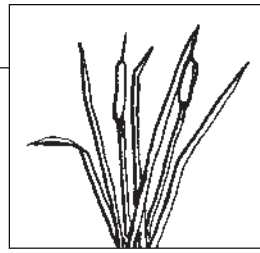
Water Quality Series: WQ-55

A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes

MICHIGAN STATE UNIVERSITY EXTENSION



A Citizen's Guide for the Identification, Mapping and Management of the Common Rooted Aquatic Plants of Michigan Lakes

by

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May 2007 (2nd edition)

Acknowledgements

Reviewers . . . . David Kenaga, David Schipper and Ralph Bednarz
(Michigan Department of Environmental Quality)
Tony Groves, Pam Tyning and Paul Hausler (Progressive AE)
Bruce Bonnell (Michigan Lake & Stream Associations, Inc.)
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This manual was also reviewed and field tested by several Michigan lake associations and individual riparians.

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Support for this publication has been provided by:

DEPARTMENT OF FISHERIES AND WILDLIFE
Michigan State University

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
Steven Chester, Director
Jennifer Granholm, Governor, State of Michigan

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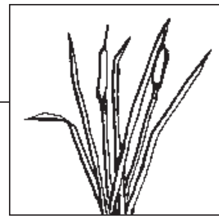

Preface

This citizen's guide to the identification, mapping and management of rooted and some non-rooted aquatic plants is for riparians and others interested in Michigan lakes. It does not replace the advice of a professional aquatic ecologist, which most lake associations will find essential. Effective management requires informed citizens and professional guidance. The purpose of this manual is to help citizens know and understand aquatic plants and work with their professional consultant, contractor, Extension agent and governmental agencies to effectively manage an incredibly valuable resource — their lake.

Rooted aquatic plants include both the attached and free-floating rooted plants. Some of the larger aquatic plants, such as coontail and stonewort, are also included in this guide even though they do not possess true roots. Algae, the small, often microscopic plants, are not addressed in this manual. Though not covered here, the algae are important to the lake ecosystem. Any comprehensive lake management plan will address not only the rooted plants and algae but animal communities, watershed inputs and recreational needs. The lake is a complete ecosystem and should be managed holistically to provide the greatest benefit for present and future generations.

Aquatic plants are a natural and essential part of the lake, just as grasses, shrubs and trees are a natural and essential part of the land. Their roots are a fabric for holding sediments in place, reducing erosion and maintaining bottom stability. They provide habitat for fish, including structure for food organisms, nursery areas, foraging and predator avoidance. Waterfowl, shore birds and aquatic mammals use plants to forage on and within, and as nesting materials and cover. Though plants are important to the lake, overabundant plants can negatively affect fish populations, fishing and the recreational activities of property owners. In this situation, it is advantageous to manage the lake and its aquatic plants for the maximum benefit of all users.

The chapters of this manual cover important topics for understanding aquatic plants. The first seven chapters are building blocks for Chapter 8, the management plan. Working through the chapters, the user will learn to recognize the importance of lake ecology and watershed management (Chapter 1), discern the values of aquatic plants and their interactions in the lake environment (Chapter 2), identify and characterize the common plants of Michigan lakes (Chapter 3), make a plant collection (Chapter 4), map the plants growing in a lake (Chapter 5), secure public input (Chapter 6) and select appropriate management options and tools (Chapter 7). Chapter 8 then guides the user through the development of a plant management plan for the lake.

The purpose of the manual is to assist in the development of a management plan, but the user may employ individual chapters for specific needs. Periodically, Michigan Lake & Stream Associations, Inc., MSU Extension and others may offer training in the use of this manual.

In this edition, updates are provided on herbicides, scientific name changes for plants and the invasive species hydrilla. As of Spring 2007, hydrilla has not been found in any Michigan lakes.

