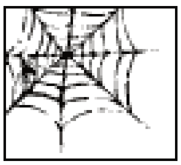
The Volunteer Monitor

The National Newsletter of Volunteer Water Quality Monitoring
Vol. 12, No. 2, Fall 2000

	Note: This information is provided for reference purposes only. Although the information provided here was accurate and current when first created, it is now outdated.

Issue Topic: Monitoring Flora

Table of Contents

The following articles appear in this edition of *The Volunteer Monitor*
(not all graphs and figures available)

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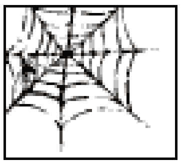
Volume 12, No. 2, Fall 2000



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Next issue

CWA, TMDLs, etc.

In our Spring 2001 issue, we'll be looking at how volunteer monitoring fits into the Clean Water Act, with special emphasis on water quality standards and TMDLs (Total Maximum Daily Loads). Have your program's data been used to help compile your state's 303(d) list (listing of impaired waters) or to develop TMDLs for a water body? Or do you have another monitoring story related to the Clean Water Act? Please contact the editor (see address below) with ideas and suggestions.

The coediting group for the Spring 2001 issue will be the Lower Colorado River Authority's Colorado River Watch Network in Austin, Texas.

About *The Volunteer Monitor*

The Volunteer Monitor is a national newsletter that facilitates the exchange of ideas, monitoring methods, and practical advice among volunteer monitoring groups.

A different volunteer monitoring program serves as coeditor for each issue. This issue was coedited by the New Hampshire Department of Environmental Services Weed Watchers program, which for over 10 years has been actively training volunteers to monitor their water bodies for exotic invasive aquatic plant species.

Reprinting material from *The Volunteer Monitor* is encouraged. Please notify the editor of your intentions, and send us a copy of your final publication.

For editorial inquiries only, contact Eleanor Ely, Editor, 50 Dartmouth St., Apt. 9, Pawtucket, RI 02860; 401-723-5151; ellieely@earthlink.net.

How to Subscribe

The Volunteer Monitor is published twice yearly. It is distributed by River Network, a national nonprofit organization working to protect and restore rivers and watersheds through active partnerships. For a free subscription, or for address changes or back issue orders, use the form on page 23 or contact River Network at 520 SW 6th Avenue, Suite 1130, Portland, OR 97204; 503-241-3506; volmon@rivernetwork.org.

The Volunteer Monitor *is also available online at www.epa.gov/owow/volunteer/vm_index.html*.

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Surveying Lake Vegetation

by Elizabeth Herron

How many times have you heard "We never had weeds there five years ago"? Or "That kind of plant has always been here"? While those statements may be true, it's awfully hard to base lake management on that type of "data." A much more effective approach is to conduct aquatic plant surveys.

A viewscope helps University of Rhode Island Watershed Watch interns Erin Gervais and Katie

Even a quick survey that simply maps the plant beds shows you where the most dense growth is located. By going a step further and identifying the plants, you can learn which species are dominant, whether invasive exotic species are present, and whether there are rare or beneficial plants that need to be protected. Armed with this information, you are in a position to determine whether the lake actually has weed problems, where the major problem areas are, and what management strategies might help solve the problems.

Wall see submerged plants.

Responding to the desire of some of our volunteer monitors to learn more about "weeds," the University of Rhode Island Watershed Watch (URIWW) program initiated an aquatic plant surveying project several years ago. The idea was to train a number of our more experienced monitors to map lake vegetation and identify common Rhode Island aquatic plants. These trained volunteers would then serve as "local experts" for other volunteers with concerns or questions regarding aquatic plants, while URIWW staff would provide assistance and support as necessary.

Our goals were to obtain baseline data on aquatic plant distribution and to find out whether surveyed lakes were affected by nonnative species such as Eurasian watermilfoil. We adapted our survey protocols from the EPA's *Volunteer Lake Monitoring: A Methods Manual* (currently out of print but available online at www.epa.gov/OWOW/monitoring/lakevm.html) and from methods developed by the New York Citizens Statewide Lake Assessment Program and the Wisconsin Department of Natural Resources Self-Help Lake Monitoring program.

Aquatic plant surveys are even more useful if they are repeated at regular intervals (annually or less frequently) to show whether plant beds are increasing in size or density or whether new species are arriving. Tracking changes over time reveals natural fluctuations, helping lake users to recognize that a weed "problem" may only be temporary and not require any intervention.

The protocol you follow for your survey largely depends on how you intend to use the data. For example, if your goal is simply to watch out for exotic species, volunteers need only be trained to look for a few specific plants.

Survey Protocols

Below is a brief description of the URIWW protocols. For a copy of our full aquatic plant survey procedures, please contact the author.

Step 1. Initial survey: Mapping plant beds. Using a viewscope to help see the plants, a volunteer paddles, cruises, or (in very shallow ponds) wades around the perimeter marking the location of emergent, submergent, floating-leaved and free-floating plant beds on a map of the lake. The depth at which emergent plants give way completely to submergents is also marked. The extent of the beds is mapped either by estimating with the help of landmarks, or by using a GPS unit. It is helpful to have two people work on this if possible: one to observe the plants and another to mark the map. If that is not possible, copying the map onto card stock or waterproof paper can be useful for dealing with the inevitable soggy-map problem.

These preliminary maps help to locate major plant beds as well as areas where there are no plants. They are used to compare with future surveys (addressing the "This is the worst weed year ever" issue) and help to identify areas for more detailed surveys (Step 2, below).

Step 2. Detailed survey: Setting transects and identifying plants. For the detailed survey, the volunteer identifies plants and estimates bed densities at a number of specific locations. Ideally you would try to survey each of the major plant beds identified on the plant bed map from Step 1, above. If that is not possible, try to concentrate on locations with more nutrients or sediments, sites of special interest, or sites where plants are more likely to cause problems (examples: inlets or outlet, boat launches, marinas, beaches).

At each selected location, establish a transect line that runs from shore out to the maximum Secchi depth, or about 3 meters deep if you don't know the Secchi depth (3 meters is the typical maximum depth of aquatic plants here in southern New England).

At three sampling points spaced at equidistant intervals along the transect line, measure the depth, then observe the plant bed to record the estimated percent coverage. Then, using a sampling rake or "weed weasel" (see drawing), collect four samples of plants. Typically you sample off the bow, stern, and each side of the boat. Place the plants into a large plastic bag, using a separate bag for each of your three sampling points.

After all the samples are collected, volunteers sort and identify the plants. This is best done on shore as it requires quite a bit of space. Sort plants into piles, one pile for each type of plant. Estimate the relative amount of each type, then identify the plant. (If our volunteers are unsure of an identification, they put the plant into a baggie for later identification by program staff).

Rick McVoy leads an aquatic plant identification workshop for lakeshore residents in eastern Massachusetts.

Equipment needed

The only really expensive equipment needed is a boat or canoe, which many volunteers already have. Other equip- ment includes a viewscope (see photo on page 1) or diving mask; a Secchi disk or weighted measuring tape to determine depth; and plant-collecting tools such as a rake or grappling hook. Optional equipment such as GPS, depth finders, or range finders can help you pinpoint locations more accurately, but require more training to use properly and are often quite expensive.

Training

The key to an effective aquatic plant training program is repetition, repetition,

repetition. People really need to see the plants and work with the keys more than once to get comfortable with them. We found that having several different people presenting the training sessions allowed information to be repeated without getting boring.

Since the best time of year to conduct an aquatic plant survey is midsummer, when most plants are flowering (flowers are a critical component for identifying some species), early summer is a good time for training. A minimum of four 2-3 hour sessions is strongly recommended. At URIWW we hold introductory sessions in the classroom to reduce distractions. At the first session, we focus on the use of aquatic plant identification keys. The next step is plant identification using live specimens in water-filled trays, which can easily occupy an entire evening. This step is crucial as many of the identification keys use terms that may not be readily understandable--for example, "whorled" or "pinnately divided."

At the next session we go out into the field. Plants often appear quite different when seen in their natural environments, with many species resembling each other. Several field sessions in different settings should be scheduled to allow for repetition and confidence building.

What we learned

In exchange for the free training URIWW volunteers received, we asked that they complete aquatic plant bed maps for several lakes, and detailed surveys for at least one of those. While the level of detail varied somewhat, the resulting information was the most comprehensive aquatic plant dataset generated in Rhode Island in the 1990s. We learned, among other things, that Eurasian watermilfoil was not present in any of the lakes surveyed. This confirmed past records which indicate that Rhode Island doesn't have that invasive species (yet). For several of the sites surveyed, records from a professional 1989/90 study existed. We found that there was a great deal of agreement between the professional and volunteer surveys. While aquatic plant beds had shifted locations, generally our volunteers had not recorded huge increases in the size of most plant beds.

We hope to conduct another aquatic plant survey in the next year or two, and especially to resurvey several key lakes. We will be adding photographs of the transect areas to the information gathered. This idea came from one of our volunteers who used a disposable panoramic camera to record the transects that she surveyed. The visual record generated at a comparatively low cost was so wonderful that that we decided to purchase similar cameras for other

Workshop attendees take a close look at aquatic plant specimens.

volunteers to use, and to make photographs a requirement for future efforts. As the public becomes more aware of the impact of invasive and nuisance species we expect that interest in aquatic plant surveying will rise, and we anticipate helping our volunteers meet that need.

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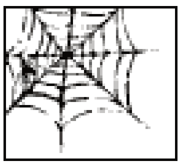

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When Are Plants a Problem?

Interview with Jeff Schloss

Jeff Schloss is a Water Resources Specialist for the University of New Hampshire (UNH) Cooperative Extension and a Research Scientist in the UNH Center for Freshwater Biology. He has coordinated the New Hampshire Lakes Lay Monitoring Program for 15 years and has advised dozens of lake groups who have had concerns about aquatic vegetation. In this interview, he shares some of his insights and experiences.

Why can lake vegetation be a controversial issue?
"Too many weeds" is a matter of people's preferences and perceptions. I've had volunteers call for help with a weed problem, and they would take me out on the lake to show me the problem and I'd say, "Tell me when we get there"--and we were there! It's all relative.

Some people may have come from a deep lake with limited shallow areas. Then they move to a lake that has weeds, and they think there is something wrong. A fisherman might look at the same lake and say, "This is the lake I want to be on."

Or sometimes people develop a shoreline that used to be shaded. They put a house up, they clear the land, they open up the sun, and all of a sudden they see more weeds.

It really comes back to conflict of use. For example, water lilies are very aesthetic, and people take pictures of them and painters paint paintings. But they might be a nuisance for someone who purchased shoreland property and expected to have a beach they could swim out from.

Water lilies are admired for their beauty--but can create navigation problems when growth is thick.

What is the value of aquatic plants?

We call these things weeds but we shouldn't. Many aquatic plants provide important habitat--hiding places for young fish, forage for bugs and fish. They stabilize shorelines and reoxygenate the water. In a well-balanced system, plants are providing lots of benefits.

How can a lake group determine if they have a weed problem?

There are two questions they need to answer. The first is, Are we seeing changes in the diversity or the extent of the plants that are normally here? And the second is, Do we have any nonnative invasive species? You really need this two-pronged approach.

To answer the first question, you need to get baseline data on the current extent of the weed beds and the major species, and then every few years revisit and look for changes: Have you gone from scattered pockets to abundant weeds? Have the beds progressed further out from shore?

To maintain a vigil against encroachment of nonnative species, many states have a separate monitoring program--for example, here in New Hampshire we have the Department of Environmental Services Weed Watchers program. [*Note:* See Weed Watchers: Standing Guard Against Exotic Invaders]

How do volunteers in the Lakes Lay Monitoring Program monitor aquatic vegetation?

For monitoring the nonnative invasives, we encourage all our volunteers to participate in the Weed Watchers Program.

For monitoring plant productivity in general, there are different levels. At the most basic level, the volunteers look for diversity--that is, do they see a good number of different types, even if they don't know what they are--and they tell us what is the most dominant plant in the stand. At the other extreme, you would classify all the plants to genus and species and map their extent.

Can you just do a quick-and-dirty tracking of bed size--"How far out does it go?"
Extent is one of the things you look for. We provide viewscopes to use with our Secchi

disks, so it's very easy for our monitors to use the viewscope to look down in the water and see how far those weed beds go out and to what depth.

