Image-based Plant Estimate Protocol

A Field Assessment Method for Surveying Freshwater Wetland Vegetation in New England with Volunteer Groups

New England Interstate Water Pollution Control Commission

Boott Mills South, 116 John St.
Lowell, Massachusetts, 01852
www.neiwpcc.org

Principal Author:
Matthew Witten
Environmental Analyst
July, 2005

Acknowledgements

The New England Interstate Water Pollution Control Commission (NEIWPCC) heartily thanks the following individuals for their contributions in making this document possible:

Joe Przypek, Smokey House Center in Danby, Vermont, and Lynn Fosher, Science teacher at Milton High School in Milton, Vermont, for field-testing the digital-photography based protocol; Joe Przypek also for providing sample photographs for this document; Mark Gernes and Michael Bourdaghs, wetland ecologists for the Minnesota Pollution Control Agency, for valuable advice and for providing an early draft of the *Minnesota Citizen's Guide to Biological Assessment of Wetlands: Vegetation Index of Biological Integrity* as a model to use; Siobhan Fennessy, Professor of Botany at Kenyon College, Ohio for advice on sampling methods and metrics; several scientists at the Vermont Non-game and Natural Heritage Program, Vermont Fish and Wildlife Department - Eric Sorenson, Dan Farrell and Everett Marshall - for information and advice on vegetation sampling methods and metrics.

Anna Hicks, formerly of University of Massachusetts Extension Service, Bruce Carlisle, Massachusetts Coastal Zone Management, and Jan Smith, Massachusetts Bays Estuarine Program, have done much of the fundamental work related to involving volunteers in wetland habitat assessment and bioassessment in New England. Ethan Nedeau, of Biodrawversity, Inc, kindly provided the electronic version of Anna Hicks's *New England Freshwater Wetlands Invertebrate Biomonitoring Protocol: A Manual for Volunteers*, whose format was borrowed for some aspects of this protocol.

Our reviewers: Jen Drociak and Ted Diers of the New Hampshire Department of Environmental Services; Siobhan Fennessy, Professor of Botany at Kenyon College, Ohio; Matt Schweisberg, U.S. EPA New England; and Alan Quackenbush, Vermont Department of Environmental Conservation.

NEIWPCC's volunteer wetland monitoring work, including the development of this protocol, has been funded by the U.S. Environmental Protection Agency, Region 1.

TABLE OF CONTENTS

(APPENDIX F and APPENDIX G are separate Excel files.)

PART I: INTRODUCTION

Preface

This document lays out a protocol for characterizing plant communities in freshwater wetlands, with volunteer groups in mind as the users. The protocols and data collection systems outlined herein are meant to be as complete as possible but also adaptable and amendable according to each group's needs. To ease readers in becoming familiar with wetland monitoring terms, all words included in the glossary are placed in bold within the text at the first instance of each term.

This document, while complete, is not set in stone. Although the Image-based Plant Estimate Protocol has been both field-tested and peer-reviewed, neither process was exhaustive. We intend the methods and metrics used hereinto be used, experimented with, and improved upon if necessary.

Some printed copies of the Image-based Plant Estimate Protocol will be distributed, but its principal distribution will occur on line, where both text and spreadsheets are downloadable for use by the public. We strongly encourage any and all users to download both text and spreadsheets and use as-is or adapt them to your needs.

The New England Interstate Water Pollution Control Commission website is: www.neiwpcc.org, and our telephone is: 978-323-7929. Feel free to contact us!

Background

Volunteer monitoring programs require accurate data to perform natural resource monitoring and assessments. Students, volunteers, and amateur naturalists do not always have the time or ability to correctly identify plant species (or **genera**) in the field. The Image-based Plant Estimate **Protocol** (IPEP) allows for the accurate collection of **wetland** plant data by volunteers without always positively identifying the plants on-site.

IPEP relies on digital photography and careful documentation to provide critical and unique characterization of each plant encountered during field sampling. Unknown plants can then be identified and verified by professional botanists in the lab, thereby ensuring the quality of the data collected by volunteers. The data can then be used to **monitor** and **assess** wetland condition or "health". Volunteers, using IPEP, can thus provide natural resource agencies and conservation organizations with information that may be used to help protect and restore wetland **ecosystems**.

A distinct advantage of IPEP is that the use of images instead of dried, pressed samples reduces the **disturbance** in the field as well as the processing time in the lab. It also creates an easily stored record of plant data (*i.e.*, digital data on Compact Disk) that can be accessed by professional scientists as well as lay people.

IPEP is designed for use in freshwater wetlands that have some obvious standing water. This includes **marshes**, vernal pools, floodplain forests, fens, and others. This protocol is less applicable in drier wetlands, such as wet meadows and many forested bogs. IPEP is restricted to these wetland types in order to standardize the methods as much as possible and nevertheless cover a large portion of the **freshwater wetlands** in New England and New York.

Objectives
The objective of IPEP is to facilitate the protection and restoration of wetland resources by providing a method for volunteers to monitor and assess one aspect of wetland condition. This document provides the basic framework for trained citizens, working in teams of 2 to 5, to collect high quality wetland **plant community** data for monitoring purposes and to perform at least a preliminary **bioassessment** of wetland condition, "integrity," or "health".

A bioassessment normally entails the establishment of regional multimetric indices by professional wetland biologists. Such indices have been created for wetland assessments in other regions of the country (in states such as Minnesota and Ohio). Because such indices have not yet been created for vegetation in the Northeast, this protocol does not contain an **index**, but rather a very simple, two-metric initial assessment of integrity based on work in those regions as well as in New England. In addition, IPEP is a valuable wetland science educational experience for interested lay persons.

Level of Technical Expertise
IPEP is suitable for use by minimally trained volunteers and students under the leadership of an expert team leader who can train and coordinate volunteers. Basic compass and digital photography skills are combined with rudimentary plant characterization skills in the field. Data analysis requires basic mathematical skills and spreadsheet experience.

Sources
The principal source drawn on for information about establishing ***relevé*** plots and organizing wetland vegetation data is *A Citizen's Guide to Biological Assessment of Wetlands: The Vegetation Index of Biological Integrity* (IBI), which was developed by the Minnesota Pollution Control Agency. Other sources drawn on for data sheet templates and protocol structure are the *New England Freshwater Wetlands Invertebrate Biomonitoring Protocol*, by Anna Hicks of the University of Massachusetts Extension Service; and the *Vermont Rapid Community Assessment Form*, by the Vermont Fish and Wildlife Department, Nongame and Natural Heritage Program.

Applications
While primarily designed to measure wetland condition in concert with the *New England Freshwater Wetlands Invertebrate Biomonitoring Protocol* (Hicks, 2000), IPEP can also be utilized for:

- **Inventorying** vegetation within specific wetlands
- Evaluating the success of restoration

- Monitoring progress in created wetlands
- “Before and after” studies (*e.g.*, pre- and post-restoration monitoring)
- Establishing **reference sites** and **reference condition**

Biomonitoring and Bioassessment

Plants are excellent **indicators** of wetland condition because of their responses to environmental change and ease of identification. Human alterations to the environment can cause quantifiable changes in wetland plant community structure. **Hydrologic** changes and water quality are two of the most influential factors on wetland plant communities.