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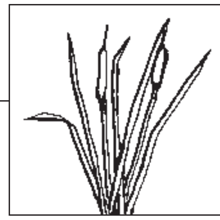

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Chapter 1

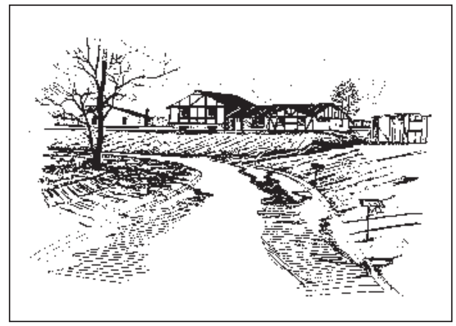
The State of Your Lake and Watershed

Introduction

Lakes are not created equal — some are naturally large, deep and clear; others are naturally small, shallow and muddy. Generally, large, deep lakes have limited aquatic plants, while small, shallow lakes have an abundance of plants. Good resource management of aquatic plants requires knowledge of the condition of the lake and the land surrounding it. Though important, the scope of this manual does not permit a comprehensive presentation of lake ecology or land management. These issues are more completely developed in other references specifically devoted to aquatic science and resource management. The reference section at the end of the chapter refers the user to these other documents, which should be consulted for additional information. This chapter provides only an introduction to lakes and their watersheds. A lake's watershed is the land surrounding the lake across which water drains to reach the lake.

Eutrophication — the State of Lakes

All lakes "age" or naturally become more fertile with time. The rate of this aging process, referred to as "natural eutrophication", depends on the lake's characteristics and the quantity of sediments and nutrients that wash into the lake from the watershed. The more sediments and nutrients a lake receives, the more fertile it becomes and the more plant life it produces. In most lakes, natural eutrophication is a very slow, gradual process requiring thousands of years to evolve. Rapid lake aging, often referred to as cultural eutrophication, is an accelerated input of these materials and is associated with the activities of people. Human development of a lake's watershed increases the supply of nutrients available on the land and the speed at which these nutrients are transported to the lake. With cultural eutrophication, the fertility of a lake is increased rapidly and a decline in water quality often occurs.


Urban street runoff.

Scientists have classified lakes by their level of fertility into three groups or "trophic states". These trophic states are "oligotrophic", "mesotrophic" and "eutrophic". Lakes exhibiting these three trophic states are characterized in Box 1.1.

It is important to know the trophic state of the lake for management of aquatic plants, because oligotrophic lakes naturally have few aquatic plants, while eutrophic lakes naturally have many. Aquatic plant control program goals should be realistic and appropriate for the lake's trophic state. Merely controlling plants will not bestow upon a eutrophic lake the qualities of an oligotrophic lake. Excessive and inappropriate vegetation control in a eutrophic lake is detrimental to its plant and animal communities. It also increases the lake's instability and susceptibility to exotic invaders and aggressive native species. Chapter 2 will explain more about aquatic plant communities and the need to manage them appropriately.

Box 1.1 **Lake Classifications**

Oligotrophic	The lake is typically deep with a sandy bottom. The water is clear because of low algal populations. Aquatic plants are few and limited to protected bays and inlet areas where incoming nutrients and sediments allow some growth. The deep water maintains dissolved oxygen during the summer months. Trout and other cold-water fish species are present. **Measures :** 1. Summer Secchi disk average is greater than 15 feet. 2. Summer surface total phosphorus values are less than 10 ug/l. 3. Summer chlorophyll a values are less than 2.2 ug/l.
Mesotrophic	The lake is usually of good quality, but bays tend to have mucky bottoms. Aquatic plants are common on protected shores but less prevalent on wave-washed shores. The water is less clear and an occasional algal bloom will occur. The water below 30 feet loses oxygen during the summer, and cold-water fish species are rare. **Measures:** 1. Summer Secchi disk average is between 7.5 and 15 feet. 2. Summer surface total phosphorus values are between 10 and 20 ug/l. 3. Summer chlorophyll a values are between 2.2 and 6 ug/l.
Eutrophic	The lake is generally shallow, and the water is usually turbid and colored. Aquatic plants are usually abundant in shallow water. Water below 30 feet is often devoid of oxygen, and the lake supports warm-water fish such as bass, bluegill and pike. **Measures:** 1. Summer Secchi disk average is below 7.5 feet. Water clarity may be higher if rooted plants are very abundant. 2. Summer surface total phosphorus values are over 20 ug/l. 3. Summer chlorophyll a values are over 6 ug/l. (Chlorophyll a values may be less than 6 ug/l if rooted plants are very abundant.)