You also want to look at diversity because one of the early signs of a problem, before the bed really extends itself, could be a change in dominance or a more aggressive species appearing and taking over.

And then the next level would be to pull up some of the plants and identify them?
Yes, that's the next step, and there are some good user-friendly guides out there like *Through the Looking Glass*, and manuals provided by various state agencies, that show pictures or diagrams. [*Note:* See "Resources".] And the next step past that would be to have someone who has the expertise to identify everything to genus or species.

Is it worth the effort to identify every plant?
It is if the lake group is very concerned and has the person-power. But it's a very intensive effort for the volunteer monitors to do all the sampling, and it also requires someone--whether at a sponsoring agency, or on the monitoring program staff, or at a university, or perhaps one of the volunteers--who knows how to use an identification key and identify plants.

What type of aquatic plant conditions do you consider a real problem?
As an aquatic ecologist I mainly get concerned about drastic changes in systems, especially when the species diversity changes over to more nuisance species. It can happen with weeds when we get overgrowths of nonnative, obtrusive, aggressive weeds. It can happen with algae when, instead of a nice mix, we get a changeover into more filamentous forms, or forms that can produce toxins or create scums.

When it's just an increase in the normal native plants that usually grow in that lake, I don't necessarily get very concerned. Because I find that if I look at 15-year records of lakes--not necessarily records of all the plants mapped and measured, but just the perceptions of the people who live there--some years there is an extreme amount of weed growth and some years there isn't. It suggests that there are natural cycles; that when certain variables reach an optimum condition we see an extension of weed growth, and the next year it could be gone.

How often do you see this kind of cycle or natural variability?
This happens a lot. I've gotten calls from lake residents, and we go out and all we find are the regular native species of plants that have been in the lake forever, but suddenly these plants seem to have taken over the lake and we can't explain why. And a lot of times, the next year the problem is gone.
So you would advise people not to overreact or overtreat?

It depends on what species they have. If it's a nonnative species, and it's in a limited area, then by all means you definitely want to treat it aggressively and quickly, whether by means of a drawdown, or mechanically pulling it, or applying permitted herbicides, or putting a bottom barrier on it. Because the unfortunate truth of the matter is that once a nonnative becomes established it's going to be extremely hard to eradicate it.

On the other hand, in some lakes people have reacted negatively to what I would consider a very excellent habitat species, that I would feel happy to have off my shoreland. But people who are used to a plantless system perceive it as a large threat.

We've been spoiled; we want a quick fix. I always remind people to be very careful in the treatment they select, even when we're talking about invasive nonnative species. If you remove all the plants, or if you create a disturbance in your efforts to get rid of the weeds, the first thing that is going to come back is the more aggressive weed. People use herbicides to control weeds and then wonder why they have an algal problem--or exotics--or lower dissolved oxygen, and fish kills.

In other words, treatment efforts can backfire.

Yes. Many people forget that a lot of aquatic plants reproduce two ways. They reproduce sexually, through pollen, but they also reproduce by fragmentation. People have called me up and said they were raking their beach every year and they couldn't understand why it seemed to be getting worse and worse. Well, it was getting worse every year because they were fragmenting the plants.

There needs to be an understanding that development in any watershed is going to increase weed growth, and unless the plants are intrusive nonnative species they might not be a bad thing because they are buffering or absorbing some of the new nutrients coming into the system, so you don't get greener waters or algal blooms.

This Florida lake is choked with excessive growth of several types of plants.

Excessive plant growth is not a disease but a symptom--a symptom of nutrients in the water. If you remove one symptom you'll get another. As long as nutrients are high something will use them; if you get rid of weeds you may end up with algal blooms, scums, or mats. In most cases you probably would prefer increases in native vegetation rather than more algae. Do you get upset because you're stepping on squishy little green things or do you get upset because you can't see your toes?

Do algae respond more to nutrients than plants do?

Well, certainly algae in the water are going to be more closely tied to nutrients because they don't root--they're working with whatever is out there in the water.

Do algae have benefits?

Algae aren't bad, it's just that excessive amounts of algae are bad, and the response to nutrient loading is worse on the algal side than on the plant side--you often get that shift over to nuisance algal species.

Algae have lots of benefits. They are the basis of the food web. But usually we don't need to worry about not having enough algae. Ultra-pristine systems are the only case where you might not find enough algal productivity to maintain a diverse and healthy fishery.

Which algae tend to be nuisance algae?

The blue-greens (actually they are now classified as bacteria--cyanobacteria--but we still tend to call them by their old name of blue-green algae) create forms that are more colonial and filamentous and have mucous covering; some of them even produce toxins. Blue-greens as well as some other algae can create taste and odor problems in drinking water and fish.

Do volunteers monitor algae?

There are some coastal programs that monitor for toxic algae, as mentioned in previous issues of *The Volunteer Monitor* [*Note:* See Fall 1998 and Spring 2000 issues], but they are just looking for particular species that are related to "red tides."

Apart from that, not many volunteer groups attempt to identify algae or do cell counts. There are a lot more different types of algae than plants that can be in a system, and identification often requires expensive microscopes and can be very time-consuming. This is not a problem, though, because we usually don't need to know the exact species of algae; we tend to be more concerned with the level of algae--i.e., how green the water is. To determine the level of algae, many volunteer programs test chlorophyll a concentration, which gives an estimate of algal biomass.

Do other parameters that volunteers measure, like Secchi depth or nutrients, help in monitoring plants?

Those can play a big role in understanding the cycles of plant growth. For example, if there is improvement in Secchi disk depth, then we might expect to see a little more extent of the weed beds. If nutrients are going up, that could explain why this year there are more weed problems than in other years. On the other hand, if the nutrients cause a big increase in algae, the algae might shade the water more and limit plant growth.

Why do we hear so much about nuisance plants in lakes, but not in estuaries or wetlands?

Sometimes we look at lakes only for our recreational purposes, not really the system as a whole. In communities around estuaries there are typically people whose livelihoods depend upon healthy aquatic plant systems. The fishermen know that the marshes are the nurseries for finfish and shrimp; scallopers know the importance of eelgrass. So there is more understanding of the system.

Of course, people who live around estuaries and tidal wetlands are concerned about the invasion of aggressive nonnative species like reedgrass (Phragmites) and purple loosestrife that have minimal habitat value.

Any final comments?

I've been taking the ecologist point of view here--what should be in the system, when should we be concerned. It's justifiable for people who purchase a piece of shoreland property to have some concerns about limitations to their use--and, of course, we always need to be vigilant about the spread of nonnative species. But I think that if people had a better understanding of how the lake system functions, and what plants are natural in that system, they would not have as many concerns.

Jeff Schloss *may be reached at UNH Cooperative Extension, 224 Nesmith Hall, 131 Main St., Durham, NH 03824; 603-862-3848; jeff.schloss@unh.edu.*

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Resources for Plant Monitoring

Locally produced guides: For good, inexpensive (or free) guides to local aquatic plants, your state environmental agency is often the best place to start. Many states have produced easy-to-use keys or guides, often including color photos, of the major native and invasive species for their region.

Borman, Susan; Robert Korth; and Jo Temte. 1997. *Through the Looking Glass ... A Field Guide to Aquatic Plants.* Stevens Point, WI: Wisconsin Lakes Partnership. 248 pages. A beautiful book with large, detailed drawings (several of which are reproduced in this newsletter). Text is written for the layperson and includes helpful discussions of similar-looking species. Focuses on plants found in Wisconsin, but most are widely distributed. Order from Wisconsin Lakes Partnership, 715-346-3424. $20.

The Center for Aquatic and Invasive Plants at the University of Florida Institute of Food and Agricultural Studies provides many helpful resources, including books and videos; plant "identification decks" (sets of laminated color photos of plants, bound together by a metal fastener); collections of line drawings of aquatic plants (some are reproduced in this newsletter); and a database of scientific literature related to aquatic plants. For more information visit http://plants.ifas.ufl.edu/ EXIT EPA or call 352-392-1799 to order the free catalog.

Magee, Dennis W. 1981. *Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast.* Amherst: University of Massachusetts Press. A good beginner's guide. 245 pages.

Prescott, G. W. 1980. *How to Know the Aquatic Plants,* 2nd edition. Dubuque, IA: William C. Brown Company. Good intermediate-level guide.

Tiner, Ralph W. 1993. *Field Guide to Coastal Wetland Plants of the Southeastern United States.* Amherst: University of Massachusetts Press. Intermediate-level; organized by type of plant. 328 pages.

Crow, Garrett and C. Barre Hellquist. 2000. *Aquatic and Wetland Plants of Northeastern North America*. Madison: University of Wisconsin Press. This revised, enlarged edition of Fassett's classic 1957 manual (now out of print) is comprehensive (nearly 900 pages in two volumes), fairly technical, and extraordinarily detailed--with a price to match.

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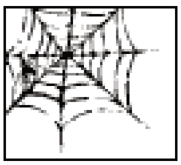

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Upcoming Events

Estuary Monitoring Workshops
Since 1994, the Environmental Protection Agency's Oceans and Coastal Protection Division has offered free training workshops for leaders of volunteer estuary monitoring programs. In winter/spring 2001, workshops are being held in Thibodaux, LA (January 25-26); Surrey, British Columbia (February 26-27); and Tijuana, Mexico (March 15-16).

The two-day workshops are presented in partnership with the Center for Marine Conservation (CMC). Day 1 focuses on methods, equipment, quality assurance, and data analysis. Topics for Day 2 include publicity, fundraising, and forming partnerships.

Participants are selected on a first-come, first-served basis, with priority given to local non-governmental organizations. Limited travel reimbursement is available. For further information, contact either Ron Ohrel or Laura Titulaer at CMC, 757-496-0920, rohrel@vacmc.org or ltitulaer@vacmc.org; or Joe Hall at EPA, 202-260-9082, hall.joe@epa.gov.

Coastal Monitoring Symposium
The EMAP Coastal Symposium 2001 is scheduled for April 24-27, 2001, in Pensacola Beach, Florida. While not specifically geared toward volunteers, this free symposium includes some sessions that may be relevant to volunteer monitors, especially those in coastal areas. Check the EMAP Website at www.epa.gov/emap/ for more information.

River Cleanup Week

The 10th National River Cleanup Week will be held May 12-19, 2001. For more information, or to register your group and receive free materials, call 865-558-3595 or visit www.americaoutdoors.org.

Secchi Dip-In

The Great North American Secchi Dip-In will be held June 30-July 15, 2001. This annual event produces a snapshot of transparency in water bodies across North America. The Dip-In is open to any program that measures turbidity or transparency, whether on a river, lake, or estuary. For more information, and to register your group to participate, visit http://dipin.kent.edu/.

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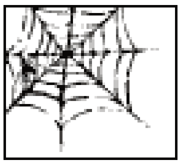	Note: This information is provided for reference purposes only. Although the information provided here was accurate and current when first created, it is now outdated.

Why Monitor Aquatic Vegetation?

by Scott Kishbaugh

A weed is a weed is a weed . . . or is it? Plants residing under water or along the fringes of streams, ponds, and lakes have a multitude of identities. For frightened young fish, they mean shelter from predator peril. For frogs and backswimmers, they mean floats for life and leisure. And for minnows to moose to manatees, they mean food, from the smallest alga to the soggiest lily.

The scientist may call them macrophytes, though weed whackers define that as the size of their fight. The frustrated layperson calls them seaweeds, whether they reside by land or in the sea. Other folks hold aquatic plants in shrouded reverence, marveling at the gentle swell of the purple bladderwort or the primitive majesty of the horsetail. Any or all of these people may want to conduct an aquatic plant survey, though most likely not for the same reasons.

Here at the New York Citizens Statewide Lake Assessment Program (CSLAP), I've found that the public and the sponsoring agency (New York State Department of Environmental Conservation, or NYS DEC) have slightly different motives for wanting to know about the quantity and identity of plants in lakes. The lay monitors tend to focus most on the concerns of "their" specific lake. Meanwhile the agency, charged with gazing into the crystal ball, takes a broader view, looking for regional or statewide trends and patterns. Fortunately the two sets of objectives dovetail nicely, so the volunteers' data are equally useful to both monitor and manager.