IPEP offers a method for taking a representative sample of the population of the plant species within a wetland. By pinpointing two indicators of wetland health within the vegetative community, IPEP helps distill plant data into characteristics that can be easily tracked over time (*i.e.*, biomonitoring) and also synthesizes a rough “screening” of the wetland’s health (*i.e.*, bioassessment).

IPEP offers a very a scaled-down version of a bioassessment. A bioassessment provides a way of rating one or more **assemblages** of a wetland’s **biota** (*e.g.* invertebrates, amphibians, or vegetation). Bioassessments comprise a series of **metrics** – usually very simple formulas – that collectively express the biological condition of an ecosystem. Each metric is based on empirical knowledge of how a biological **attribute** responds to human influence. For example, one metric often used is **taxa richness**, because it has been empirically shown that taxa richness, with few exceptions, decreases as human impacts increase. One possible exception to this rule is the existence of **invasive exotic** plants in a wetland, which might initially boost the diversity of the wetland. However, in most cases, the presence of invasive exotic species will decrease the overall species richness of a site due to the fast growth and dominance that are the hallmarks of these invaders. The encroachment of invasive exotic species is nearly always a sign of human disturbance.

The two metrics contained in IPEP are used as a solid basis for an initial bioassessment. Ideally, wetland monitoring groups will add their own metrics to these two when more thorough assessments are required.

Any bioassessment must be coupled with an independent landscape and/or **habitat** assessment so that it can be measured against another standard of wetland quality. Usually this measuring of biological indicators versus habitat score is expressed by plotting the former on the *x* axis and the latter on the *y* axis of a graph. Measuring one against the other helps verify the robustness of each method of assessment, much as a blood pressure reading can be measured against a patient’s physical appearance and medical history. To this end, we recommend that IPEP be used, at the very least, in concert with the habitat assessment included in the *New England Freshwater Wetlands Invertebrate Biomonitoring Protocol: A Manual for Volunteers* (Hicks, 2000). Other types of habitat and landscape assessments are also available in other protocols found in the reference section of this document.

Reference Condition
Wetland bioassessments need to be based on data that represent a reference condition against which subject wetland(s) may be compared for degree of severity of impact. This reference condition is defined as wetlands that are "minimally influenced by human actions" and is established from pooled data gathered from a set of reference wetlands. The selection of reference sites is important as they must be representative of the natural conditions within the same landscape setting (riverine, lacustrine, depressional, fringe); geological (mineral or organic soils) and climatic setting; the same hydrological regime (see Brinson and Reinhardt, 1996); and dominant vegetation class or classes as the subject wetland(s).

Reference conditions need to be established for the individual wetland classes for bioassessment data to have real meaning. Reference conditions for many of the classes however, have not been established in New England. Research aimed at establishing a reference condition may be necessary to fully interpret IPEP data. Ideally, every wetland bioassessment project that makes use of IPEP will incorporate a study of at least one reference site in addition to the wetland site(s) of primary interest.

A reference site should be a minimally impaired representative of the expected ecological conditions and integrity of other sites of the same type and in the same region (USEPA, 2002). Once reference sites are established they should be studied simultaneously with your principal study site(s) for the same parameters. It is anticipated that over time, through a step-by-step process, reference conditions will be developed for the different wetland classes in New England.

Plant Metrics
IPEP utilizes a combined metric approach to analyze the raw data obtained from the plant sampling. Multimetric indices commonly involve five to ten or more individual metrics. IPEP contains only two in order to simplify both the sampling and analysis for volunteer groups while still allowing for a very basic level of assessment. The following are the metrics used in IPEP. These two were chosen for their ease of measurement in the field and laboratory, and their overall robustness in indicating the health of a wetland in multiple ecologic scenarios.

<u>Metric 1. Number of vascular plant genera</u>

It has been observed that natural communities usually have more diverse species of organisms (*i.e.* greater taxa richness) than do human impacted communities. This metric measures the richness of **vascular plant** genera within a wetland, and is simply a count of all the different genera found, *excluding invasive exotic plants*. The focus is on vascular plants because they are in most cases easier to identify than non-vascular plants.

Metric 2. Percent abundance of invasive, exotic species

Invasive species are aggressive colonizers of natural and disturbed areas, often forming extensive dense stands that can crowd out native species. Invasive species are frequently exotic (also termed alien or non-native), meaning they are not indigenous to this continent or region. Examples of invasive exotic wetland and **aquatic species** are: *Phragmites australis* (common reed), *Lythrum salicaria* (purple loosestrife), and *Myriophyllum spicatum* (Eurasian milfoil).

A healthy wetland will have few, if any, invasive exotic plants. This metric indicates the abundance of invasive exotic taxa compared to the total of all plant taxa in the sample plot. It is a measure of how virulent the encroachment of non-native plants is. This metric is especially useful when monitoring occurs over several years, because an increase in the abundance of invasive exotics is a strong indicator of a degrading and stressed ecosystem.

Although the presence of invasive exotic species may initially increase the diversity of a wetland's vegetation, by their nature these plants will crowd out native species and form monotypic stands, thereby decreasing species richness over time. Nevertheless, in order to preclude the small possibility of this metric being skewed by a recent encroachment of invasive exotic taxa, we exclude invasive exotic plants from the count of species richness in Metric 1.

CATEGORY	**METRIC**	**RESPONSE TO IMPAIRMENT**
1. Diversity	Taxa richness, excluding invasive exotics	Decline
2. Encroachment of invasive exotic taxa	Percent abundance of invasive exoticplants	Increase

PART II: PREPARATION

Quality Assurance Project Plan

A Quality Assurance Project Plan documents the planning, implementation, and assessment procedures for a particular project, as well as any specific quality assurance and quality control activities. It integrates all the technical and quality aspects of the project in order to provide a "blueprint" for obtaining the type and quality of environmental data and information needed for a specific decision or use. All work performed or funded by the U.S. Environmental Protection Agency (EPA) that involves the acquisition of environmental data must have an approved Quality Assurance Project Plan.

Wetland monitoring and assessment can certainly be done without the use of a Quality Assurance Project Plan, but the data from such projects would have very limited use. A Quality Assurance Project Plan (or "QAPP") is an important planning and operating tool, and it outlines procedures that will ensure that collected data meets the requirements of the project a group sets out to achieve. In turn, data collected under a QAPP is likely to be viewed as credible and therefore may be put to use by town, county, state and/or federal agencies. A QAPP may not only serve to convince skeptics about the quality of a group's findings, but also to record goals and methods for current and future volunteers.

Start the QAPP process well in advance of when you expect to do field work, typically, a year in advance. Among the aspects of study design that are important to define are:

- Scope of project, both temporally and geographically
- Whether or not there is a need for simultaneous study of reference sites
- To whom data will be reported/delivered
- What other monitoring and assessment tools will be utilized (such as a habitat assessment and/or invertebrate survey).

Some important resources for developing QAPPs are: *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* *(PDF 120KB)* – March 2001, EPA/240/B-01/003. (Defines specifications for Quality Assurance Project Plans prepared for activities conducted by or funded by EPA.); EPA's *Volunteer Monitor's Guide to QAPPs* (see References, Appendix B); and the EPA website, www.epa.gov/quality/qapps.html.

Reconnaissance

The best initial exploration of potential wetland assessment sites is by analyzing maps on paper or electronically with a Geographic Information System (GIS). U.S. Geological Survey maps, U.S. Fish and Wildlife Service National Wetland Inventory maps, and local zoning/tax maps, are all high quality resources. The discussion of site selection is thoroughly explained in other manuals (*e.g.*, U.S.E.P.A. 2001; Minnesota Pollution Control Agency, 2004; Hicks, 2000), and thus will not be treated here.