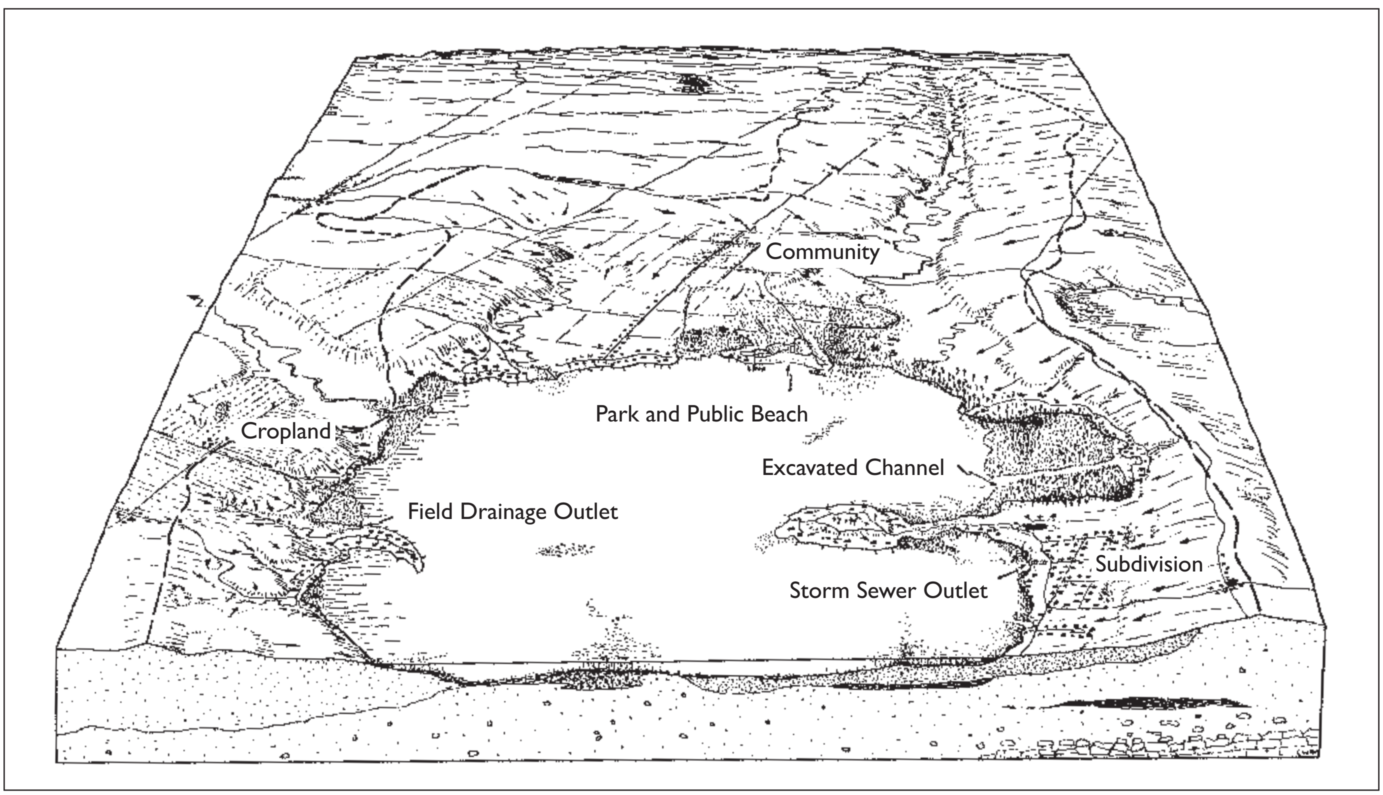
Lake Watersheds

A lake's fertility, and therefore the amount of aquatic plants present, is greatly influenced by its watershed characteristics, including watershed size, topography, soil fertility, drainage patterns and land use. These watershed characteristics determine the quantity of nutrients, such as nitrogen and phosphorus, that will be washed into the lake from the land to stimulate plant growth. Generally, the larger the watershed and the greater the percentage of agricultural and urban land in the watershed, the greater the supply of nutrients to the lake. Without an understanding and consideration of how watershed characteristics influence aquatic plant growth, a control program may be incomplete and/or misdirected. Please see the reference section for information on watersheds and their management. The book *Developing a Watershed Management Plan for Water Quality* (available online at: www.deq.state.mi.us/documents/deq-swq-nps-watershe.pdf) is an excellent resource on Michigan watersheds. For many lakes, a watershed component will be an important and critical element of an aquatic plant management plan.