Monitors' objectives

First let's take a look at some of the lay monitors' major reasons for monitoring aquatic plants:

Volunteer Joann Figueras identifies aquatic plants from a Cape Cod pond.

1. To Get Rid of Them. For those samplers to whom weed is a four-letter word, proper plant identification is necessary to pick the "poison"--herbicides, mechanical harvesting, lake drawdown, etc.--for each plant species reacts differently to these treatments. For example, when CSLAP monitors from the Otter Lake Association discovered that their biggest problems were bladderwort and naiad, several favored control strategies dropped out of favor (see sidebar).

2. To Get Rid of Them NOW. Early detection and identification of pioneering plant invasions can be very effective at stopping, or at least delaying, the spread of exotic plants. Volunteers engaged in various "weed watcher" programs throughout the country vigilantly identify and hand-harvest individual milfoil plants or small beds of water chestnut before they have an opportunity to expand.

3. Looking for Mr. Goodplant. Even if weed worries provide the impetus for monitoring plants, the survey often uncovers the presence of ecologically beneficial plants (eelgrass, elodea, Sago pondweed) or rare and endangered plants that need protection.

Volunteers at the Spring Lake Association began monitoring and identifying plants when many local residents were concerned that an outbreak of new weeds signaled a threat to the health of their lake. This monitoring prior to applying control measures, rather than after the fact, proved fortuitous when these plants were identified as *Potamogeton amplifolius* (bass weed), which provides important habitat and food for fish, snails, and ducks.

4. Take Heed of Weeds. Aquatic plant populations often fluctuate for seemingly mysterious reasons, usually signifying nothing more sinister than natural variability. However, sometimes shifts in aquatic plant communities are more foreboding, warning of problems in an aquatic ecosystem. A shift from reeds and rushes to lilies and cattails can indicate increased loading of organic matter or nutrients to a lake, even though the plants themselves may not represent a problem. The appearance of exotic plants may signal an increase in lake usage by "alien" boats.

Program managers' objectives

For agencies or researchers who manage monitoring programs, data from volunteers' aquatic plant surveys are valuable in helping to answer questions like the following:

A participant in the University of Florida's Youth Aquatic Education Program in Gainesville examines a specimen of frog's bit *(Limnobium spongia).*

1. How Did It Get There? Agencies are often responsible for tracking the spread and range of invasive exotics, from zebra mussels to pesky weeds. Volunteer data documenting both the location of these exotics and the characteristics of "violated" waters (access, boat use, water flow and quality, proximity to other infected waters) provide insight on the how and why of these invasions. For many of the lakes on New York's state list of known infected waters, volunteers provided the first evidence or confirmation of the presence of exotic plants.

2. How Can We Keep It There? Agencies are also charged with protecting rare and endangered species. Volunteer monitoring can discover these plants, showing the agencies where protection efforts are needed.

3. Did It Work? Volunteer and agency alike are very interested in evaluating the effects of plant management efforts. Relatively simple plant coverage surveys generated by CSLAP volunteers have helped New York's DEC assess present management strategies and fine-tune future activities. For example, volunteers vigilantly track seasonal and annual changes in aquatic plant populations at Snyders Lake and Burden Lake, two lakes treated with recently permitted aquatic herbicides. This information is very useful in evaluating the efficacy of these herbicides.

4. Who Made the List? State water quality lists include water bodies for which recreational uses are impacted by aquatic plants. However, these impacts are not easily assessed through traditional agency monitoring programs. User perception surveys conducted by CSLAP volunteers help show connections between recreational impacts and aquatic plants--information that plays an important role in moving water bodies onto or off of these lists.

These are but a few of the reasons why volunteers monitor aquatic plants. For whether heralded for their beauty or cursed for their tenacity, aquatic plants are at once perhaps the most visible and least understood part of our aquatic environment and thus are increasingly the focus of lay monitoring programs.

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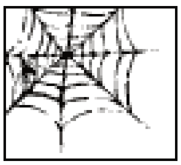

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Otter Lake: Plant Survey Guides Treatment Choice

In selecting the best treatment for a nuisance weed problem, it pays to look before you leap. For the Otter Lake Association, learning exactly which plant species were responsible for problems in their lake allowed them to avoid several potential treatments that actually could have made the problem worse.

Otter Lake is a quiet, relatively shallow, 125-acre lake in the southwestern Adirondack region of New York State. In recent years, residents' complaints about nuisance plant growth prompted the Otter Lake volunteer monitors from the New York Citizens Statewide Lake Assessment Program (CSLAP) to take action. Together with representatives of the state Department of Environmental Conservation, the citizens conducted a lakewide plant survey which revealed that the majority of the complaints about nuisance weeds centered on *Utricularia* species (bladderwort) and, to a lesser extent, *Najas* species (commonly called water naiads, bushy pondweed, or, more poetically, water nymphs).

With this information in hand, Association members ruled out several possible control strategies. A drawdown was probably the least expensive option under consideration, and it would have been practical because Otter Lake's water level could be manipulated with a dam. However, it would be the wrong way to solve a naiad problem. A drawdown can actually select for naiads, whose seeds are able to survive the icy, desiccating environment resulting from a winter drawdown. The next summer, naiads are liable to come back as a far more significant problem than before.

Mechanical harvesting would also be likely to make the problem worse by dislodging bladderwort (a poorly rooted plant) and spreading it to new areas of the lake. The surveys had shown that the plant growth was too dense and extensive to be effectively controlled by "local" management strategies such as hand-harvesting or benthic barriers. Finally, herbicides were not a viable option because none of the herbicides registered for use in New York State are selective for bladderwort (and in any case, most selective herbicides require a long contact time, whereas Otter Lake has a relative short flow-through time).

Having rejected most other options, Otter Lake Association members concluded that a grass carp stocking would likely be the most effective means for controlling this nuisance plant problem. This story does not (yet) have a happy ending, for a long permitting process has unfortunately delayed the stocking of grass carp. But despite this setback, the plant surveying was still very beneficial because it steered the Association in the direction of strategies with a greater likelihood of success and away from activities that could have exacerbated the problem and/or emptied the pockets of lakefront residents.

--*Scott Kishbaugh*

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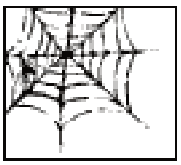

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Homemade Plant Monitoring Tools

Looking Beneath the Surface

A Plexiglas-bottomed viewing tube or viewscope eliminates surface glare and choppiness, making it much easier to observe submerged plants. (This device is also widely used for reading Secchi disk depth.) Viewscopes are available from equipment suppliers such as LaMotte Company (800-344-3100) and Lawrence Enterprises (207-276-5746).

Several volunteer monitoring programs save money by making their own viewscopes. The New Hampshire Lakes Lay Monitoring Program uses a scope made from a 2- to 3-foot length of lightweight, 4-inch-diameter PVC pipe (described in *The Volunteer Monitor*, Fall 1991 issue).

Volunteers with Vermont's Lay Monitoring Program and Milfoil Watchers Program use a "Stangel scope," which provides a larger viewing area than conventional viewscopes. Designed by Vermont Department of Environmental Conservation (VT DEC) biologist Peter Stangel, the Stangel scope is made from two 5-gallon plastic buckets painted black on the inside and screwed together top-to-top. A Plexiglas "window" is installed in a hole cut in the bottom of one bucket, and a face hole is cut at the other end of the scope. Foam padding around the face hole seals out light. (A shorter model can be made from a single bucket with a lid.) For more detailed instructions, contact Ann Bove at VT DEC, 802-241-3777; annbo@dec.anr.state.vt.us.

Plant Sampling Rake

Staff at the Massachusetts Department of Environmental Protection (MA DEP) use this homemade double-sided throwing rake (which they have affectionately dubbed a "weed weasel") to collect submerged plant samples for identification. Volunteer monitors with Massachusetts Water Watch Partnership also use this handy tool.

"The weed weasel is far superior to the grappling hook we used to use," says Rick McVoy, an Environmental Analyst with MA DEP. "It's also better than a regular rake, which often lands tine side up."

The weed weasel is made from two sawed-off garden rakes bolted together back-to-back. The tines are tied together with "quick-connect" ties, and a 20- to 30-foot length of rope is attached by means of an eyebolt.

Note that the weed weasel is for sampling only--NOT for "cleaning up" the lake bottom. Also, when using any sampling rake, be sure to remove plant fragments from the water.

For more information, contact Rick McVoy at 508-767-2977; richard.mcvoy@state.ma.us.

The Volunteer Monitor

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Volunteers Tackle Invasive Species

by Eleanor Ely

Lakeshore residents worried that an invasive exotic plant may get established in their lake ...
A state agency wondering whether the dreaded zebra mussel has infested any of the state's waters ...
Wetland managers concerned about the spread of purple loosestrife ...
Who are they gonna call?

Well, they could do worse than to call on local citizen volunteers. In water bodies around the nation, volunteer monitors are serving as sentinels to detect exotic invaders and help prevent their spread. According to the 1998 edition of *The National Directory of Volunteer Environmental Monitoring Programs,* 156 of the 772 listed programs include invasive species monitoring. Monitoring lakes for Eurasian milfoil appears to be the most widespread activity. Also common are watching for zebra mussels in lakes and rivers, and monitoring wetlands for purple loosestrife and *Phragmites.* Often volunteers not only find exotics but also help remove them.

Two of the first states to organize exotic-species monitoring programs for volunteers were New Hampshire and Vermont. The New Hampshire Department of Environmental Services Weed Watchers program, founded in 1988, is discussed in the article on page 12. The Vermont Department of Conservation started its Milfoil Watchers program in 1987; the name was later changed to Aquatic Nuisance Species (ANS) Watchers when the program expanded to include monitoring for water chestnut and zebra mussels.

Over the years, the ANS Watchers have made significant contributions in Vermont's battle against exotic species. For nine of the state's 53 known milfoil-infested lakes, citizen volunteers were the first to find the invasive milfoil. Three years ago, in Lake Bomoseen in southwestern Vermont, a trained volunteer spotted water chestnut early enough that DEC was able to eradicate it with hand-pulling.


Vermont volunteers pull water chestnut in Lake Champlain.

But the most dramatic exotic species "success story" to come out of Vermont is that of Matthew Toomey, who at the age of 13 became the first person to find zebra mussels in Lake Champlain. In 1993, Matt was fishing from his family's dock when he reeled in a brick with a mussel attached. He and his family compared the mussel to the picture on a zebra mussel identification card that had been distributed at Matt's school, then called in a report to the Lake Champlain program. DEC biologists confirmed that the creature was indeed a zebra mussel. (Toomey is now studying biology at the University of Vermont, where he is doing research on--what else?--zebra mussels.)

In Minnesota, citizen volunteers have been watching for purple loosestrife--an attractive but aggressive nonnative species that displaces native wetland plants--since 1987. When they spot a stand of this invader, volunteers note the location and approximate number of plants and mail the information to the Exotic Species Program at the Department of Natural Resources, where it's entered into a database. Exotic Species Program Coordinator Jay Rendall says, "The volunteers help us locate new infestations while they are still small enough to be controlled by chemical or manual methods. Their observations have allowed us to identify nearly 2,000 purple loosestrife infestations statewide."

Recently some Minnesota volunteers, including several school classes and 4-H clubs, have started helping raise and release certain species of insects for biological control of purple loosestrife. Minnesota volunteer monitors also watch for Eurasian watermilfoil and zebra mussels. Just this fall, a citizen volunteer found the first known zebra mussel infestation of an inland lake in Minnesota.

The idea behind the Massachusetts Riverways Program's Invasive Plant Watch (IPW) project is to catch new infestations of water chestnut (*Trapa natans*) early and pull the plants before they have a chance to go to seed. Water chestnut is more susceptible to eradication than many other invasive aquatic plants because it's an annual that dies back each year; only the seeds survive the winter. Last summer, about 30 IPW volunteers monitored nearly 150 lakes and ponds in the Massachusetts portion of the Connecticut River watershed and discovered five infestations of water chestnut, all of which they pulled. Next summer they'll return to those sites and pull any new chestnut plants they find.

Matt Toomey speaks to a reporter about his discovery of zebra mussels in Lake Champlain.