> **_Wetland Classification – Why and How?_**
>
> In order for one wetland to be measured in relation with another, they have to be comparable. The health of one wetland can only be assessed if it is compared to others in the same category. Thus a wetland under study must be carefully characterized in the correct classification.
>
> Several classification schemes exist. The most widely recognized and used is the U.S. Fish and Wildlife Service's "Cowardin" method, which is based largely on wetlands' plant communities. Due to the influence of other classification methods based on other variables, the U.S. Fish and Wildlife Service has developed a more rounded classification scheme that includes not only vegetation, hydrology, substrates and human impacts, but also:
>
> - Landforms (*e.g.*, slope, fringe, floodplain)
> - Landscape Position (*e.g.*, lentic, lotic, terrene)
> - Waterflow Path (*e.g.*, throughflow, inflow, isolated)
> - Waterbody Type (*e.g.*, lake, pond, stream)
>
> For more information, see the U.S. Fish and Wildlife Service's wetland website at: http://www.wetlands.fws.gov or contact Ralph Tiner at: ralph_tiner@fws.gov.
>
> In addition, each state's Natural Heritage Program usually has a natural community classification scheme that includes a number of wetland types in detail. These can also be used to characterize the wetland under study.

All potential wetland sites should be visited initially for reconnaissance. We highly recommend that a professional wetland ecologist or state wetland official accompany you on the reconnaissance. Once permission to access a site is obtained, an informal visit to the wetland can help determine:

- Potential issues with landowners or adjoining landowners
- If it is feasible to enter the wetland
- Possible routes for walking around and entering the wetland
- Potential safety issues
- How deep the water may be (will we need waders or just rubber boots?)
- Where to base the crew when studying the wetland
- The physical and vegetation type ("class") of the wetland
- Where and how the wetland will be best approached from the road
- If the parameters to be assessed indeed are present and make the most sense to study (*e.g.*, it may make more sense to study amphibians rather than to study vegetation in a site that is heavily forested)
- Possible presence of rare or endangered species

One of the most important of these determinations will be what "class" of wetland you are monitoring. An examination of U.S. Fish and Wildlife National Wetland Inventory (NWI) maps will provide you with a classification of the wetlands in question (for help deciphering their codes, see Cowardin *et al.*, 1979). However, these NWI classes were assigned using remote methods, and therefore a closer look at the wetland may reveal a different, more accurate picture of actual wetland type. This will best be done with the help of a wetland scientist. Wetland class is determined largely by vegetation, but also by a wetland's position on the landscape and its hydrology and geology. Often it takes a professional to be able to sort through these variables to determine the wetland class or type.

Relevé Plot Surveys

There are numerous ways to sample plant communities. The plant community sampling technique used in IPEP is a method adapted from those used by the U.S. Forest Service and many Natural Heritage Programs around the U.S. This sampling method is called the *relevé* sample (see Mueller-Dombois and Ellenberg, 1974). This method consists of one large plot which is used to characterize the target plant community. In the case of IPEP, the *relevé* plot is a standard 100 meter-squared (100 m^2) plot that is located in the emergent plant zone, which is typically located in the near-shore area of the wetland. The idea of focusing plots in the emergent zone originates with Minnesota Pollution Control Agency's *Citizen's Guide to Biological Assessment of Wetlands: The Vegetation Index of Biological Integrity* (IBI).

Learn Plant Features

Although IPEP does not require positive identification of plants in the field, field workers must nevertheless become familiar with some botanical terms in order to provide complete information for each plant characterization. It is important to note features such as opposite or alternate branching, flower types such as an umbel and spike, and leaf types such as toothed, lobed, entire, simple and compound. The more descriptive text provided, the more supplemental information there is to the photographs, which cannot be relied upon to be perfect or provide all necessary information for positive identification.

Most field guides to wildflowers, shrubs, grasses, and trees provide a few pages of this basic information to study or at least have handy in the field when collecting data. These can be studied, and also the **IPEP Plant Notation Sheet** (see Appendix D) can be used to practice in any outdoor setting with some vegetation.

Timing

Vegetation sampling is conducted in the summer, when most plants are either in bloom or fruit. You can never document all flowers, seeds, berries, etc. at their height, but early- to mid-summer ("peak growing season") is usually the best time for the more difficult-to-identify plants such as the grasses and sedges. If the site is more wooded, late spring may be better to catch more of the flowers.

If multi-year monitoring is planned, it must be done at approximately the same point in the growing season each year.

Teams

IPEP works best when people work in teams of 2-5 people. One team member should have some training in biology or other sciences (such as a high school biology teacher or a retired geologist/engineer).

PART III: FIELD SAMPLING

Practice Plots

The relevé sampling method requires the observer to visually estimate the area each plant species or genus occupies in the plot when looking straight down on the plot. This is called a percent **cover** estimate and is an effective way to measure the abundance of plants. A mental exercise to practice before going into the field is the estimation of percent cover. This can be done by deploying a 1 meter sq., 5 meter sq., or 10 meter sq. plot in any convenient meadow, field, or lawn. This will work best where there is some variety of vegetation, such as clover, wildflowers, and other plants besides grass. Stand over the plot and visually estimate the percent cover that each species of plant occupies, and then assign a cover value based on the table below. Remember that plants overlap each other, so that the total sum of your percent cover estimates may add up to well over 100%. This is especially true in wetlands that contain **submerged**, emergent and **woody plants**.

Pourquoi "relevé?"

The relevé method of sampling vegetation was developed in Europe by the Swiss ecologist Josias Braun-Blanquet, who helped classify much of Europe's vegetation. The relevé is especially useful when volunteers are rapidly assessing the diversity of plant cover over large areas. A "semiquantitative" method, the relevé relies on visual estimates of plant cover rather than on counts of each encounter with of a particular species in random plots along a transect line (CA Native Plant Society, 2004).

Cover values

6	75-100%, complete or nearly complete cover
5	50-75%, large group, definitely > 50% cover
4	25-50%, substantial group, near 50% cover
3	5 – 25%, plant is common in plot, > 5 % cover
2	1 – 5%, plant is well established, but has minimal cover
1	0 -1%, plant is rare, insignificant cover

Equipment Care

The most important repositories of your data are the cameras and the **IPEP Field Data Sheet** (Appendix F). Therefore, these must be kept out of the rain and in places where they will not be damaged or lost. To that end, it may be useful to have one person in charge of each clipboard and the papers on it, and another person in charge of each camera. Writing with pencil is helpful as well, because rain will not wash it away.

Other tips for protecting your data are to bring large, clear plastic storage bags, or dry bags, to wrap the clipboards and cameras. Camera cases are often adequate for protecting the cameras, so keeping these on hand can be useful.