Watershed Management as Part of a Plant Control Program

Just how important is a watershed management program for your lake? A preliminary assessment of the desirability and feasibility of watershed management as part of an aquatic plant control program may be made by considering the lake's trophic state and watershed size. A lake's trophic state is important to consider because low fertility oligotrophic and mesotrophic lakes change more dramatically with increased nutrient concentrations than more fertile eutrophic lakes. Watershed size affects management efforts by determining the magnitude of the problem and the level of effort needed to control the problem. The larger the watershed, the greater the number of potential sources of sediments and nutrients. With more sediment and nutrient sources, lakes with large watersheds will need greater efforts to make meaningful reductions in nutrient and sediment inputs. As the watershed gets larger, the feasibility of managing the sediment and nutrient sources decreases.

To help determine the importance of having a watershed management program, a matrix using trophic state and watershed size, as measured by watershed/lake area ratio, is provided in Box 1.2. A lake's watershed/lake area ratio is calculated by dividing the area of the watershed by the area of the lake. Watershed size is available for many lakes from state resource agencies or can be delineated by a professional consultant or estimated by an individual familiar with map interpretation. A lake's trophic condition may be estimated by comparing the values provided in Box 1.1 with data collected in a quality-controlled study or program such as the Cooperative Lakes Monitoring Program sponsored by Michigan Lake & Stream Associations, Inc., and the Michigan Department of Environmental Quality. The importance of



A lake and its watershed.

(from Marsh & Borton, *Inland Lake Watershed Analysis — A Planning and Management Approach.*)

watershed management is weighted toward the low fertility lakes. It is more practical and economical to prevent cultural eutrophication in oligotrophic and mesotrophic lakes than to try to reverse its effects once the lake has become eutrophic.

Using the data for your lake's trophic state and watershed/lake area ratio, find the recommended importance of watershed management in Box 1.2. Depending on your lake and watershed, a watershed management component may be a very important element of your aquatic plant management plan. Use the documents listed in the reference section below to guide your watershed management efforts.

Box 1.2 **Importance of Watershed Management**

Ratio watershed/lake area	Trophic state of the lake		
	Oligotrophic	**Mesotrophic**	**Eutrophic**
Less than 10	Extremely Critical	Critical	Important for long-term benefits
10 to 30	Critical	Important	Where economically and practically feasible
Greater than 30	Important	Where economically and practically feasible	Management only of major discharges

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The references below discuss lake ecology, watersheds and watershed management.

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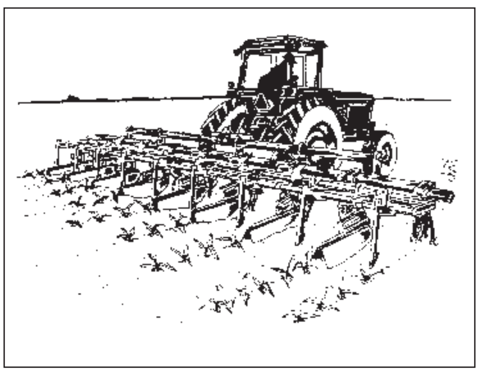
Chapter 2

Aquatic Plant Communities

Introduction

Biological communities are made up of individuals from many species. In harsh environments such as the arctic tundra or deserts, the community consists of a few species but many individuals of each species. Such environments are said to have low species diversity. Alternatively, a tropical rain forest has thousands of species, each represented by a small to moderate number of individuals. Such an environment is said to have high species diversity.


Monoculture farm field.

Diversity provides stability to a community. In highly diverse communities, a serious decline in one species generally has little impact on the overall community. In a community of low diversity, however, a serious decline in one species cascades through the entire community. Impacts are major, and it may take years to reorder community structure. Consequently, maintaining community diversity is important in good resource management of natural environments.