"Training was simple," reports IPW Project Director Eric Marshall, "because water chestnut is easy to recognize." Still, Marshall says he felt it was worthwhile to do in-person training, as opposed to simply mailing literature to volunteers. "A plant in the hand is better than a little picture," he says. "It gives you a sense of the size and texture."

While some states have special volunteer programs exclusively devoted to monitoring invasive species, in other states exotic species monitoring is incorporated into larger ambient monitoring programs. For example, many participants in the Wisconsin Department of Natural Resources Self-Help Lake Monitoring Program watch for Eurasian watermilfoil while conducting other sampling activities. Self-Help Program staff don't have the resources to offer volunteers hands-on training in milfoil identification, but they do have another idea for helping volunteers observe real plants--next spring, they plan to send an actual specimen of Eurasian milfoil, pressed on paper and laminated, to all the monitors.

"A lot of the specimens volunteers send me are actually bladderwort," says Laura Herman, the Self-Help Monitoring Program coordinator for the northern part of the state. "The new laminated specimens should help them distinguish bladderwort from milfoil." Even without the benefit of laminated specimens, Wisconsin's lake monitors have been doing quite well: Out of five new Eurasian watermilfoil infestations found last year in Herman's region, three were discovered by volunteers.

In both Wisconsin and neighboring Illinois, volunteer lake monitors are watching out for zebra mussels, fingernail-size nonnative mussels that reproduce rapidly and attach to almost anything, clogging water intake pipes and decimating populations of native mussels. Amy Walkenbach, Lakes Manager for Illinois EPA, says that about 95 percent of Illinois EPA Volunteer Lake Monitoring Program participants, representing about

150 lakes, currently include zebra mussel monitoring. She adds, "We look at it as an educational program--not just monitoring, but raising awareness so people don't transfer the mussels from one body of water to another."

The Wisconsin and Illinois volunteers monitor zebra mussels by placing one or two zebra mussel samplers (four stacked plates, resembling the Hester-Dendy sampler used to sample stream macroinvertebrates) in their lake, usually near a boat launch site or an inlet. At intervals, they pull up the samplers and inspect them with the help of a hand lens. They also visually inspect docks, piers, and rocks for attached zebra mussels.

In 1998, the King County Department of Natural Resources in Washington state provided training in exotic plant identification to 32 volunteers who were already monitoring lakes. During a two-year pilot project, the volunteers identified and mapped the locations of purple loosestrife, Eurasian watermilfoil, and reed canary grass on 15 lakes. Also in Washington, the nonprofit organization Adopt a Beach sponsors projects for monitoring spartina, purple loosestrife, and Phragmites along estuarine shorelines and wetlands. (For more on the Spartina Watch program, see *The Volunteer Monitor*, Fall 1998 issue.)

Zebra Mussel (Dreissena Polymorpha).

Invasive species monitoring may soon be getting more attention, since President Clinton signed an Executive Order last February establishing an Invasive Species Council. Considering the important role volunteers have already played in the battle against invasives, volunteer monitoring clearly should be included in any future strategies to combat nuisance species.

In many ways, citizen volunteers and exotic species monitoring are a perfect match. Volunteers greatly increase the number of "eyes" looking out for invaders, and since most volunteers live or recreate on the water body they monitor, they visit it often and know it well enough to spot anything unusual. Training is minimal, since only a few species need to be learned--and some species, such as zebra mussels or water chestnut, are so easy to recognize that a mailed brochure or identification card can suffice. Finally, volunteer involvement means increased public awareness about problem species, which translates to more people taking precautions to prevent the spread of these troublesome invaders.

The Volunteer Monitor

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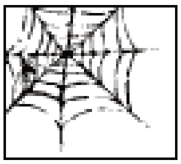

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Quick Reference Plant Field Guide

Volunteers and professionals who work with aquatic plants face the constant threat of their person or equipment becoming waterlogged. For those who don't want to risk damaging expensive field guides, the New Hampshire Department of Environmental Services, Exotic Species Program, has created a simple homemade field guide that eliminates that worry (though you may still have to dive for it if you drop it in the lake!).

To make the guide, first find pictures of common aquatic plants in your area (your local natural resources agency may be able to help out with reference books or pictures). Then, if you are technically savvy, scan the plant images into your computer and use a desktop publishing program for layout. Otherwise, simply cut and paste pictures onto plain white paper and photocopy these sheets to obtain a clean final copy. Group the plants on separate pages according to growth habit (emergent plants, floating-leaved plants, and submerged plants).

Insert the finished pages into heavy-duty laminate pouches (about $1 apiece) and run them through a laminator to seal (most copy centers have the necessary equipment). Punch holes through the plastic and insert pages into a three-ring binder, or have the pages bound with a plastic spiral binding at a copy center.

With this rigid, waterproof guide in hand, you are ready to go weed watching!

--*Amy P. Smagula*

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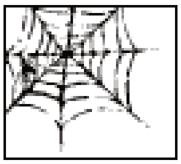

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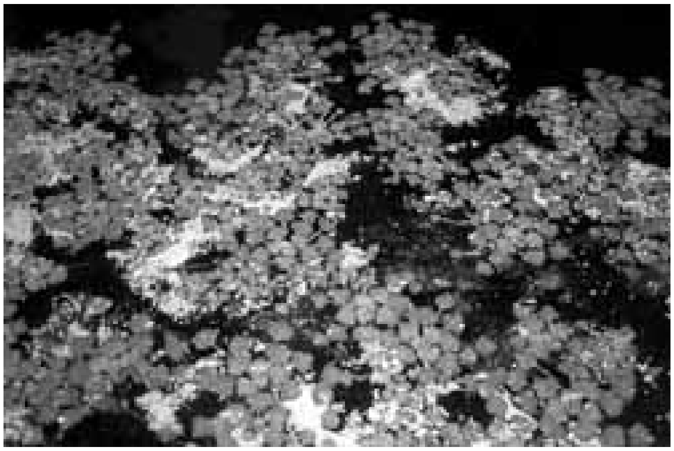
Weed Watchers
Standing Guard Against Exotic Invaders

by Amy P. Smagula

Call them what you will--exotic plants, invasive species, alien invaders--introduced aquatic plants have become nuisances in the water bodies they invade. Exotic plants are competitive, aggressive, and resistant to control, often dominating a system in less than one year. Their advantage lies in the fact that they left behind their native predators when they invaded new areas. Further, since these plants can reproduce rapidly through fragmentation (i.e., a small fragment can develop roots and form a new plant), even a single piece introduced into a water body can cause a large-scale infestation. Eurasian milfoil, variable milfoil, fanwort, hydrilla, Brazilian elodea, purple loosestrife, common reed, giant salvinia, and many more are blanketing water bodies throughout the nation. Infestations of these plants lead to diminished wildlife habitat, decreased recreational potential, and lowered property values.

Our best available strategies for combating invasive species are prevention and early detection. Eradication of these exotics is rarely possible--unfortunately, when an exotic plants enters a water body it is usually there to stay. But if new infestations are caught early, low-tech methods like hand-pulling can keep them under control and prevent their spread to other areas of the water body. (If you are dealing with annuals like water chestnut the outlook is a little more hopeful. New Hampshire and Vermont have had success in reducing water chestnut density by harvesting the plants each summer before they go to seed. Eventually, eradication may be possible.)


Water Chestnut (Trapa natans)

Through our volunteer Weed Watchers program, the New Hampshire Department of Environmental Services (DES) has taken a proactive approach to exotic plant control for 12 years. We have had great success in recruiting volunteer lake monitors to include Weed Watching in their summer sampling activities. Today, over 100 New Hampshire water bodies have active Weed Watching programs, with anywhere from 2 to 50 volunteers per lake.

Anyone can become a Weed Watcher. We have trained lake residents, retirement groups, youth groups, fishing enthusiasts, and many others. Volunteers like these are the best line of defense because they are often the most familiar with the water bodies they choose to monitor, allowing them to notice even a subtle change in vegetation.

Easy as 1,2,3

An exotic weed monitoring program can have a big impact without requiring a big investment of time or money. For both the sponsoring organization and the volunteers, weed watching is relatively simple because:

1. Volunteers don't need to identify every plant in the lake, just the most prevalent exotics in that region. For example, New Hampshire Weed Watchers so far only need to know four species--variable milfoil (*Myriophyllum heterophyllum*), Eurasian milfoil (*Myriophyllum spicatum*), fanwort (*Cabomba caroliniana*), and water chestnut (*Trapa natans*). Attendance at a training session is encouraged, but when that is not possible we simply mail new volunteers our Weed Watcher Kit, including our homemade plant identification key, and they are ready to go.

2. Equipment needs are few: just a small boat (canoe, kayak, rowboat, or boat with a short-shaft motor), an outline map of the lake, a plant key, a weed rake, and a device to help see below the surface of the water, such as a viewscope or polarized sunglasses. (Polarized sunglasses cut glare but don't help with chop on the water.)

3. Monitoring just once each month throughout the growing season is usually sufficient.

How to Weed Watch

Weed Watching requires at least two people--one to drive the boat, and one or more to look for exotic plants. A slow perusal of the littoral zone (the area of the lake that is shallow enough to allow for light to reach the bottom sediments) will allow you to take note of any suspicious plant growth. Move the boat in a weaving or zigzag pattern and look both below the surface at the submerged (underwater) plants and on the surface of the water at the floating-leaved plants. Calm days are best for Weed Watching, since waves and ripples make it harder to see down into the water. Don't become intimidated if your lake is large--it can be broken down into shoreline segments, each patrolled by a different pair of volunteers.

While it is important to thoroughly inspect all areas where light penetrates to the bottom, particular attention should be paid to boat launch sites, areas with muckier organic bottoms, wetlands, and anyplace where native vegetation has been disturbed. If you see a suspected exotic plant, gently pull it up with a rake (being very careful not to create fragments) and inspect it more closely. Whenever you see an exotic, or a questionable plant, mark its location on your lake outline map. Be sure to use permanent landmarks on the shore (an inlet, island, or house) to mark the spot.

When New Hampshire Weed Watchers find what they believe may be an exotic plant, they send DES biologists a live, fresh specimen, preferably in flower (but representative of what is in the water body if they find no flowers). Volunteers simply wrap the plant in a wet paper towel, place it in a sealable plastic baggie, put the baggie into an envelope along with a copy of their map showing the plant's location, and mail it to DES.

New volunteers tend to feel that the various feathery and submerged plants "all look alike." Take comfort--it gets easier the more you watch. When my experienced volunteers send me packages of plants with their identifications, they are most often right!

Fanwort (Cabomba caroliniana)

One important but often overlooked aspect of Weed Watching is that finding nothing is good! By nature, we find ourselves searching for things and becoming excited when we discover our "quarry." Over time volunteers' fascination with the plant communities may wane if they don't find these threatening exotics. It is important to remember that we really don't want to find these exotics in our water bodies.

Is there an end to the weed woes?

With increases in both shorefront development and uses of water bodies by the transient boater, the problem of exotic species is not likely to end soon. In fact, some researchers think that exotic species will soon become the next major environmental crisis.

Weed Watching is one of the most proactive ways to protect the valuable surface water resources we all enjoy so much. New Hampshire has seen firsthand what a difference a group of Weed Watchers can make. Finding exotic plants early can lead to successful management and containment. Don't let your lake become choked with exotic plants--Weed Watch to save your lake!

Amy P. Smagula *is New Hampshire Department of Environmental Services Exotic Species Education Coordinator. She may be reached at NH DES, 6 Hazen Dr., Concord, NH 03302; 603-271-2248; asmagula@des.state.nh.us.*

The Volunteer Monitor

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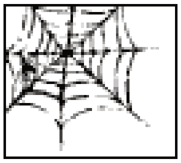

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A Story of Success--And a Warning

During the summer of 1999, Bill Martin, a regular Weed Watcher on Mascoma Lake in western New Hampshire, noted the growth of a new plant in his lake. Being familiar with exotic-species literature developed by the New Hampshire Department of Environmental Services (DES), Martin immediately brought a sample of the plant to the state laboratory for identification. The verdict: Eurasian watermilfoil (*Myriophyllum spicatum*), an invasive exotic aquatic plant.

Eurasian watermilfoil (Myriophyllum spicatum)

This finding was of particular concern because Mascoma Lake is used as a drinking water supply. If milfoil were to get out of control on this lake, it could not be managed with chemical herbicides.