Sampling Method Sequence

1. Determine the dominant plant communities

a) Make sure you can see enough of the wetland you are sampling to choose a representative plot location. Take a walk around the wetland (or a section of it that will give you a view of most of it) to look for variations in species composition and in structure. If there is a higher vantage point, use it to achieve a view of as much of the wetland as possible.

b) Determine the dominant, co-dominant and minor vegetation communities present in the wetland. For example, if reeds and grasses comprise 70% of the wetland's surface, this is the dominant community. An example of co-dominant communities: reeds and grasses cover about 20% and an aquatic bed (of pondweed, watershield, waterlilies, etc.) covers about 20%, and everything else is in the minority.

c) If you have a clearly dominant vegetation community, place your plot so that the highest number of minor communities will also be included as well as the dominant.

d) If you have a co-dominant community, make sure to include both of these co-dominants in the plot, if possible. The second priority is to include as many minor communities as possible.

e) In any case, locate the plot so that it captures the apparent edge of the wetland, or at least the edge of standing water and adjacent unflooded land.

f) Depict on your **Site Sketch Sheet** (Appendix E) any differences in the vegetation pattern from one area of the wetland to another.

2. Locate a spot for a representative plot

After you have identified the major vegetative patterns, determine where you could place <u>one</u> 100 m^2 plot that would best capture or represent the various vegetation types found in that wetland. If possible, have a professional wetland specialist help with this critical stage of the survey – the actual location of your sample plot.

Since emergent plants respond to human stressors more readily than woody plants, locate at least part of your sample plot in the emergent vegetation. If there is not an emergent community present, locate the plot so that it straddles what appears to be the wetland's edge. Show the location of your *relevé* plot on your **Site Sketch** Sheet. If the wetland is very large and has distinct enough areas that cannot be captured in a single *relevé* plot, consider establishing more than one plot.

Tips on how to choose a representative plot location

- When you are at your site, the wetland in question may seem extremely varied or divided into two or three distinct or patchy communities of plants. In such cases, it is a challenge to place the plot in a way that best captures a "snapshot" of the entire wetland. You will actively be using your own best judgment to find a representative example; you are not randomly selecting a plot. To greatly increase the validity of your judgment, one option is to hire a professional or schedule a natural resource agency staff member to accompany you on this very important step in the monitoring and assessment process. She or he will be able to observe and explain vegetation patterns and also whether or not there is more than one wetland class at your site.

- If the wetland is indeed one class, your task is to proceed to choosing a representative plot. If the wetland area encompasses more than one class, you must choose the class that you will focus on for this study. At this point, exclude the area that is determined to be of one or more different wetland classes. Depict the two or more classes by making a rough map on the **Site Sketch Sheet**.

- Do not be concerned if your plot does not capture all the vegetative patterns in the wetland. Although a representative plot is advantageous, the most important aspect of monitoring is watching change over time within the wetland plant community studied in one sample plot.

- Different and distinct plant communities within a wetland do not necessarily indicate the presence of more than one wetland type. If the wetland at hand has a relatively uniform landscape position, hydrology, and geology, it is probably one wetland type even if it encompasses very different plant communities.

- Specific plant species matter less than the general patterns you see in the vegetation community pattern. For example, you might see large areas of very tall grasses and reeds, some open water, and a swampy area with trees. Or, there could be an alder swamp thicket with wet sedge and grass meadow alongside. This variation is called "patchiness" within an ecosystem.

3. Determine the shape of the plot

Now that you have found a location for the plot, determine which plot shape; both equal to 100 m^2, would best capture the emergent plant community at that wetland:

5 meters x 20 meters OR ***10 meters x 10 meters.***

4. ***Lay out the 100 m^2 plot***

a) Pick a point to be corner #1 of your plot. Stake this corner and tie a piece of bright flagging tape to the top of the stake.

b) Using a compass, measure along a compass bearing the first side of the plot, walking so that the inside of the plot is to your left and the outside of the plot is to your right. On each side, choose a distant landmark for your bearing to get a straight line staying on the same degree reading. Stake and flag this corner (corner #2).

c) Now turn 90 degrees to your left and measure or pace the next side of the plot. Stake and flag corner #3.

d) Again, turn 90 degrees to your left and measure or pace to corner #4. The four staked and flagged corners should enclose an area equal to 100 m^2 (which can be checked by measuring the diagonal. In a 10m x 10m plot, the diagonal should be approximately 14.1m. In a 5m x 20m plot, the diagonal should be approximately 20.6m). If not, make adjustments as needed.

e) Go back and put wire flag stakes at approximately every 3 meters along the lines you just made (*i.e*., 2 flag stakes for a 10m side, 1 stake for a 5m side, and 6 flag stakes for a 20m side).

5. Record plot location using GPS

At each stake, take a reading using a Global Position System unit, if available. This will be an important back-up to your site sketch. In the case where stakes must be removed, GPS coordinates will help workers find a plot in subsequent years. This will be especially useful for multi-year monitoring of the same plot. Please note: although GPS units are valuable tools, they may not function properly due to the occasionally poor alignment of satellites or due to the complexity of certain types of terrain. We thus recommend that you carry the relevant USGS topographic map and note your position on it in the event of a non-responsive or inaccurate GPS.

6. Survey the different plant genera

Inventory the plants within the plot while trying not to trample the plot. It is ideal if one to three people walk the plot, finding new plants and photographing them, while one or two people record their observations and the necessary details about the photographs. Here are the detailed steps for the survey:

a) To begin surveying the plot, walk from the first corner just inside the plot boundary toward corner #2, and record the plants as you encounter new ones in the plot. Record each plant on the **IPEP Field Data Sheet** (Appendix F) and add new plants as you encounter them (see specifics in the Photography section, #2, below). *Count plants on the border as well as plants rooted outside of the plot but with branches extending over the plot.*

b) Reach into any standing water every meter to see what submerged plants you find in your hand (no need to pull). Measure the depth of the deepest water encountered in the plot (use either a straight stick or a weight at the bottom of tape measure), and note on data sheet.

c) Continue walking the plot proceeding past corners 2, 3 and 4. After passing corner #4, proceed about 1/3 of the way down the plot, and cut through the plot to the opposite side. When you get to the opposite side, move down another 1/3 of that side and cut through to return to corner #1. The plant inventory step should now be complete. If you use a 5m x 20m plot, walk through the plot three or four times instead of just twice. The given procedure assumes a 10m x 10m plot.

7. Assign cover values

One of the primary jobs of the researcher is to estimate what percentage of area is covered by each **genus** of plant. Estimating "percent cover" is not an exact science, which is why cover values are used here instead of precise percentages. Estimating percent cover consists of imagining yourself taking a bird's-eye view of the 100 m^2 plot, picking out only the plant in question, and observing how much area ALL individuals of that plant occupy within the plot as you look down upon it***. Do not be concerned if the percentages of various plants will add up to more than 100%.*** They probably will. Treat each plant in its own right and do not think about the total coverage of all plants.

One trick for helping estimate percent cover is to mentally divide the plot into four quadrants and estimate the cover of the plant in each of the four, then taking the average. Another mental trick is to send or "squash" all the individuals of the species into one corner, and now that they are bunched, estimate their cover. For more tips on estimating percent cover, see: California Native Plant Society Vegetation Committee, 2004.

For purposes of this protocol, the following definitions apply.

Keeping the three categories separated helps aid in identification and adds definition to the plant inventory of the site.

Herbaceous
Herbaceous plants (herbs) are soft-stemmed, and have relatively pliable stems that either wilt or do not survive winter (do not include nonvascular taxa such as algae). Herbs include ferns, grass-like plants, and emergent genera such as cattail, iris or arrowhead. We include emergent plants - those rooted in standing water but emerging from the surface of the water - in the herbaceous category.

Submerged
Submerged are those that are underneath the surface of standing water (again, do not include nonvascular taxa). Although floating plants are not technically submerged, we include them in this category for the sake of simplicity.