In artificial environments, such as a farm field, diversity is completely eliminated to benefit one species, the crop being grown. In such environments, tremendous energy and cost must be expended to maintain the monoculture community. These efforts can never be terminated or reduced as long as the crop is going to be grown. Relaxing the efforts even slightly allows aggressive "weed" species to colonize the highly disturbed and unnatural environment.

An environment greatly altered from its natural condition, such as a farm field, must progress through a succession of changes before again resembling its original natural state, most commonly a forest. The first stage of this succession, as a general rule, is the colonization of the altered environment by one or two aggressive "weed" species. Gradually, additional species return to the community. The number of individual organisms remains basically constant, but the number of species increases, expanding diversity and community stability. After many years, a forest is again growing where the farm field had been.

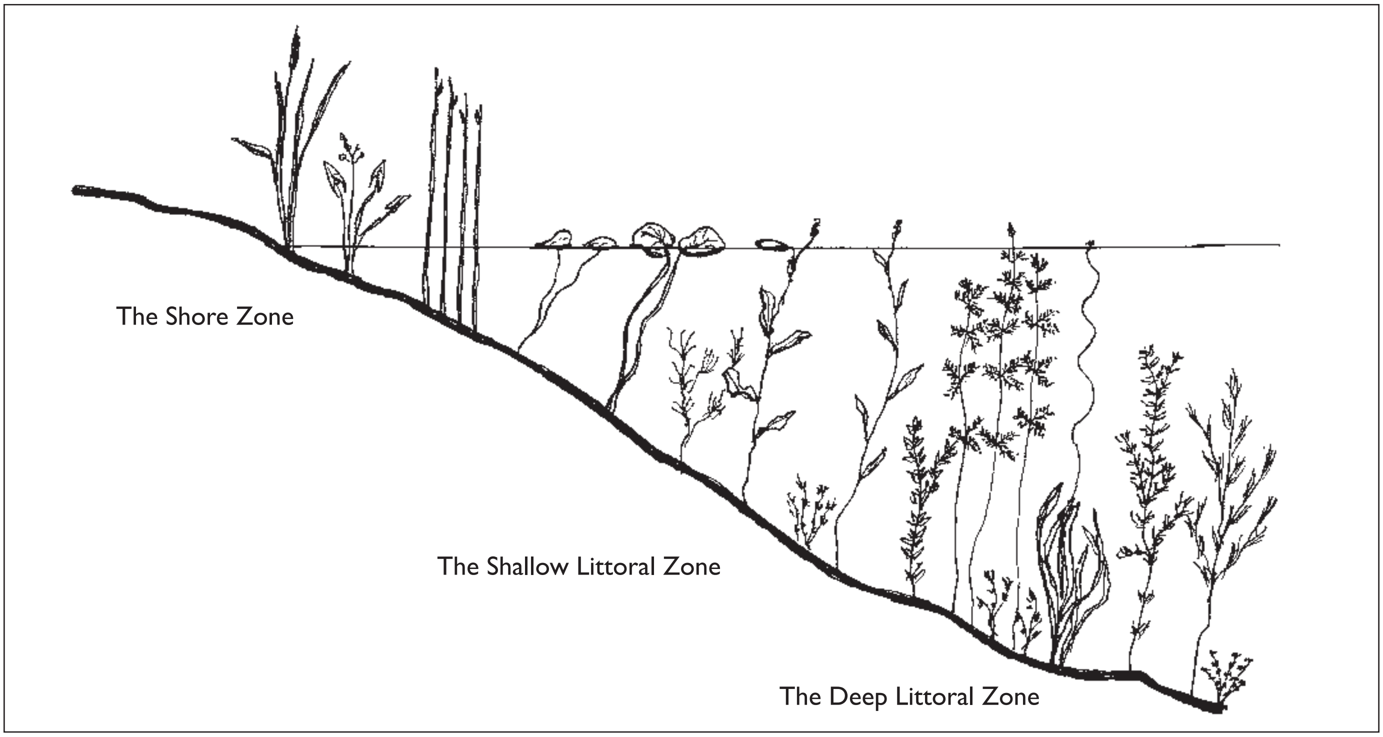
It is important to know and understand a lake's natural condition or trophic state. If a lake is naturally fertile, or eutrophic, it should have an abundant plant community. Aquatic plant control projects that greatly alter this community can damage its diversity and increase susceptibility to aggressive weed species. Once it's altered, many years may be needed to reestablish the lake's natural plant community.