Martin was able to tell state biologists the location and relative abundance of the plant. With this information, state divers immediately decided to go to Lake Mascoma to hand-pull this exotic species of milfoil. Fortunately, the patches of milfoil were small.

But when battling an exotic species, you can't declare victory after the first skirmish--or the second, or the third. Like any monitoring effort, Weed Watching never stops. During spring and summer 2000, Martin and his team of volunteer Weed Watchers continued to monitor the shallows of Lake Mascoma, using buoys to mark locations where they spotted new or persistent patches of exotic milfoil. State divers returned several times to hand-pull the plants. The encouraging news is that each time the divers return, the beds are smaller and less dense.

It will take several consecutive summers to be sure that we have the milfoil under control. We are even hopeful that eventually we may be able to eliminate all the milfoil from the lake, thanks to early detection by a vigilant volunteer.

On the other hand ...

In 1996, a resident along the Cocheco River in western New Hampshire noted some plant growth near her boat landing. Not having seen any literature on invasive species, she did not report the growth.

Six years later, the same individual attended a DES training session for volunteer water quality sampling and saw pictures of exotic milfoil. Stunned by the realization that the plant was the same as those she had seen growing near her dock, she informed me of the discovery.

State biologists went to investigate and found that the plant, which was identified as variable milfoil (*Myriophyllum heterophyllum*), covered several large areas along a mile-long stretch of the river bottom. If this plant had been recognized and hand-pulled six years earlier, the infestation could likely have been thwarted.

Weed Watchers can make a difference!

--*Amy P. Smagula*

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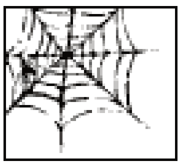

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Monitoring Massachusetts Marshes

by Eleanor Ely

"What do you think--about 50 percent Distichlis?"
"Yes, that seems right, and I'd say 20 percent Juncus."
"Look at these bare spots--let's put down 15 percent for 'other.'"

Crouching over a 1-meter-square frame laid in the coarse grasses of Essex Marsh in Essex, Massachusetts, Vivian Kooken, Ewa Newman, and Liz Sorenson peer closely at the plants inside the square, examining leaves, stems, and flowers. From time to time they refer to plant identification keys, or to a sheet of diagrams that helps them estimate the percent cover of each plant.

A few hundred feet away from where they work runs Conomo Point Road; beyond the road lies more marsh and then the open water of Essex Bay. The stone culvert under the road, built 40 or 50 years ago, was too small in the first place and has collapsed over the years, blocking much of the tidal flow from reaching this portion of the marsh.

The three women will spend several hours at this impaired site. By the time they are finished, they will have positioned the square frame at 18 different spots along six randomly selected transects within the site. At each spot they will identify and quantify the vegetation within the 1-meter quadrat. Last week they (along with several other volunteers) did the same thing at the reference site--a site just on the other side of Conomo Road, where no barriers impede the free flow of the tides. Already today they are noticing differences in this site compared to the reference site. This site has less *Spartina alterniflora* down near the creek channel and a lot more tall stands of *Phragmites* australis at the upland edge. *P. australis* is frequently an indicator of an impaired site.

Vivian Kooken (left) uses a measuring tape to determine the location for sampling while Liz Sorenson (center) and Ewa Newman prepare to place the 1-meter frame.

The vegetation survey being done here on this bright September morning is just one small piece of a much larger effort. Throughout the summer, groups of three to five volunteers have repeatedly visited four Massachusetts salt marshes as part of a project known as WHAT, or Wetland Health Assessment Toolbox. Actually the Toolbox contains six "tools." In addition to the vegetation bioassessment, there are two other bioassessment protocols (one for macroinvertebrates and one for birds), as well as tools for assessing water chemistry, land use, and tidal influence. For each marsh, all six assessments are done at both a reference site and a study (impaired) site.

This project for training citizen volunteers to collect data on wetland health was developed by the Massachusetts Bays National Estuary Program (Mass Bays Program) in response to a request from the U.S. EPA's Wetlands Program. Working through one of its regional citizen groups, Salem Sound 2000, the Mass Bays Program recruited Vivian Kooken to be the WHAT Volunteer Coordinator.

In addition to accompanying volunteers on site visits, as she is doing today at Essex Marsh, Kooken's responsibilities include organizing WHAT training workshops and scheduling the monitoring sessions. Each of the six tools, or protocols, has its own separate training, and volunteers may attend as many as they like. About 50 volunteers attended the first series of workshops in the spring of 1999, and 35 more were trained in 2000.

Quality, not quantity

The Toolbox grew out of work initiated by scientists Bruce Carlisle and Jan Smith at Massachusetts Coastal Zone Management (MCZM) in 1995. Smith, who is now the Director of the Mass Bays Program, recalls, "Bruce and I were frustrated because everyone seemed to be talking about wetlands in terms of quantity--the number of acres saved. But we could see that a lot of those acres were degraded. We wanted to look at quality, specifically the links between land use and wetland ecological health."

Carlisle and Smith began developing protocols for assessing wetland birds, plants, and land uses. Soon they were joined by Anna Hicks, who had been working on wetland macroinvertebrate biomonitoring (see Hicks' article in the Spring 1998 issue of *The Volunteer Monitor*). Supported by funding from the U.S. EPA, the team of scientists adapted these assessment protocols for volunteers to use.

For the WHAT vegitation survey, volunteers identify all plants inside a 1-meter quadrat and estimate the percent cover of each type.

Evaluating restoration

"One of the benefits of training citizens is to get them personally involved in wetland stewardship," says Smith. "Another exciting application for the citizens' data is in making sure restoration projects are succeeding. In Massachusetts, the regulatory requirement is 70 percent revegetation in two years. We're asking, 'Revegetation with what?' If it's invasive species like *Phragmites* and purple loosestrife, should that count? No, because they are not indicators of a good, healthy wetland."

All the WHAT sites currently being monitored will provide opportunities to evaluate restoration. The collapsed culvert at Essex Marsh is due to be replaced in October, and the other three WHAT project sites are also slated for new culverts or other restoration work. At all four marshes, volunteers will continue monitoring post-restoration at both the study site and the reference site.

Since the volunteers' methods are often more in-depth than the monitoring required by permits, their data will yield detailed information about which plant and animal species are present each year following completion of the restoration project. Hopefully, over time, the impaired sites will come to more closely resemble the reference sites.

Developing reliable metrics

The volunteers are also contributing to ongoing scientific research to improve bioassessment protocols for wetlands. As many readers of *The Volunteer Monitor* know from hands-on experience, stream health can be assessed by looking at various attributes of the macroinvertebrate population, such as the number of different taxa present or the percentage of pollution-sensitive groups. These attributes are called *metrics*, and they have been chosen after years of careful and repeated testing to confirm that they provide a reliable indication of human disturbance. But in the case of wetlands (and especially salt marshes), the search for suitable metrics began only recently.

"There are still a lot of questions about which metrics to use," says Carlisle, who heads MCZM's effort to develop wetland plant bioassessment protocols. By comparing the vegetative community at impaired versus reference sites, Carlisle has come up with a number of promising metrics, including taxa richness, abundance of invasive species, and salinity tolerance of species. But more data is needed to further evaluate and refine these metrics, and to find new ones.

Carlisle explains that metrics are tested by plotting them on a graph against some quantitative indicator of disturbance, such as the amount of tidal restriction or the percentage of impervious area in the watershed. The goal is to find metrics that respond in a predictable way to disturbance. For example, as percent imperviousness increases, abundance of invasive species also increases, so abundance of invasive species is a useful metric.

"The data being collected by WHAT volunteers will be a big help in our efforts to develop reliable metrics," says Carlisle. "If I can test metrics using data from 20 sites instead of five sites, I'll have a lot more confidence that those metrics really work."

For more information, contact WHAT Volunteer Coordinator Vivian Kooken at Salem Sound 2000, 201 Washington St., Suite 9, Salem, MA 01970; 978-741-7900; vivian. kooken@salemsound.org.

Lake Sampling Video

"Lake Sampling Techniques," a 15-minute video produced by the Massachusetts Water Watch Partnership (MassWWP), gives a detailed demonstration of techniques for measuring lake temperature, determining Secchi disk depth, and collecting samples for chemical analysis. Available for $5 from MassWWP, Blaisdell House, UMass, Box 30820, Amherst, MA 01003-0820.

NERMC Videos

The New England Regional Monitoring Collaborative (NERMC) has recently completed two volunteer monitoring videos. They are designed primarily to be used in NERMC training workshops. However, since they may be useful beyond New England as introductions to the monitoring procedures they cover, NERMC is making them available for $25 each.

"Benthic Macroinvertebrate Monitoring" (24 minutes) shows field and lab protocols developed by River Watch Network (now River Network) for two levels of effort: a simple streamside survey in which organisms are identified in the field, and a more intensive survey in which critters are brought to a lab for processing and identification. The video provides step-by-step instructions for collection, preservation, sorting, and identification, and describes some of the metrics that can be used to summarize and interpret results.

The second video, "Following the Flow: Assessing Non-point Source Pollution" (21 minutes) describes a visual survey method developed by UNH Cooperative Extension that can be used to assess the impacts of various land-use practices on watershed health. The survey involves the use of site-specific questions to evaluate the production, transport, management, and fate of nonpoint source pollution for different land uses. The resulting assessment helps determine if the site is currently posing a threat to water quality.

The NERMC is a collaboration among various volunteer watershed monitoring service providers in the region. For more information on the videos or to order copies, contact River Network's Vermont Office: 802-223-3840.

Websites to Check Out

For information about river and wetland restoration, check out the new, improved, and very comprehensive Restoration Website created by the Wetlands Division of EPA's Office of Wetlands, Oceans, and Watersheds at www.epa.gov/OWOW/wetlands/restore/.

Another useful and very extensive Website from EPA is the Biological Indicators of Watershed Health site at www.epa.gov/ceisweb1/ceishome/atlas/bioindicators/.

The Volunteer Monitor

The National Newsletter of Volunteer Water Quality Monitoring
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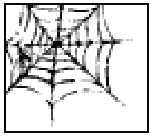

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Chlorophyll Methods: Let Me Count the Ways...

When *The Volunteer Monitor* recently conducted an informal telephone survey asking several volunteer program coordinators how they measure chlorophyll, many initially responded, "Well, we follow *Standard Methods."* But when these folks went on to describe their procedures step by step, it turned out that no two of the ten programs interviewed were doing exactly the same thing (see table). In fact, there was not even a single step in the procedure, from sample collection through laboratory analysis, that was being done in quite the same way by all the programs.

Yet the funny thing was, most of these programs were correct in stating that they were following *Standard Methods.* The fact is that chlorophyll methods are not well standardized. Different water body types and different situations require different methods. Also, methods are constantly evolving. Hence, the APHA's *Standard Methods* for the Examination of Water and Waste Water offers a variety of options. There are almost as many differences in chlorophyll procedures among agencies as among volunteer programs. Indeed, one reason for all the variation among the volunteer groups is that many are trying to match their state agency's methods, and the agencies are using different methods.

With the bewildering array of choices, what's a volunteer monitoring program coordinator to do? Well, first, don't panic. There's really no "right" or "wrong" way. Despite their many differences, all the programs in our survey are collecting useful data. As long as you use consistent methods throughout your program, you will be able to make valid comparisons between water bodies and over time.

In choosing a chlorophyll method, you need to weigh many factors about your water body, your resources, and the ways your data will be used. If you want to compare data with other programs or agencies, it's best to follow methods that are as similar as possible to theirs. Before making your final decisions you may want to run your own comparisons. Conditions in your water body, such as the amount of algae and/or what specific types are present, will affect which procedures work best. Moreover, there are a number of seemingly minor procedural details that can cause problems if not done correctly.

The discussion below offers some guidance through the maze of methods. Much of it was adapted from Carlson and Simpson's *A Coordinator's Guide to Volunteer Lake Monitoring Methods*, which is recommended to readers who would like a more in-depth treatment of the subject (see "Resources" listing below for ordering information).