Woody
Shrubs and vines as well as trees are grouped in the woody-stemmed plants. The stems or trunks of woody-stemmed plants easily endure winter and are rigid, solid and firm. Seedlings and sprouts of trees should be placed in the woody category and noted on the data sheet (as "SP").

It is best to have at least two people estimating cover, as their collective sense of percent cover may be more accurate than one person's. ***The same people should remain on the percent cover estimation task throughout the field survey***, because changing personnel may cause inconsistency in results.

For each identified or unidentified submerged, herbaceous, or woody plant genus found in the plot, estimate a percentage, and then assign the correct cover value (6, 5, 4, 3, 2, 1). Try not to labor over estimating cover class values. If half the team thinks the cover class of *Sedge A* is 3 and the other half thinks it's 4, but both agree that *Sedge A* covers somewhere around 25% of the plot, select the lower value.

Cover values

6	75-100%, complete or nearly complete cover
5	50-75%, large group, definitely > 50% cover
4	25-50%, substantial group, near 50% cover
3	5 – 25%, plant is common in plot, > 5 % cover
2	1 – 5%, plant is well established, but has minimal cover
1	0 -1%, plant is rare, insignificant cover

8. *Estimating cover of woody plants*

For each **taxon** (species or genus) of woody plant, you may need to use creative spatial relations to estimate percent cover. In the case of most woody shrubs and trees, you will not be able to look down on them to estimate cover area, and so you will be estimating their "crown coverage" by either measuring with your tape measure or estimating with your eye. In the case of tall trees that form a canopy above your head, look up to estimate their crown coverage in the space directly above the plot. If there are more than one species within the genus (such as silver and red maple, or different dogwoods), make note of this on the data form and be sure to photograph what you think are the separate species (e.g., *Acer A*, *Acer B*). For tips on estimating cover of trees, see California Native Plant Society Vegetation Committee, 2004.

Photography

1. *Check equipment and complete written data forms*

a) Check the digital camera's operations. Write down the model of the camera and note the numeric prefix of the "shot" numbers (*e.g.*, DSC00). Complete meta-data such as location, workers, date and time, etc.

b) On the Dry-erase board, write in a corner an abbreviation or acronym of your wetland site, such as "LLO" for Lower Lamoille Oxbow. Later, you will be adding "S," "H," or "W" (for Submerged, Herbaceous, or Woody) to the number of the "shot". Also write either hash-marks or a grid with regular measured intervals such as one or five centimeters.

Cameras

The key piece of equipment for IPEP is the digital camera; therefore, it must be well maintained. To assure that your digital camera will be in good working order in the field you should:

- Adjust the camera to a setting that will yield adequate resolution when printed. In other words, err on the side of higher quality photos, especially if your camera has a lower capacity than 2 Megapixels
- Take sample photos well beforehand, download to a computer, and print one to make sure all functions are operational, and that photos are of good quality
- Have an extra set of batteries for the camera, and make sure both sets are fully charged or fresh
- Have an extra memory card or disk in camera case/bag
- Line up an extra camera in case one malfunctions. The two or more cameras should be distinct from each other. If they are the same make and model, they should be numbered with indelible marker.

2. ***Take and record photographs***

a) Number the first plant specimen on the data form according to the "shot" number your camera assigns to the first photograph. While one person works with the camera, others can begin making and recording observations about the plant on the data form such as "opposite branched, compound leaves, bark looks braided". Use the **IPEP Plant Notation Sheet** (see Appendix D) to facilitate and record observations about the plant.

b) Use the same number (as the "shot") and write it on the Dry-erase board, adding it to the abbreviation or acronym of your wetland site, such as "LLO," and add "S," "H," or "W" after a hyphen for the type of plant. Thus, in the corner of the Dry-erase board you would have: #655 LLO-H. *Write this in large lettering!* Otherwise it will not be visible in the photograph. The "LLO" portion of the heading will remain constant, whereas the number of the photo shot will be erased and replaced after each shot and the "S," "H," or "W" will be erased and replaced as you proceed from one type of plant to another type.

c) Use the "code" column of the data sheet to record the condition of the specimen, if notable. It is not necessary to enter a code in many cases.

Codes for Specimen Condition	
DD dead DY dying SP sprout/seedling	LD leaves discolored IN insect damage LS leaf spots

d) Lay plant parts against the Dry-erase board to take photos. Try to capture stem, leaf, and the sexual part of the plant (flower, seed, or fruit) in one shot. If this is not possible, take two or three shots of the plant, making sure to capture any or all of these three parts that are present. Data regarding each shot should be entered on the data form in sequence. When taking more than one photo of the same plant, use the same number but add a "b," "c," etc. to the number. For example, when several photos of plant #656 are taken (*e.g.*, leaf, twig, bark) the shots will be recorded as 656a, 656b, and 656c. The photography can usually be done without actually picking any parts of the plant, but if the plant is too small or if it is too awkward to photograph the plant *in situ*, pick it and place on the white board.

e) When aiming the camera at a sample, ***hold as still as possible when taking the photograph!*** One method to help do this is to take a deep breath, exhale, and then press the button for the shot. We recommend disabling the flash for most outdoor conditions, as sometimes flashes can wash out the color and depth in the photo.

f) ***Avoid picking plants*** whenever possible. The disadvantages of picking samples are: risk of picking rare, threatened or endangered species, which is illegal and also may compromise the species' population in that area, and risk of spread of exotic, invasive species if samples are not handled correctly. We do not recommend picking plants for IPEP, but if you think a plant will be especially difficult to identify, picking and pressing may be an acceptable choice.

g) For some trees, it may be difficult to obtain fruits, leaves, flowers, etc., and therefore it is important to photograph bark as well as other features. If possible, bring down a branch to eye level.

PART IV: DATA MANAGEMENT

Lab Methods

1. Store data

Once you are back indoors, back up written records by photocopying them. Also as soon as possible after returning from the field, save the photographs to a computer hard drive as well as to a Compact Disk. Save files with the following file naming format: Wetland abbreviation, Shot number, date. You can also add the scientific plant name if you are sure your identification is correct. It would look like this: "LLO shot 655b 9/4/06" or "LLO shot 655b 9/4/06 Eupatorium" Photos should also be printed on hard copy, and captions must be printed as well. Printing in black and white can be done at first to save cost, but if this renders identification too difficult, some photos may need to be printed in color (especially flowers and berries).

2. Identify plants

Once the photographs are printed, assemble a variety of plant keys (see suggested reference books in Appendix B). Also have on hand the filled-out **IPEP Plant Notation Sheet** (Appendix D) if they give extra details about some of the plants photographed.

Use the keys to identify the plant, focusing on fruits, flowers, bark, leaves, or other important features. If a plant is not found on the first three pages of the **IPEP Lab Sheet** (Appendix G), it may be found on page 4, which is the page for invasive exotics. If you have any doubts about the final determination about the plant's name, make note on the lab sheet any questions you have about its identity. Write the cover class value and percentage midpoint on the **IPEP Lab Sheet** next to the subject plant. You will basically be transferring the "Shot#" and the cover class value from the **IPEP Field Data Sheet** (Appendix F) in order to make your identification traceable.

Where to Find a Botanist?