The Lake's Plant Community

A lake's rooted plants (except the free-floating ones) extend from the moist soils of the shoreline to water depths of 15 to over 20 feet in clear Michigan lakes. This part of the lake is called the littoral zone. Typically, plants form concentric rings or zones from shore within the littoral area (see Figure 2.1).

The **shore zone** is dominated by plants with emergent leaves extending above the water surface such as cattail, bulrush, arrow arum, arrowhead and pickerelweed. These plants have root systems that extract minerals and nutrients from water-saturated soils and aerial leaves to obtain carbon dioxide from the air. They grow from the wet soils of the beach out to a water depth of 2 to 4 feet. These are the transition plants bridging the zone from the terrestrial to the aquatic environment. They are the critical habitat for amphibians, fish, reptiles, aquatic mammals, shore birds and waterfowl living at the water's edge. It is the shore zone vegetation that has been most significantly altered by human development. Many lakes

Figure 2.1 **A Lake's Aquatic Plant Communities**



have little of their original native shore left. Most of this zone now consist of lawns, seawalls and filled beaches, which provide little or no habitat for the animals that once lived at the shore.

Beyond the shore zone is the **shallow littoral zone**, which is populated with species of submerged plants, many of which have floating leaves. Common plants of this zone include water lilies, water shield, and many species of the pondweed or *Potamogeton* genus. The zone extends from about 2 feet of water depth out to 6 to 8 feet.

In the **deep littoral zone**, plants grow entirely submerged or with only a small tip breaking the water surface. Plants of this zone tend to have small, thin or finely divided leaves. These leaves have a high surface area/volume ratio, possibly improving photosynthesis and gas exchange in the darker deep water. Common plants of this zone are milfoil, coontail, sago pondweed, other thin-leafed pondweeds, bushy pondweed, stonewort, waterweed and wild celery. This zone starts at about 6 feet of water depth and extends out to the limits of rooted plant growth — 12 feet in more turbid lakes, and 20 feet or more in very clear lakes.

These zones create distinct and unique conditions for a wide range of plant species. Indeed, most lakes have many plant species growing during the summer season. Plant surveys of lakes conducted by Dr. Miles Pirnie (see publication in reference section) and associates in the 1920s found an average of 12 to 16 relatively abundant species of aquatic plants per lake. The Michigan Department of Natural Resources (MDNR) found similar results during lake surveys in the 1970s and '80s.

Exotic Invaders

Every plant and animal species has control agents such as predators, herbivores, parasites, fungi and/or diseases regulating its population. This is a natural process in continuous operation in the environment. Even humans have agents that control their numbers. Aquatic plants also have controlling agents. In a natural, diverse environment not artificially controlled or manipulated by humans, no one aquatic plant species significantly dominates for long. As its population expands, so do its control agents. Eventually, these control agents reduce its population.

Sometimes, however, a plant community is altered by an action favoring one or more species. This may occur with the intentional or accidental introduction of an exotic species. The new colonist is often able to outcompete the native plant species and expand to exceptional population levels. Support for this population explosion comes from the fact that agents that limited the exotic species' numbers in its home range are not present in the new environment. Without control agents to curb its population, the exotic has a competitive advantage over native species and is able to reach great densities. The native species trying to compete with the exotic are often greatly reduced or even eliminated.

A population explosion of an exotic plant sometimes gives rise to inappropriate plant control measures. As an example, when Eurasian milfoil invades a lake, some citizens notice the change not as a shift in plant species but as a case of all the plants "going wild". In reality, the number of individual plant organisms is relatively constant, but diversity has been lost as a community of many native species, with a few individuals in each species, has shifted to a community of one or two exotic and aggressive native species with many individuals. Without recognizing that a shift in the plant community has occurred, control actions are directed at the entire plant community rather than targeting the nuisance exotic. Indiscriminate controls on the entire plant community further encourages the exotic by reducing competition from the remaining native vegetation, thus prolonging the dominance of the exotic invader.