Sample	URIWW Discrete, subsurface	NY CSLAP Discrete, subsurface	VT LMP Integrated for deep lakes, subsurface for shallow lakes	MI CLMP Integrated to 2X Secchi depth	UNH LLMP Integrated to thermocline	FL LAKEWATCH Discrete, subsurface	IL VLMP Integrated to 2X Secchi depth	IN VLMP Integrated 6' tube	WI Self-Help Old: discrete subsurface New: integrated; 6-ft tube	MA WWP Discrete, subsurface
Volume filtered	50 ml	20 ml	100 ml	50 ml	250-1000 ml	100 ml/foot of Secchi Depth	Depends on Secchi Depth	Depends on Secchi Depth	Depends on Secchi Depth	Depends on Secchi Depth
Filter	Glass fiber	Membrane	Glass fiber	Membrane	Membrane	Glass fiber	Glass fiber	Glass fiber	Membrane	Glass fiber
$MgCO_3$	4 drops before filtering	6-8 drops before filtering	No	5 drops before filtering	No	No	No	Yes (with grinding filter)	No	No
Preservation	Freeze w/ desiccant	Freeze	Freeze	Freeze	Air-dry	Freeze w/ desiccant	Freeze	Freeze	Freeze	Forced-air-dry
Solvent	90% acetone	Chloroform-methanol	90% acetone	90% acetone	90% acetone	90% ethanol boiling for 5 min.	90% acetone	90% acetone	90% acetone	90% acetone
Grinding	No	No	Yes	vortex, steep, vortex	Yes (glass/glass)	No	Yes	Yes w/ $MgCO_3$ for abrasion	Sonic bath, 25 minutes	Yes (ceramic/ceramic)
Steeping time	Overnight	24 hrs.	24 hrs.	1 hr.	4 hrs.	24 hrs.	24 hrs.	Overnight	Overnight	Overnight
Measurement	Fluorometer	Fluorometer	Fluorometer	Fluorometer	Spectrophotometer	Spectrophotometer	Spectrophotometer	Spectrophotometer	Spectrophotometer	Spectrophotometer

Chlorophyll methods used by selected volunteer monitoring programs.

URIWW = University of RI Watershed Watch; NY CSLAP = NY Citizens Statewide Lake Assessment Pgm; VT LMP = VT Lay Monitoring Pgm; MI CLMP MI Cooperative Lakes Monitoring Pgm; UNH LLMP = Univ. of NH Lakes Lay Monitoring Pgm; IL VLMP = IL EPA Volunteer Lake Monitoring Pgm; IN VLMP = IN Volunteer Lake Monitoring Pgm; WI Self-Help = WI Self-Help Lake Monitoring; MA WWP = Massachusetts Water Watch Partnership

Why monitor chlorophyll?

The pigment chlorophyll--the crucial vehicle for photosynthesis--is found in all plants and algae. When we measure chlorophyll, we are really trying to obtain an estimate of the amount, or biomass, of microscopic algae (phytoplankton) in the water. This information is very useful to lake managers because algae are usually the most important determinant of water clarity, and they are closely linked to the level of nutrients in the water body.

Direct measurement of algal biomass is difficult and impractical because it requires identifying and counting algal cells and estimating their volumes. In the 1930s and 1940s, researchers began to develop an easier alternative--the measurement of chlorophyll as a surrogate for algal biomass. Even today, chlorophyll measurement is still the best option for estimating algal biomass, and it is commonly used by researchers and agencies.

Unfortunately for the analyst, algae have evolved several varieties of chlorophyll (termed chlorophyll a, b, c, and d) as well as several accessory pigments (xanthophylls, carotenes, and phycobilins) to enhance their ability to capture light at different wavelengths. Chlorophyll a is the predominant type in algae, and the one we usually are trying to measure. However, as discussed below, the other pigments (as well as their breakdown products) can interfere with the attempt to quantify chlorophyll a and cause under- or overestimation.

Sampling

Florida LAKEWATCH volunteer Susan Wright measures a water sample before filtering.

The very first step in chlorophyll analysis--collecting the water sample--already requires decisions to be made. The first question is whether to collect a discrete ("grab") sample or an integrated sample that captures a vertical "core" of the water column. The volunteer groups in our survey are about evenly divided between these two methods (see table).

A discrete sample can be collected by lowering a water sampling bottle such as a Van Dorn or Kemmerer sampler to the desired depth (usually 0.5 to 1 meter below the surface). In some programs volunteers simply use a plastic jug extended at arm's reach below the water. Methods for collecting an integrated sample include combining a series of discrete samples taken at different depths, lowering a weighted sampler that slowly collects water as it is lowered and/or raised through the water column, pumping water up to the surface, using a weighted hose that is crimped or closed at the surface end to capture the water, or similarly using a solid tube or pipe that has been designed with a closing mechanism to trap the water.

The choice between discrete and integrated sample is influenced both by practical considerations (collecting a discrete sample may be easier and less expensive, especially if the volunteers already use water samplers for other procedures) and by water body characteristics. In shallower, well-mixed waters, algae may be distributed evenly. In more productive eutrophic systems, algae usually occur mainly in the very upper surface waters. In either of these cases, discrete subsurface sampling may be appropriate.

In other waters, however, algae may be distributed unevenly in the water column both vertically (by stratification) and horizontally (by natural patchiness or wind). In addition, it is not uncommon to find high algae concentrations in places where density gradients exist due to either temperature (the thermocline in deep lake and open ocean sites) or salinity (the salt water "wedge" that occurs in some estuaries). In such situations, taking a single discrete sample near the surface will most likely not be representative of the algal biomass that actually is present, so an integrated sample would be preferable.

If you choose to collect an integrated sample, you are now confronted with another question: To what depth should the water column be sampled? One approach is to sample through the "photic zone"--that is, the area in the water where enough light penetrates to allow photosynthesis to occur. To estimate the extent of the photic zone, some programs use a formula based on Secchi disk depth (usually one to two times the Secchi depth). In other cases, programs choose to sample all or part of the upper warm water layer (epilimnion), or a combination of the epilimnion and the middle layer (thermocline). The depths of these layers are determined either by conducting a temperature profile before sampling or by using estimates based on past studies.

Once collected, the water sample must be kept cool (but not frozen) in an opaque or dark bottle. At this point there are two choices: deliver the sample to a lab where all further procedures will be done, or filter the sample and preserve the filter.

Option 1: Deliver sample to lab

If the sample is to be delivered to a lab, it must be kept dark and cool and delivered for filtration within 24 hours at the most (the most stringent protocols require delivery within 4 to 6 hours). Since the sample volume may be a liter or more and the lab may be far from the volunteer's sampling site, this option is often impractical.

Option 2: Filter and preserve

To avoid the problems associated with lab delivery, many volunteer monitors filter the sample immediately, then preserve the filter by either freezing or air drying. The filtering procedure requires some skill on the part of the volunteers. Filters must be handled carefully, and never touched with the fingers (because oils on the skin are acidic, and chlorophyll is very sensitive to acid). Also, volunteers must carefully measure and record the volume filtered.

Filtration equipment. Most of the programs in our survey use a filter funnel and handheld vacuum pump to filter the sample. Under no circumstances should the filtration vacuum exceed 1/2 atmosphere to avoid cell breakage during filtration. A syringe with a filter holder is a less expensive option, but since only a small volume can be filtered this method can only be used if the lab analysis will be done by fluorometry (see below), which typically requires a smaller sample. Care must be taken not to use too much pressure on the syringe. Whichever method is used, if filtration is done in the field it is important to pick a shady spot.

Volume to filter. Your goal is to filter enough sample to get adequate chlorophyll to measure, but not so much that filtration takes an excessively long time or the filter becomes clogged. When sampling a lake for the first few times, having a hint as to how much water to filter can be very helpful. Several states have developed guidelines based on Secchi disk transparency (for example, Florida LAKEWATCH volunteers filter 100 ml per foot of Secchi depth). These guidelines, which are based on the assumption that Secchi depth is indicative of algal concentrations, are useful. However, sometimes conditions that are not reflected in the Secchi reading, such as an abundance of colorless bacteria or zooplankton, can affect filtration rate.
The analytical method used (fluorometry vs. spectrophotometry) will also influence the volume to be filtered. As mentioned above, fluorometry is more sensitive, so less chlorophyll needs to be captured on the filter.

Type of filter. Here the choice is between membrane filters or glass fiber filters. Membrane filters may retain more of the smaller-sized algae because the pore size typically used is 0.45 micrometers or microns (for comparison: a typical rod-shaped bacteria is about 1 micron wide and 3 microns long, so these holes on the filter are small!), but these filters clog more quickly than glass fiber filters. Glass fiber filters are recommended by *Standard Methods* for several reasons: they allow larger volumes of water to be filtered, they may assist in the breaking of algal cells during extraction, and they create no precipitate after the acidification step in analysis. Glass fiber filters do not have a specific pore size but are listed by a membrane-equivalent retention size. *Standard Methods* recommends a minimum particle retention size of 1 micrometer.

Magnesium carbonate (MgCO3). A suspension of MgCO3 is often added before filtration to increase the retention efficiency of glass fiber filters. MgCO3 is also thought to prevent degradation of chlorophyll during preservation and extraction, so it may be used with membrane filters as well. In this case the suspension can be added either before or after sample filtration. While no conclusive data exist to support the value of using MgCO3, there is also no indication that it negatively affects the results, so its use should be considered in cases where very small algae are known to occur or where waters have low pH or low alkalinity.

Preservation

Chlorophyll is very sensitive to light, acid, and temperature. Storage of glass fiber filters without using some means of drying and/or freezing and protecting from light will result in quick degradation of the pigment. *Standard Methods* indicates that freezing is effective for up to 21 days. Several studies report no significant degradation for up to 4 or even 6 months. The frozen filters must be kept frozen during transit; samples that are frozen and thawed degrade quickly.

An alternative to freezing is air-drying. The chief advantage is that air-dried filters can be mailed without the need for special packaging or overnight delivery. The New Hampshire Lakes Lay Monitoring Program uses membrane filters because, unlike glass fiber filters, they are hygrophobic (do not absorb water) and consequently dry very quickly. After being allowed to dry for a few hours in a cool, dark, desiccated compartment, they may be kept for several days or more at room temperature before analysis or freezing. Users of glass fiber filters may be interested in a new drying technique using forced air, which is described in this issue (see "Air-Drying: A New Way to Preserve Chlorophyll Samples). Filters dried by the forced-air method may be held for up to 15 days before being analyzed.

Laboratory analysis: The devil is in the details

From this point on, the sample is out of the hands of *The Volunteer Monitor*. Also at this point our discussion becomes a little more technical, being aimed primarily at readers who have some experience with the procedures described or those who need to become knowledgeable. Once again, more adventurous readers who desire a fuller discussion are urged to consult Carlson and Simpson's manual.

Extraction

Now that we're in the lab, we still have choices and variations to contend with. The first step is to extract the chlorophyll from within the algal cells into a solvent. Many algal species have been notoriously resistant to removal of all the pigment. Researchers have tried a variety of solvents, mixtures of solvents, and hot solvents. For all-around use and relatively low toxicity, 90% acetone seems to be the most frequent choice and is the recommendation of *Standard Methods.*

Investigators have also tried a variety of ways to physically break the cells apart, and most have found that grinding of the algal cells and filter improves extraction efficiency. Heat during the grinding process is to be avoided. Even though membrane filters largely dissolve in acetone, *Standard Methods* still recommends grinding or sonication. Membrane filters are generally ground using a glass-to-glass mortar and pestle. Glass fiber filters are typically ground with a Teflon-glass tissue homogenizer at relatively slow speeds (to avoid heat). The Massachusetts Water Watch Partnership has had good results using a small ceramic mortar and pestle.

Once the filters are dissolved or ground into a fine slurry, the slurry is poured into a centrifuge tube. More solvent is added up to a set volume (usually 10 to 15 ml) and the tube is set aside to steep for at least 2 hours at 4¡C in the dark. Steeping practices range from no steeping to steeping for over 24 hours. Note that in our survey, programs that do not grind the filters use a longer steeping time.

After steeping, tubes are centrifuged or filtered and the solvent with extracted pigments is carefully decanted into the measurement cell.

Measurement

Chlorophyll a concentration in the extract may be measured in one of three ways: spectrophotometrically, fluorometrically, or by high pressure liquid chromatography (HPLC).