- State Department of Environmental Conservation
- State Natural Heritage Program
- The Nature Conservancy
- New England Wild Flower Society
- Local Conservation Commission

After identification of photos is complete, have a professional botanist check at least a portion of them. Because it is unlikely a botanist will have the time to check all photo shots, she or he may spot-check the photos (randomly select), as well as the corresponding written data sheets. It is best for the botanist to sample at least 20 in all for each site studied: 5 from the submerged layer, 10 from the herbaceous layer and 5 from the woody layer.

Keep relevant records in a safe, retrievable place. All the data sheets that you have filled out (**IPEP Plant Notation Sheet, IPEP Field Data Sheets, Site Sketch Sheet,**

IPEP Lab Sheets, Calculation of Metrics, all of which are appendices to this document) should be kept as back-up records of the work the group has done.

Interpretation of Results

1. Calculation of Metrics

a) Metric 1: Number of vascular plant genera

Using tallies from the **IPEP** (Appendix G), count the number of different genera of **submerged plants**, herbs, and woody plants within the sample *relevé* plot. Do NOT include invasive exotic species in this count.

b) Metric 2: Percent abundance of invasive exotic species

Unlike the other plants in the survey, invasive exotic plants should be identified to species level. This specificity is necessary in this case because often members of the same genus have very different invasive characteristics and can originate in different parts of the world. Some species are more invasive and widespread than others. We suggest that you consult with experts in your area (Fish and Wildlife Dept., Nongame and Natural Heritage Program, etc.) for which species are particular threats.

Some of the better known invasive exotic species are noted in many publications. The primary source we have obtained our list from is the Invasive Plant Atlas of New England. Contact for "IPANE" is: www.ipane.org; c/o Les Mehrhoff, University of Connecticut, 75 North Eagleville Rd. U-3043, Storrs, CT 06269. The website features up-to-date threats and thorough descriptions of each plant's characteristics, habitats, and threats.

To calculate the ratio of the abundance of invasive exotic plant taxa to all plant taxa, you will first need to convert cover class values of *ALL PLANT TAXA FOUND* back to percentages. This is done by using the midpoints of the ranges of percentages for the cover classes. For example, if a plant was given a cover class of 3, it will have a percentage midpoint of 15%. These figures are provided on each page of the IPEP Lab Sheet

Once all percentage midpoints have been assigned (in the third column from the left on the IPEP Lab Sheet), add up all the percentage midpoints of the native taxa. Then add up all the percentage midpoints of the invasive exotic taxa. Then take the ratio of the sum of percentage midpoints of only invasive exotic plants to the grand total of percentage midpoints for all plants.

See Appendix C: Calculation of Metrics, to facilitate this calculation.

2. Comparison to Reference Sites

As noted earlier, data gathered using IPEP will be most useful when paired with equivalent data from one or more reference sites. If your study design includes a plan to monitor the same site(s) and plot(s) for multiple years, it is possible that charting change only within the subject wetland will be sufficient to meet the needs of your study.

In any case, it is important to write a Quality Assurance Project Plan that makes explicit whether or not it is necessary to study reference sites concurrently with the monitoring and assessment of your subject site.

3. Overall Assessment

It is recommended that at least two assemblages of biota be studied within a wetland when assessing biological integrity. Information from studying one assemblage (such as vegetation) can offer insight into a wetland's condition, but indications of health or impairment become much clearer when and if a second assemblage (such as invertebrates, amphibians, or fish) is also studied.

At the very least, an IPEP study should be coupled with a habitat assessment. A visual assessment of the apparent condition of the wetland (based on parameters such as vegetative buffer, impervious surface in immediate watershed, human alterations to hydrology, etc.) will afford a set of environmental data against which to measure biological data.

4. Reporting Findings

Before starting a wetland assessment and/or monitoring project, study objectives must be determined and collaborative agencies must be identified. For more information about study design see U.S.E.P.A. 2001; and Hicks, 2000. It is also necessary to establish a Quality Assurance Project Plan (QAPP) for the wetland study. Both efforts – creating a study design and developing a Quality Assurance Project Plan (they often go hand in hand) – will go a long way toward determining how reporting will occur and to whom.

For this type of study, which seeks to characterize the vegetation in a subjectively chosen area of a wetland (as opposed to randomized samples which may be more scientifically representative), data presentation can be relatively simple. Downloading and entering data into the spreadsheets provided by NEIWPCC on-line will suffice as the primary reporting tool as well as data management tool. Appendix C., Calculation of Metrics, will also be important to include in the report.

GLOSSARY*

Aquatic species: those species only found in habitats containing some standing water (inundated areas).

Assemblage: an association of interacting populations of organisms that belong to the same major taxonomic groups. Examples of assemblages used for bioassessments include: algae, amphibians, birds, fish, amphibians, macroinvertebrates (insects, crayfish, clams, snails, etc.), and vascular plants.

Assess: to evaluate using the best available information; to synthesize data in order to reach an overall judgment of the health of a water body.

Attribute: a measurable component of a biological system. In the context of bioassessments, attributes include the ecological processes or characteristics of an individual or assemblage of species that are expected, but not empirically shown, to respond to a gradient of human disturbance.

Bioassessment: using monitoring data of samples of living organisms to evaluate the condition or health of a place (*e.g*., a stream, wetland, or woodlot).

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

Biota: all the plants and animals inhabiting an area.

Cover: the area, taken on a 2-dimensional, horizontal plane, occupied by all parts (leaves, flowers, branches, etc.) of a chosen plant taxon within a designated plot.

Disturbance: any discrete event in time that disrupts ecosystems, communities, or population structure and changes resources, substrate availability or the physical environment. Examples of natural disturbances are fire, drought, and floods. Human-caused disturbances are referred to as “human disturbance” and tend to be more persistent over time, *e.g*., plowing, clearcutting of forests, and conducting urban stormwater into wetlands.

Ecosystem: any unit that includes all the organisms that function together in a given area interacting with the physical environment so that a flow of energy leads to clearly defined biotic structure and cycling of materials between living and nonliving parts.

Emergent: organisms that are partly in water and partly exposed, such as plants that are rooted in water but whose upper parts are aerial. Emergent wetland vegetation includes sedges, rushes, and grasses.

Freshwater wetlands: marshes, bogs, fens, swamps, oxbows, vernal pools, and other types of wetland containing non-saline water.

Genus/genera: taxonomic category above the species level (and below the family level), designated by the first word of a species' binomial Latin name.

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

Herbaceous: plant with no persistent parts above ground, as distinct from shrubs and trees.

Hydrologic: pertaining to the properties, distribution, and circulation of water, both on the surface and under the earth.

Impairment: adverse changes occurring to an ecosystem or habitat. An impaired wetland has some degree of human disturbance affecting it.

Indicator: organism or structural feature so strictly associated with a particular environmental condition that its presence signals the existence of this condition.

Invasive exotic species: species introduced to an area where they are not native, and where they are able to proliferate and aggressively alter or displace native natural communities.

Inventory: an exhaustive listing of all members of a particular assemblage or community in a given area.

Marsh: wetland characterized by frequent or continual inundation, emergent herbaceous vegetation such as cattails and rushes, and mineral soils.

Metric: an attribute with empirical change in value along a gradient of human disturbance.

Monitor: to perform and record observations and measurements of a water body repeatedly over a designated period of time. The purpose of monitoring is to compare readings over time so that changes and trends become apparent.

Plant community: all vegetative organisms living together in the same area, usually interacting or depending on each other for existence.

Protocol: a codified method offering prescriptive guidance on all relevant operating procedures.