Given enough time, the environment evolves to restrain exotic species. Diseases, parasites and predators of native species similar to the exotic species shift to take advantage of the exotic's large population. Eventually, the exotic becomes just another member of the community. The time required for this naturalization process varies greatly, depending on the species involved and environmental conditions, but it usually takes many years.

To accelerate the naturalization process, environmental regulatory agencies often return to the home range of a nuisance exotic to find controlling agents. After many years of quarantine and research to ensure that the control agent itself will not create problems, it is released to provide long-term control of the nuisance exotic.

The Altered/Managed Plant Community

Maintaining a desirable plant community in a large-scale plant control program will be difficult. Community succession attempts to fill the void left by plants that have been controlled with aggressive species. To achieve the best results and minimize the spread of exotic and aggressive native species, careful monitoring of the plants and continual adjustment in the control tools will be necessary to fine-tune the management plan.

In developing a management plan for aquatic plants, a key element is a vegetation goal. What will the plant community look like after implementation of controls? This is particularly important if controls are to be implemented on a large scale, resulting in significant changes in the plant community. The locations and densities of desired species should be plotted to produce a vegetation goal map. The map is used to audit the success of the control program and to implement changes to the program so results better approximate the goal.

Vegetation provides habitat for fish.

If the management plan calls for significantly altering the plant community from background conditions (see Chapter 7 — Large-scale continual maintenance), the Department of Natural Resources has provided a recommendation (Fisheries Division Position Statement – Aquatic Nuisance Control – 4/22/05) for maintaining the environmental integrity of the lake.

> *"Fisheries Division recommends that native macrophytes (submerged, floating-leaf, and emergent aquatic plants) not be removed or killed. Limited removal of nuisance aquatic vegetation may be warranted in certain situations (such as removal to provide access channels); however, treatment should not adversely affect the diversity and relative distribution of native aquatic plants in the water body. Any removal of nuisance aquatic vegetation should preserve 60% to 80% of the native aquatic plants as a measure of cover during the active growing season (May-September). Aquatic vegetation management should be performed only in conjunction with watershed management practices that reduce unnatural nutrient loading."*

Knowing the lake's natural trophic state, setting realistic management goals, defining and mapping the management objective, and monitoring for project results and modifications needed to achieve management goals will minimize damage to the lake environment and improve the potential for success.

References

See references at the end of Chapters 3 and 7.

Chapter 3

Identification and Portraits of the Common Aquatic Plants of Michigan Lakes

Introduction

When managing aquatic plants, it is important to know them well enough to encourage beneficial species and discourage those that often cause problems. This chapter provides an identification key and descriptive portraits for about 35 of the most common plants found in Michigan lakes. Each species has unique growth characteristics, shape, reproductive pattern, germination time and other features. For most lakes, the key and portraits will identify 70 percent or more of the plants found in them. If a plant does not fit key descriptions, it is possibly not a species identified by the key. For more complete references and plant keys, see the reference section at the end of the chapter.

When identifying plants, the citizen monitor needs to know and understand lake conditions. Environmental circumstances can significantly alter plant growth and characteristics. As an example, a drop in lake level results in water lily leaves extending out of the water, rather than floating on the surface. Nutrients and light levels can alter the size of a plant and its leaves. If uncertain about a plant, a monitor should consult with an aquatic ecologist for assistance. Pressing and mounting unknown plants, as described in Chapter 4, allows an aquatic ecologist to identify them later.

Materials Needed

The following items are helpful when identifying plants. A shallow white pan keeps the plants damp. If unavailable, use wet paper towels. A magnifying glass assists viewing of smaller plant parts, which are sometimes important in identification. A toothpick or pointed tool is useful for separating leaves for viewing. A ruler will be needed for measuring the plant and leaves.

How to Use the Key

There are seven parts to the key (see page 13). Each part is a grouping of plants with similar characteristics. The first step in identification is deciding which part of the key best describes the unknown plant.

To continue identification, turn to that part of the key best describing the plant. At this point, the key becomes dichotomous, requiring the user to choose between two alternatives. Each choice directs the user to the next set of alternatives to evaluate. This process of selecting between two alternatives continues until identification is complete and a scientific and common name are provided for the plant, as well as a portrait number. The descriptive plant portraits, depicting the characteristics of each plant, are grouped together and follow the identification key.