HPLC is the only way to achieve complete separation of all the different pigments and breakdown products and quantify each individually. However it is not used much because it requires expensive special equipment and is very time-consuming (a single analysis takes 10 to 30 minutes compared to the few seconds for fluorometric or spectrophotometric readings).

So in practice the choice really comes down to spectrophotometry vs. fluorometry. There are a number of method variations for analyzing chlorophyll by either spectrophotometry or fluorometry. However, none of them yield a truly accurate measure of chlorophyll a because in every case there are interferences from other pigments present in the sample, including chlorophyll *a* breakdown products (especially pheophytin *a*); chlorophylls *b* (from green algae) and *c* (from diatoms and golden algae) along with their breakdown products; and others. All the methods can either over- or underestimate chlorophyll *a*, depending on which interfering pigments are present in a particular sample.

If you do not already have either a fluorometer or a spectrophotometer and are trying to decide which to purchase, consider that while you can probably find either instrument with the needed specifications at a similar cost, a spectro- photometer has the advantage of being useful for other analyses in your program (nutrients, color, etc.). On the other hand, a fluorometer is more sensitive so it requires less sample, which may make it a better choice for chlorophyll analysis in less productive, ultra-oligotrophic systems (pristine lakes, open ocean). While *Standard Methods* does not recommend the use of a fluorometer for freshwater samples because interference from green algae (chlorophyll b) can bias the result, newer fluorometer configurations are available to deal with this problem (discussed below).

Chlorophyll--living or dead?

As stated above, interference from chlorophyll degradation products and other photosynthetic pigments can cause an overestimation of the actual "living" chlorophylls--that is, chlorophylls derived from living algae in the sample. This can be partially countered by taking readings from the extracted sample both before and after acidification. The acidification process essentially degrades all the chlorophyll to pheophytin. An equation is used to calculate an estimate of chlorophyll a concentration based on the ratio of the pre- and post-acidification readings.

Spectrophotometric methods

Spectrophotometric methods measure the amount of light absorbance at specific wavelengths. While two variations exist, the monochromatic method and the trichromatic method, the former is more widely employed.

The monochromatic method simply measures for chlorophyll a at its absorption peak (around 664 for 90% acetone extracts). An additional reading should be made at 750 nm to correct for turbidity in the extract. Acidification (described above) is used to correct for interference from any pheophytin a that might be present. When performing the acidification step, current wisdom suggests not using too strong an acid or waiting too long a time before measuring the acidified extract. An HCl concentration of approximately 3-10 mM (since concentrations as low as 30 mM can quickly create interfering compounds) and a consistent time interval of no longer than 60 seconds are now recommended.

The trichromatic method gained early popularity in oceanographic studies. Absorbance is measured at three wavelengths, corresponding to the peak absorbance of chlorophylls a, b, and c. (The wavelengths vary depending on which solvent is used for extraction and whose equations you believe.) These values are plugged into equations that yield estimates of chlorophyll *a, b* and *c* concentrations. While this method sounds good in theory, due to potential interferences from pheophytin a and other pigments it is rarely used in freshwater and is losing popularity in marine studies.

Whichever method is used, sufficient sample should be filtered to result in absorbances in the spectrophotometric range of 0.1 to 1.0 absorbance units (the middle range of most instruments). Typically this translates into "the filter should have a noticeable greenness."

In the University of Rhode Island Watershed Watch program, samples are filtered using a 60-cc syringe with attached filter holder. Because this program uses flourometry for analysis, a relatively small volume needs to be filtered.

Spectrophotometric equipment

The specifications of the spectrophotometer used in the analysis are crucial. It is important to check that the spectrophotometer is sensitive in the red and far red wavelengths. While this is common for current models, older models required a red-sensitive photomultiplier tube. In addition, because the chlorophyll absorption peak is relatively narrow, the spectrophotometer should have a narrow bandwidth (0.5 to 2.0 nm). According to *Standard Methods*, use of a spectrophotometer with a 20 nm bandwidth, such as the popular Spectronic 20 series spectrophotometers, may underestimate chlorophyll by as much as 40 percent. This critical specification is often not stated in catalogs or advertising literature so you need to check the specifications sheet. It is also desirable that the spectrophotometer have the capability to use cells longer than the common 1 cm. Longer cells (3-5 cm) increase the sensitivity substantially.

Fluorometry

Fluorescence measures the amount of light emitted at a particular wavelength (emission wavelength) upon exposure to light at a different wavelength (excitation wavelength). The excitation wavelength for chlorophyll a is in the blue range (around 430 nm) and the emission wavelength is in the red range (around 663 nm). Fluorometric determination of chlorophyll is a highly sensitive method, 10 to 100 times more sensitive than spectrophotometry. However, the fluorometer must be calibrated against a spectrophotometer or by using an extract that has already been calibrated against a spectrophotometer. As with spectrophotometry, there are interferences from other pigments (that also fluoresce); there is also the additional problem of quenching (reabsorbance of the emitted signal) of chlorophyll a fluorescence by beta-carotene (present in many algae) and phycobilins (found in the blue-greens).

High concentrations of chlorophyll *b* and *c* will produce fluorescence near the same wavelength as chlorophyll a. After acidification, the closeness of the pheophytin b emission to that of chlorophyll a and pheophytin a can interfere greatly. The latest (1999) version of *Standard Methods* does not recommend using fluorometry in freshwater because of the chlorophyll *b* problem and discourages the acidification step for pheophytin correction in either fresh or marine waters. However, studies by Axler and Owen have found that fluorometric analysis of a wide range of freshwater chlorophyll samples can produce accurate readings of chlorophyll *a* if the fluorometer has the proper combination of lamp and filters, the final acid concentration is kept low, and readings are taken no longer than 60 seconds after acidification. Axler and Owens did find all fluorometers tested to slightly overestimate pheophytin a in the presence of chlorophyll *b* when compared to spectrophotometry.

A recently developed fluorometric method called the Welschmeyer technique uses very sharp cutoff filters and a narrower light source specific to chlorophyll *a* excitation and emission. This eliminates interference from pheophytin *a* and thus there is no need for acidification.

Reporting total chlorophyll

Since no available method accounts for all sources of interference or variation, Carlson and Simpson comment that so-called chlorophyll a as measured by any method "is really an operationally defined term whose meaning and values change with each alteration of the technique." They therefore support the 1972 suggestion of the International Biological Programme to make a single reading at the chlorophyll a peak and report the concentration as "total chlorophyll." The advantage, they write, is that this "is the only value that remains fairly independent of chlorophyll methodology." Other studies have demonstrated that this approach allows for more confident comparisons between methods using different formulas and instruments. If desired, the ratio between pre- and post-acidification readings can also be reported to further characterize the chlorophyll.

Your way or mine?

Many options are available at all stages of the intricate process of monitoring chlorophyll. These options all have their specific advantages and disadvantages, potential or actual, that relate back to your particular circumstances. However, in spite of all the variations, final results may not be as different as is often supposed. Axler and Owen found that for freshwater samples, if *Standard Methods* are carefully followed and instruments meet the specifications, chlorophyll results from fluorometers and spectrophotometers are comparable. In addition, they write, "differences in filter type, storage time, filtration/extraction method (always using 90% acetone), and buffering were not found to cause significant differences in chlorophyll estimates."

References

APHA (American Public Health Association). 1999. *Standard Methods* for the Examination of Water and Waste Water, 20th edition. APHA, Washington, DC.

Axler, Richard P. and Christopher J. Owen. 1994. *Measuring Chlorophyll and Phaeophytin: Whom Should You Believe?* Lake and Reservoir Management 8(2):143-151.

Carlson, Robert and Jonathan Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods.* North American Lake Management Society (NALMS). Available from NALMS, P.O. Box 5443, Madison, WI 53705-5443; 608-233-2836. $15 ($12 for NALMS members) + $4 S&H.

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The Volunteer Monitor

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Collecting an Integrated Sample

Illinois Volunteer lowers weighted sampler.

Volunteer monitoring programs have devised a variety of low-cost methods for collecting an integrated sample (a vertical "core" of the water column). Volunteers with the Illinois EPA Volunteer Lake Monitoring Program put the chlorophyll sampling bottle in a weighted sampler, which is lowered slowly and steadily to twice the Secchi depth, then raised at the same rate.

Volunteers in the Wisconsin Department of Natural Resources (DNR) Self-Help Lake Monitoring Program have just begun using an innovative tube sampler made of PVC pipe with a reducing adapter at the bottom end. Inside the pipe is a ball that fits into the adapter. As the tube is lowered, the ball is pushed up and water enters. When the tube is raised, the ball drops, trapping the water. In the boat, the bottom of the tube is placed inside the neck of a specially designed bottle with a rod in the neck. The rod pushes the ball up, allowing water to drain into the bottle with no spillage. (For more information contact Maureen Janson at WI DNR, 608-266-3599; jansom@dnr.state.wi.us.)

Wisconsin DNR staff demonstrate new PVC tube sampler.

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Aquatic plants aren't the only kind of vegetation monitored by volunteers. In Illinois, ForestWatch volunteers are measuring tree trunks and counting shrub stems, stooping to examine plants on the forest floor and gazing up to assess the canopy above their heads.

Illinois ForestWatch was started in 1996 by the Illinois Department of Natural Resources (DNR). As of fall 2000, 625 ForestWatch volunteers have been trained. After completing the training (about 7 hours), volunteers go out to their sites, usually in teams of four to twelve, and establish three transect lines, which they mark with permanent stakes. Each transect starts at the forest edge (so it can be easily found when volunteers return) and runs 100 meters into the forest. Every other year, in spring and fall, the volunteers conduct detailed surveys.


Illinois ForestWatch volunteer lays transect line.

Let's follow a volunteer team on their fall survey. First they walk 50 meters into the woods along one of their transect lines. Here they begin their work. They set out flags at 5 meters to the left and right of the 50-meter point, then do the same at the 60-meter point. Now they've defined a 10-meter-square area for their Tree Survey. Every tree within the square is measured (trunk diameter) and identified to species. When the whole square is done and all data recorded, the volunteers move to the 60-meter point and begin all over again. After repeating the process three more times they arrive at the 100-meter point, the end of the transect line.

Now it's time for the Shrub Survey. Starting again at the 50-meter point, one volunteer holds two meter sticks together end-to-end at about waist height, so that they project straight out to either side like a pair of oars, and begins to walk slowly along the transect line. Each time one of the meter sticks brushes against a shrub, the volunteers crouch down and count all the shrub's basal stems (i.e., stems at ground level). If the shrub is an invasive species, they also record its identity on their data sheet.

When they reach the 100-meter point, the volunteers turn around and walk back, stopping every 2 meters to perform the Canopy Cover Survey. This is done by closing both eyes, holding an ocular tube (made by attaching string "cross hairs" to a short piece of PVC tube) against one eye, tilting the head far back, opening the eye, and calling out "hit" or "miss" depending on whether the cross hairs cover trees or open sky.

When all the tasks are completed along the first transect, the whole process is repeated on the other two transects. All in all, the survey takes 5 hours or so.

When volunteers return in the spring, they will have a somewhat different set of monitoring procedures to perform--for example, they will do a Ground Cover Survey that involves placing a 1/4-meter-square transect frame at prescribed locations, then identifying and estimating percent cover for a set of indicator species (such as disturbance-sensitive plants and invasive species) that fall within the frame.

"It's a bit involved," admits Pete Jackson, who coordinates ForestWatch for the DNR. "But our volunteers are very dedicated and they've shown that they're up to the task." The work has to be done carefully, because DNR is counting on the volunteers' data to help assess trends. (State biologists are particularly concerned about loss or fragmentation of forest habitat and invasions of nonnative species.)

The volunteers' manual contains 76 pages of precise instructions like "Trees that are on the edge of the 10-meter-wide belt are not tallied if the trunk base is less than halfway inside the 10-meter-wide area." Jackson says, "For us, the bottom line is, Is the information ultimately useful scientific data that we can use to assess trends? To ensure reliable data, we really need to be articulate and specific and clear about what information we want and how we want it collected."

The fall survey includes measuring tree trunk

The emphasis on usable data goes back to the Critical Trends Assessment Project (CTAP) that DNR initiated in 1991. One of CTAP's conclusions was that sufficient data to adequately assess trends for Illinois ecosystems did not exist. Out of this realization was born a plan for systematically collecting baseline data against which future conditions could be measured. From the start, volunteer monitoring was seen as a key ingredient.

diameter.