Reconnaissance: informal survey of site(s) to be studied, similar to a scouting mission.

Reference condition: a derived set of characteristics found at wetlands of the same class that are minimally influenced by human actions. This derivation is established from pooled data gathered from a set of reference wetlands (see “reference site” below), and must be representative of the natural conditions within the same landscape setting (riverine, lacustrine, depressional, fringe), geological (mineral or organic soils) and climatic setting, the same hydrological regime and dominant vegetation class or classes as the subject wetland(s).

Reference site (as used with an index of biological integrity): a minimally impaired site that is representative of the expected ecological conditions and integrity of other sites of the same type and region. The biota at a reference site are the product of evolutionary and biogeographic processes in the relative absence of the effects of modern human activity.

Relevé: plant survey plot used as an alternative to the randomized, transect-based method. The relevé is an attempt to obtain the most representative sample possible using one intentionally chosen larger plot as opposed to several randomly chosen small ones.

Representative sample: data regarding a portion of a population in which the data reflect the overall composition and characteristics of the population itself.

Stressor: any physical, chemical, or biological entity that can induce an adverse response.

Submerged plant: those plants whose entire structures are floating and/or underneath the surface of standing water.

Taxa/taxon: a grouping of organisms given a formal taxonomic name such as species, genus, family, etc. The singular form is taxon.

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

Vascular plant: vegetation containing conducting tissue such as stems or roots.

Wetland(s): several definitions exist. Three used in the U.S. are: (1) Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (EPA, and U.S. Army Corps of Engineers); (2) Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (a) at least periodically, the land supports predominantly hydrophytes, (b) the substrate is predominantly undrained hydric soil, and (c) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (U.S. Fish and Wildlife Service); (3) The term “wetland” except when such term is part of the term “converted wetland,” means land that (a) has a predominance of hydric soils, (b) is inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, and (c) under normal circumstances does support a prevalence of such vegetation. This term does not include lands in Alaska identified as having a high potential for agricultural development which have a predominance of permafrost soils (U.S.D.A.).

Woody plant: Containing xylem (tube-like, non-living structures carrying water and minerals), which tends to add rigidity and durability to the plant such that it can persist through winter and other stressors.

*Principal sources for glossary include U.S. EPA., 2002 (glossary in #1), National Research Council, 1995 (glossary), and Firehock et al, 1998 (glossary).

APPENDIX A: LIST OF EQUIPMENT

- ❑ Two or more digital cameras, at least 2 Megapixel is recommended, each camera distinct from the other
- ❑ One clipboard for each person who will be recording data
- ❑ Tape measure (in meters) – reel variety at least 25 meters long.
- ❑ Weight for end of tape measure if standing water may be deeper than arm's length
- ❑ Plant identification field guides (for flowers, grasses, shrubs, vines, aquatic plants, and trees)
- ❑ Two or more copies of **IPEP Site Sketch Sheet**
- ❑ Two or more copies of **IPEP Field Data Sheet**
- ❑ Two or more copies of **IPEP Plant Notation Sheet**
- ❑ Portable, small "Dry-erase" white board, "dry-erase" markers, and an eraser
- ❑ Box of 1-gallon ziplock bags (in case a few samples need picking)
- ❑ 4 wooden stakes
- ❑ 15 wire flag stakes
- ❑ Flagging tape
- ❑ Hammer (large framing hammer if possible)
- ❑ Compass
- ❑ USGS Topographical map of area
- ❑ Global Positioning Systems (GPS) unit (optional)
- ❑ Rubber boots and/or waders or old sneakers

APPENDIX B: REFERENCES

The following are reference materials for the content of this protocol as well as suggestions for resources to use in the field and in the lab. **Titles in bold are those that are especially user-friendly for volunteers to prepare for wetland study and to use in the field and lab.**

Andreas, B., and R. Lichvar. 1995. A Floristic Quality Assessment System for Northern Ohio. *Wetlands Research Program Technical Report WRP-DE-8*. U.S. Army Corps of Engineers, Waterways Experiment Station.

Gray, A, R. P. Brooks, D. H. Wardrop and J. K. Perot. *Pennsylvania's Adopt-a-Wetland Program Wetland Education and Monitoring Module: Student Manual*. Penn State Cooperative Wetlands Center.

Brinson, M.M., and R. Reinhardt. 1996. The role of reference wetlands in functional assessment and mitigation. *Ecological Applications* 6(1):69-76.

Brown, L. 1979. *Grasses: An Identification Guide.* Boston: Houghton Mifflin Company.

California Native Plant Society Vegetation Committee. 2004. *California Native Plant Society* Relevé *Protocol.* Sacramento, CA: California Native Plant Society.

Campbell, S.C. and F. Hyland, 1975. *Winter Keys to Woody Plants of Maine.* Orono, Maine: University of Maine Press.

Carlisle, B.K., A.L. Hicks, J. P. Smith, S.R. Garcia, and B.G. Largay. 1999. Plants and Aquatic Invertebrates as Indicators of Wetland Biological Integrity in Waquoit Bay Watershed, Cape Cod. *Environment Cape Cod* 2(2):30-60.

Cowardin et al., 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* Washington, DC: US Dept. of the Interior, Fish and Wildlife Service, Office of Biological Services.

Crow, G.E. and C.B. Hellquist. *Aquatic and Wetland Plants of North Eastern North America in two volumes. Volume 1: Pteridophytes, Gymnosperms, and Angiosperms: Dicotyledons; Volume 2 Angiosperms: Monocotyledons*

Danielson, T. 1998. *Wetland Bioassessment Fact Sheets*. EPA 843-F-98-001. Washington, DC: U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Wetlands Division.

Eastman, J. 1995. *The Book Of Swamp and Bog. Trees, Shrubs, and Wildflowers of Eastern Freshwater Wetlands.* Mechanicsburg, PA: Stackpole Books.

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

Hallowell, A.C. and B.G. Hallowell. 1981. *Fern Finder.* Berkeley, CA: Nature Study Guild.

Herman, K. D., L. A. Masters, M. R. Penskar, A. A. Reznicek, G. S. Wilhelm, and W. W. Brodowicz. 1996. *Floristic quality assessment with wetland categories and computer application programs for the state of Michigan*. Michigan Department of Natural Resources, Wildlife Division, Natural Heritage Program.

Hicks, A.L. 2000. *New England Freshwater Wetlands Invertebrate Biomonitoring Protocol: A Manual for Volunteers.* Amherst, MA: U. Mass Extension.

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

Jones, L.R. and F.V. Rand. 1979. *The Handbook of Vermont Shrubs and Woody Vines.* Rutland, Vermont: Charles E. Tuttle & Co.

Karr, J.R. and E.W. Chu. 1997. *Biological Monitoring and Assessment: Using Multimetric Indexes Effectively*. EPA 235-R97-001. Seattle: University of Washington.

Knobel, E. 1977. *Field Guide to the Grasses, Sedges and Rushes of the United States.* New York: Dover Publications, Inc.

Mack, John J. 2000. *Vegetation Indices of Biotic Integrity (VIBI) for Wetlands and Calibration of the Ohio Rapid Assessment Method for Wetlands v. 5.0.* Columbus, Ohio: State of Ohio Environmental Protection Agency.

Magee, D.W. 1981. *Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast.* Amherst, Massachusetts: The University of Massachusetts Press.

