program and the Ohio EPA's Biological Indices. In: Simon TP, Davis WS, eds. Proceedings of the 1991 Midwest Pollution Control Biologists Meeting. Environmental Indicators: Measurement and Assessment Endpoints.
- Dohner E, Markowitz A, Barbour M, Simpson J, Byrne J, Dates G, Mayo A. Volunteer Stream Monitoring: A Methods Manual. Office of Water, U.S. Environmental Protection Agency, Washington, DC. EPA 841-B-97-003.
- Ellett K, Mayo A. 1990. Volunteer Water Monitoring: A Guide for State Managers. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. EPA 440/4-90-010.
- Ely E. 1992. Training and Testing Volunteers. Volunteer Monitor 4(2):3-4
- Ely E. 1996. Are You Covered? Volunteer Monitor 8(1):22-23.
- Ely E. 1997. Parallel Testing – Volunteers Versus Professionals. Volunteer Monitor 9(1):16-19.
- Ely E, Hamingson E. 1998. National Directory of Volunteer Environmental Monitoring Programs. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds.
- Firehock K, Graff L, Middleton JV, Starinchak KD, Williams C. 1998. Handbook for Wetlands Conservation and Sustainability. Izaak Walton League of America, Gaithersburg, MD.
- Firehock K, West J. 1995. A brief history of volunteer biological water monitoring using macroinvertebrates. J North Am Benthol Soc 14(1):197-202.
- Gernes M. 1998. Wetland Vegetation Method for Wetland Evaluation, Draft Guidance on Sampling, Biological Metrics and Identification of Wetland Vegetation for Citizen Teams.
- Hannaford MJ, Resh VH. 1995. Variability in macroinvertebrate rapid-bioassessment surveys and habitat assessments in a northern California stream. J North Am Benthol Soc 14(3):430-439.
- Helgen J. 1998. Wetland Invertebrate Method for Wetland Evaluation, Draft Guidance on Sampling and Identifications of Wetland Invertebrates for Training Citizen Teams. Minnesota Pollution Control Agency and Minnesota Audubon Council.
- Hicks AL. 2001. Draft. New England Estuaries Invertebrate Biomonitoring Protocol. Massachusetts Coastal Zone Management, Boston, MA.
- Hicks AL, Nedeau E. 2000. New England Freshwater Wetlands Invertebrate Biomonitoring Protocol. Massachusetts Coastal Zone Management Boston, UMass Extension's NREC Program, University of Massachusetts, Amherst, MA.
- Hunt M, Mayo A, Brossman M, Markowitz A. 1996. The Volunteer Monitor's Guide to Quality Assurance Project Plans. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds.
- Laughlin L, Rosselli H. 1994. Water Quality Monitoring: Data to Action. Long Island Sound Taskforce, Stamford, CT.
- Jackson S. 1998. Massachusetts Calling Amphibian Survey. North American Amphibian Monitoring Program: Procedures and Protocols. UMass Extension's NREC Program, University of Massachusetts, Amherst, MA.

- Kaynor S. 1997. Bridge Builder: A Guide for Watershed Partnerships. Facilitator's Handbook. Conservation Technology Information Center, Lafayette, IN.
- Kenney LP, Burne MR. 2000. A Field Guide to the Animals of Vernal Pools. Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program, Vernal Pools Association. Westborough, MA.
- Madison S, Paly M. 1994. A World in Our Backyard: A Wetlands Education and Stewardship Program. New England Interstate Water Pollution Control Commission. Lowell, MA.
- Martin J. 1999. Learning Science Through Restoration. *Volunteer Monitor* 11(1):22.
- Mayio A, Hunt M, Brossman M, Markowitz A. 1996. The Volunteer Monitor's Guide to Quality Assurance Project Plans. Office of Wetlands, Oceans and Watersheds, Washington, DC.
- Miller T, Bertolotto C, Martin J, Storm L. 1996. Monitoring Wetlands: A Manual for Training Volunteers. Adopt a Beach, Seattle, WA.
- Neckles HA, Dionne M (eds). 2000. Regional Standards to Identify and Evaluate Tidal Wetland Restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME.
- Penrose D. 1995. Volunteer monitoring of benthic macroinvertebrates: regulatory biologists' perspectives. *J North Am Benthol Soc* 14(1):203-209.
- Riverways Newsletter. Fall 1999. A publication of the Riverways Program, Department of Fisheries, Wildlife & Environmental Law Enforcement, MA.
- Setzer W. 1997. Tips for Statistical Analyses of Parallel Studies. *Volunteer Monitor* 9(1):16-20.
- Schoen J, Walk M-L, Tremblay ML. 1999. Ready, Set, Present! A data presentation manual for volunteer water quality monitoring groups. Massachusetts Water Watch Partnership, University of Massachusetts, Amherst, MA.
- Volunteer Estuary Monitoring: A Methods Manual. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC.
- Volunteer Lake Monitoring: A Methods Manual. U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington, DC.
- Volunteer Monitor. Fall 2000. Topic: Monitoring Flora.
- Volunteer Monitor. Spring 2000. Topic: Monitoring Fauna.
- Volunteer Monitor. Fall 1999. Topic: Youth Projects.
- Volunteer Monitor. Spring 1998. Topic: Monitoring Wetlands.
- Volunteer Monitor. Fall 1992. Topic: Building Credibility.
- Volunteer Monitor. Fall 1991. Topic: Biological Monitoring.