ForestWatch is just one component of DNR's EcoWatch Network, a multi-faceted statewide volunteer monitoring network that also includes RiverWatch, PrairieWatch, WetlandWatch, SoilWatch, and UrbanWatch. (The latter three programs are still in the development stage.) The collective efforts of citizen scientists in all these programs will increase CTAP's reach to hundreds of additional sites that could not otherwise be monitored.

For more information, contact Pete Jackson, Illinois DNR, 100 W. Randolph St., Suite 4-300, Chicago, IL 60601; 312-814-4747; pjackson@dnrmail.state.il.us.

The Volunteer Monitor

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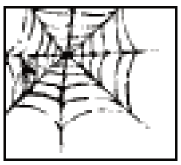

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Air-Drying
A New Way to Preserve Chlorophyll Samples

by Paul Godfrey

Many volunteer monitoring programs include testing for chlorophyll, which is the most commonly used indicator of algal biomass in lakes and streams (see article on page 16). Because chlorophyll analysis is performed in a laboratory, all a volunteer monitor needs to do is collect the water sample and get it to the laboratory without any change in the chlorophyll. Sounds simple, but it really isn't. Algal chlorophyll is very sensitive to light and temperature. In fact, the difficulties of transporting the samples can be the single greatest barrier to the widespread use of chlorophyll analysis by volunteer monitors.

If the whole water sample is delivered to the lab, it needs to kept cool and in the dark (for example, in an iced cooler) to retard breakdown of the chlorophyll. Reports vary on the maximum holding time, but times of more than a few hours may cause significant chlorophyll deterioration. The time limit and sample volume preclude mailing by even the fastest means. Furthermore, once the sample is delivered to the lab it must, at least, be filtered and frozen immediately--a problem if the sample arrives after business hours.

A common alternative used by many volunteer programs is for the monitor to filter samples immediately. Since the algal cells quickly begin to deteriorate on the still-wet filters, filters must be frozen as soon as possible. The frozen filters may be held for at least 3 weeks. The problem, however, is delivering them frozen to the lab. Even temporary thawing can ruin the samples. And if samples must be mailed, the weight of a cooler and ice packs will add substantially to costs.

Air-drying

My colleague Peter Kerr and I have developed a third alternative that will be familiar to those who dry herbs from their garden. After filtration, filters are placed on a screen above a small but powerful fan. The fan is run for approximately 45 minutes, removing all remaining moisture from the filter. The filter is then wrapped in aluminum foil. As long as it is not exposed to excessive heat, the air-dried filter can be maintained without loss or degradation of chlorophyll for at least 15 days.

The major advantage is that filters can be mailed by regular first-class mail or delivered to the lab within the next several days. The lab can accumulate filters until it has a sufficient number to merit setting up for analysis.

Testing the method

In a series of experiments designed to evaluate the performance of air-drying, we filtered numerous samples from an algal culture to create a large number of filters with equal amounts of algal cells on them. At random, some filters were analyzed immediately, others were frozen for up to three weeks, and still others were air-dried.

There was excellent agreement of the air-dried samples with both fresh and frozen samples. Air-dried samples remained relatively constant (within 10 percent of the mean) for at least 40 days. In fact, we consistently observed more chlorophyll extracted from the air-dried samples than from fresh samples, which suggests that air-drying improves the grinding and extraction process.

A parallel experiment, conducted with the help of the U.S. Geological Survey (USGS), compared air-dried and frozen samples collected by their field crew. The air-dried samples produced more chlorophyll than the frozen ones.

Detailed results of all the experiments are reported in the *Journal of Lake and Reservoir Management.*

Construction of the air-dryer

The air-dryers are relatively inexpensive and fairly easy to construct. The apparatus may also be ordered from the author, who will make a limited number upon request.
For those who wish to build their own air-dryer, full instructions are available from the Massachusetts Water Watch Partnership Website (www.umass.edu/tei/mwwp/ EXIT EPA) or from the author. The essential elements are a 100 cfm (cfm = cubic feet per minute) button fan and a grid to hold the filters in place. While volunteer lake

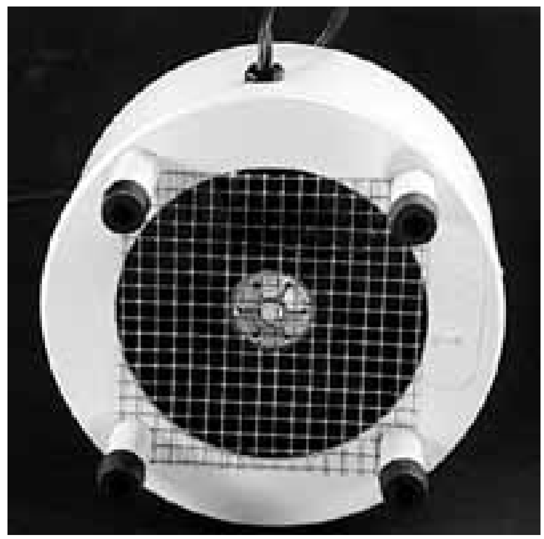
monitors will probably want to use an AC fan, professional lake managers may prefer a 12-volt DC model that can be operated from a vehicle cigarette-lighter socket.

In our model a 4 3/4" button fan is fitted inside a 6" PVC drain pipe cap. The cap has a 4 1/2" hole drilled in the end. This hole is critical for adequate air flow, as are the legs that support the device. The trickiest step in construction is making the large hole in the PVC cap. If a large drill hole-saw is used, the drill speed must be very slow--slower than available with most home workshop drill presses--or the drill will "grab" the PVC and make drilling impossible. Alternatively, a router may be used.

The upper portion of the dryer consists of a 3" length of 6" PVC pipe, to which is attached a hinged grid that holds the filters in place. The additional height provided by the 3" piece helps to distribute the air flow over the whole filter-holder area. Almost any mesh framework would work for the grid. We use 7 1/2" squares of plastic "egg crate" grid material commonly used as a light diffuser for fluorescent light fixtures. The squares are joined by plastic cable ties that serve as hinges.

Use of the air-dryer

Water samples are filtered through glass fiber filters following standard procedures. Filters are folded in half using tweezers and placed on the filter-holder grid, which is then closed to hold the filters securely in place. Four to six filters can be dried at one time (but avoid placing filters at the center of the grid where the air flow is less). During the drying process, the air-dryer should be placed in a location that allows only subdued outdoor light or indoor lighting to fall on the filter grid. The dryer is usually operated for 45 minutes; additional time should be allowed if more filters are dried or humidity is high. Filters are then enclosed in aluminum foil and labeled. They may be mailed without any special handling or delivered to a lab.



Bottom view showing air-flow hole, covered by a screen to protect fingers.

This air-drying method is now being used by the New England office of USGS and the National Park Service Cape Cod National Seashore staff, as well as by a number of volunteer lake monitoring groups in Massachusetts.

Reference

Godfrey, Paul Jos. and Peter A. Kerr. 2000. Preliminary evaluation of a promising forced air-drying technique for preserving chlorophyll on glass fiber filters. *Journal of Lake and Reservoir Management* 16(3): 222-234.

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The Volunteer Monitor

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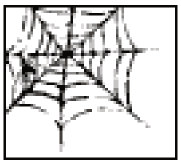

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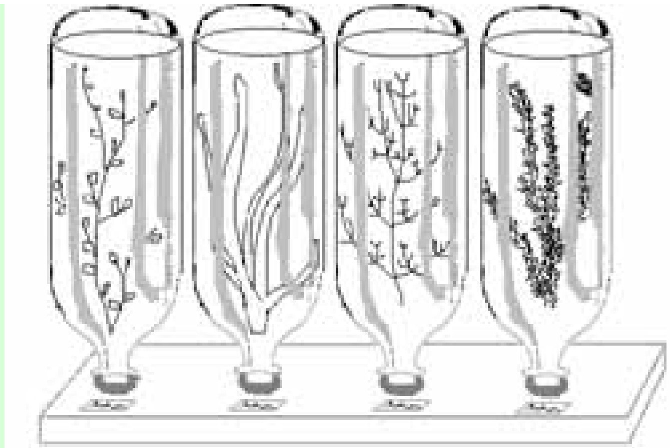
Aquatic Plant Display

(Excerpted, with permission, from *Ready, Set, Present! A Data Presentation Manual for Volunteer Water Quality Monitoring Groups*, produced by Massachusetts Water Watch Partnership. The manual is available for $5; contact Marie-Françoise Walk at 413-545-5531; mfwalk@tei.umass.edu.)

The University of New Hampshire Lakes Lay Monitoring Program produced this exhibit that displays aquatic plants in clear plastic 2-liter soft drink bottles. Plants are placed top-down in the bottles, which are filled with water, sealed, and set snugly in holes drilled in a wooden board (make sure the board is wide enough to handle the filled bottles without toppling). The plants look much as they would while alive in a water body. If the display is to be used for more than a day or two, use isopropyl alcohol (rubbing alcohol) instead of water; plants will stay green for about a month in the alcohol.



The Volunteer Monitor

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Periphyton, Anyone?

Stream periphyton (attached, bottom-dwelling algae) can be a useful indicator of stream health. However, it appears that few U.S. volunteer monitoring programs are using this tool. A recent query to the EPA's volunteer monitoring listserver elicited a number of responses from groups interested in monitoring periphyton, but few were actually doing it. (*Note:* To join *The Volunteer Monitor*ing listserver, send email to listserver@unixmail.rtpnc.epa.gov with the message subscribe volmonitor lastname firstname.)

EPA Rapid Survey

A couple of relatively simple periphyton-monitoring protocols that seem to hold potential for volunteer monitors have recently been developed. One is the "Field-Based Rapid Periphyton Survey" described in Chapter 6 (section 6.2) of the EPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish,* 2nd edition, published in 1999. (You can view this document online at www.epa.gov/owow/monitoring/rbp/, or order a free copy from EPA's NSCEP at 800-490-9198; the publication number is EPA 841-B-99-002.) In this protocol, monitors use a clear-bottomed viewing bucket marked with a 50-dot grid to view the stream bottom and estimate the coverage of different periphyton types.

Volunteers with the Salt River Watershed Watch in Louisville, Kentucky, have constructed some viewing buckets and conducted a few preliminary trials with the EPA's Rapid Survey technique. Tina Montgomery, Volunteer Coordinator for the group, reports that "the volunteers like the method because it's quantitative and there's no subjectivity." The group is also experimenting with identifying diatoms attached to stream-bottom rocks.

New Zealand method

In New Zealand, farmers and other volunteers interested in assessing the health of rural streams are using a method that involves visually examining algal films or mats on stream stones along a transect. Each stone is assigned a score based on the thickness, color, texture, and percent cover of the different types of periphyton attached to it. No identification of algae is required. The periphyton score is used in conjunction with benthic macroinvertebrate scores to help assess stream health.

For more information on the New Zealand protocols, including color photos of different types of periphyton, visit www.niwa.cri.nz/shmak/. EXIT EPA This Website also contains the entire *New Zealand Stream Health Monitoring and Assessment Kit: Stream Monitoring Manual* (published in 1998) in downloadable format; for periphyton monitoring, see especially chapters 6, 7, and 14.

The New Zealand protocol seems like a promising tool that could be tailored for use in various U.S. ecoregions. One of the method's developers, Barry Biggs at New Zealand's National Institute of Water and Atmospheric Research, notes that "some additional types of periphyton cover that we don't get here might need to be added, but our protocols should be a good start."

Julie Hambrook at the U.S. Geological Survey in Ohio recently tried out the New Zealand method with elementary students and found it useful. She points out that the EPA Rapid Survey method cannot be used in turbid streams where the bottom cannot be clearly seen, whereas "you can pick up stones and examine them from most streams."

If you're interested . . .

Judging from the response on *The Volunteer Monitor*ing listserver, periphyton monitoring could be an area that is ripe for development by volunteer monitoring groups. Beth Davis, a former Texas Watch staffer and now a graduate student in phycology (the study of algae), has graciously offered to serve as a central contact point to help put interested volunteer groups in touch with each other and with local phycologists. Anyone interested in this topic is encouraged to contact her at beth.davis@mail.utexas.edu.

-- *Eleanor Ely*