Minnesota Pollution Control Agency, 2004. *Draft: A Citizen's Guide to Biological Assessment of Wetlands: The Vegetation Index of Biological Integrity (IBI).* St. Paul, Minnesota: Minnesota Pollution Control Agency (available at http://www.pca.state.mn.us/publications/wq-bwm1-01.pdf)

Mueller-Dombois and H. Ellenberg; 1974. *Aims and Methods of Vegetation Sampling.* New York: John Wiley & Sons.

National Research Council. 1995. *Wetlands: Characteristics and Boundaries.* Washington, DC: National Academy Press.

Neiring, W. A. 1985. *Wetlands: National Audubon Society Nature Guides.* Alfred A. Knopf.

Newcomb, L. 1977. *Newcomb's Wildflower Guide.* Boston: Little, Brown and Company.

Peet, R.K., T.R. Wentworth, R.P. Duncan, and P.S. White. 1996. *The North Carolina vegetation survey protocol: a flexible, multipurpose method for recording vegetation composition and structure. Final Report*. Aiken, SC: USDA Forest Service, Savannah River Institute.

Peterson, R.T. 1968. *A Field Guide to Wildflowers of Northeastern and North-Central North America.* Boston: Houghton Mifflin Company.

Petrides, G.A. 1986. *Trees and Shrubs (Peterson Field Guides).* Boston: Houghton Mifflin Company.

Redington, C.B. 1994. *Plants in Wetlands: A Redington Field Guide to Biological Interactions.* Kendall-Hunt Publishing Co.

Reed, P.B. 1988. *National List of Plant Species that Occur in Wetlands: 1988 Vermont.* St. Petersburg, Florida: U.S. Fish and Wildlife Service.

Sorrie, B.A. 2000. *The Vascular Plants of Massachusetts: A County Checklist.*

Symonds, G.W.D. 1963. *The Shrub Identification Book.* New York, NY: William Morrow & Co.

Symonds, G.W.D. 1958. *The Tree Identification Book.* New York, NY: William Morrow & Co.

Thompson, E.H and E.R. Sorenson. 2000. *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont.* Hanover, NH: University Press of New England.

United States Environmental Protection Agency. 1996. *The Volunteer Monitor's Guide to Quality Assurance Project Plans*. EPA 841-B-96-003. EPA Office of Wetlands, Oceans, and Watersheds (4503F), Washington, DC 20460.

United States Environmental Protection Agency. 2001. *Volunteer Wetland Monitoring: Introduction and Resource Guide*. EPA 843-B-00-001. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

United States Environmental Protection Agency. 2002. *Methods for Evaluating Wetland Condition: Introduction to Wetland Biological Assessment.* EPA-822-R-02-014. Washington, DC: U.S. Environmental Protection Agency, Office of Water.

Vermont Nongame and Natural Heritage Program. 2003. *Vermont Rapid Community Assessment Form*. Waterbury, VT: Vermont Fish and Wildlife Department.

Warren, S. 1990. *Lake and Pond Plants: A Guide to Vermont's Common Aquatic Plants and Their Natural Values in Lakes.* Waterbury, VT: Vermont Department of Environmental Conservation.

APPENDIX C: CALCULATION OF METRICS

Use the information recorded on the **IPEP Lab Sheet** (Appendix G) to complete the following metrics.

Metric 1. Vascular Genera Metric: Count the number of different genera of submerged/floating, herbaceous and woody plants within the sample plot, excluding those found on the list of invasive exotic plants, or others that you have been informed about (see Appendix G, p. 4).

A. Total number of **submerged**:__________
Includes all aquatic genera (except nonvascular taxa) floating & submerged.

B. Total number of **herbs**:_________
Includes grass-like plants, and emergent genera such as ferns, cattail, iris or arrowhead.

C. Total number of **woody plants**:_________
Includes shrubs, vines and trees.

Sum A+B+C:________

Remarks:

Metric 2. Percent Abundance of Invasive Exotic Plants: This is the ratio of invasive exotic plants to all plants in the sample plot. Calculate the sum of percentage midpoint coverages of all native vascular genera. Also calculate the sum of percentage midpoint coverages of all invasive exotic plants. Then take the ratio of the percent cover of only invasive exotic plants to the grand total of percent cover for all plants.

This first requires a conversion of class cover values back to percentage values. We will use the the midpoint of the cover class range to represent the percent cover of each cover class. Below is the conversion table:

Cover Class Value	Cover Class Range	Midpoint of percentage
6	75-100%	87.5%
5	50-75%	62.5%
4	25-50%	37.5%
3	5-25%	15%
2	1-5%	3%
1	0-1%	0.5%

Next, take the sum total of the percentage midpoints of all invasive exotic plants and divide by the sum total of percentage midpoints of all native plants PLUS the sum total of the percentage midpoints of all invasive exotic plants.

A. Sum total of percentage midpoints of all native plants found: ______

B. Sum total of the percentage midpoints of all invasive exotic plants: _______

C. Grand total of A and B: _______

D. Quotient of B and C: _______

Hypothetical Example:

A. 200% (cover of all native taxa)
B. 50% (cover of invasive exotic taxa)
C. 250% (grand total cover of all plant taxa)
D. 50% divided by 250% = 20% (percent abundance of invasive exotics)

Remarks:

Metric	**Result**
1. Vascular genera count	
2. Percent abundance of invasive exotic plants	%

Additional Site Remarks: Please provide any additional information about this site and/or the vegetation survey. What are your overall impressions of the site? Does it appear to have potential to be a reference site? If impaired, how might the wetland be improved? Are there any potential threats to the site (e.g. new developments, stormwater routing plans, roads, etc.)? Did you see or hear any wildlife while at this site? Please note any unique plants or plant communities associated with this wetland but that you happened to observe outside the sampling area. Do you think the methods for evaluating the vegetation are adequate for this site?

APPENDIX D: PLANT NOTATION SHEET

New England Interstate Water Pollution Control Commission
Image-based Plant Estimate Protocol ("IPEP")

This data sheet is meant as a guide to help workers observe the features of plants they are photographing for the IPEP protocol. The notes from these data sheets do not necessarily need to be kept, but it is possible that saving them will help identify plants in the lab. Use of this form is not recommended for every plant encountered, but rather as a general guide to notation and as a record of observations for the more difficult-to-identify or rare plants seen.

Date________
Location____

Shot number(s)_______
Personnel/organization____

Please refer to these plant features when looking at a plant to take notes on it (on the IPEP Field Data Sheet, Appendix F).

LEAVES

1. What is the vein pattern like? Parallel? Branching?
2. Are the leaves opposite or alternate?
3. Are they toothed or lobed?
4. What is the shape of the leaf? ___________________________
5. Are the leaves simple or compound?

FLOWERS AND BERRIES

1. Can you see flowers or berries?________________
2. What color are they? _________________________
3. What shape?________________________________
4. If berries, how many seeds (choose several, take average) _____

OVERALL "HABIT" OF PLANT

1. Does it grow straight up or somewhat leaning or sideways?
2. Is stem or trunk single or in a group?
3. What is the geometry of the stem (round, square, triangular)?
4. Does the plant emerge from the water (is part of it rooted under water)?
5. Grow in dense stands, small groups, or mostly alone?

Other observations:

This plant's name appears to be: ____________________________________

APPENDIX E: SITE SKETCH SHEET

Create a rough site sketch and show location of sample plot. Show north and any significant landmarks. Note at least one GPS latitude/longitude reading, if available.