Figures or drawings illustrating important plant characteristics are part of the key. Of necessity, each drawing is to a different scale. To provide a perspective for size, approximate lengths for leaves, flowers or whole plants are included with most figures.

Glossary of Terms Used in the Key

The identified figures provide examples for the characteristic.

Alternate leaves — only one leaf at each position on the stem (Figures 3.24, 3.25, 3.32, 3.34 and 3.35).

Central axis — a single stalk in the center part of a leaf (Figures 3.37 and 3.39).

Clasping leaf — a leaf that has no petiole but is broadly attached directly to the stem (Figures 3.51 and 3.54).

Floral bract — a very small leaf growing on the stem just below a flower (Figures 3.38 and 3.41).

Lanceolate — a leaf shape similar to the head of a spear (Figures 3.47 and 3.57).

Midrib — a central vein in a leaf (Figures 3.17 and 3.23).

Oblong — longer than wide and with nearly parallel sides (Figures 3.52 through 3.54).

Opposite leaves — two leaves at the same position on the stem but on opposite sides (Figure 3.43).

Petiole — the stalk of a leaf, which attaches it to the stem (Figures 3.18 and 3.57).

Spike — a group of flowers growing together in an elongated cluster (Figures 3.11, 3.14 and 3.18).

Stipule — a flap-like appendage attached at the base of the petiole (Figures 3.24 through 3.26 and 3.51).

Whorled leaves — many leaves arranged in a circle around the stem (Figures 3.29, 3.37 and 3.39).

How to Use the Portraits

A descriptive portrait is provided for each of the plant species in the identification key. These portraits give valuable information about the plants that will be helpful when preparing management plans. The plant key refers the user to a portrait number for each plant species. The portrait numbering code groups the plants by general growth pattern. Free-floating plants are numbers 1 through 4. Emergent plants growing along the shore, commonly in less than 3 feet of water, are numbers 6 through 14. Short submerged plants, forming low meadows on the lake bottom, are the 20s. Submerged plants growing 2 to 5 feet tall are the 30s. Tall submerged plants growing in scattered patches are the 40s, and tall submerged plants growing in large dense mats are the 50s. Not all numbers are used. This allows the sampler to include and number plants common to their lake but not included in the key and portraits. These same numbers may be used when mapping plant populations in the lake, as described in Chapter 5.

In the portraits, each plant is generally classified as beneficial (+), neutral (0) or nuisance (–). Depending on the circumstances, however, a beneficial plant can be a nuisance and a nuisance plant can be a critical component of the plant community. The portrait also describes each plant's growth characteristics, habitat, beneficial traits, nuisance traits and other details.

References

Below are references for those monitors wishing other guides for identifying aquatic plants.

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A Citizen's Key to the Common Rooted Aquatic Plants of Michigan Lakes

Parts to the Key

Plants that float on or grow above the water surface.		
Part One	*(See page 14.)*	Free-floating Plants — Plant floats free in the water; not attached to the lake bottom in any way. Plants small, less than ½ inch in size. *(See figures on page 15.)*
Part Two	*(See page 16.)*	Plants with Leaves that Extend Above the Water — Plant with leaves that extend out of the water. *(See figures on pages 17 and 18.)*
Part Three	*(See page 19.)*	Plants with Floating Leaves — Plant with a small or large leaf that floats on the surface of the water. *(See figures on page 20.)*
Plants growing entirely below the surface of the water. Possible exception is a small flower/seed stem that extends a short distance out of the water.		
Part Four	*(See page 21.)*	Plants with Leaves Thread- or Needle-like — Submerged leaves thread- or needle-like. *(See figures on page 22.)*
Part Five	*(See page 23.)*	Plants with Long, Ribbon-like Leaves — Submerged leaves long and ribbon-like — about 10 times longer than wide. *(See figures on page 24.)*
Part Six	*(See page 25.)*	Plants with Complex and Finely Divided Leaves — Submerged leaves complex and finely divided. *(See figures on pages 26 and 27.)*
Part Seven	*(See page 28.)*	Plants with Oval, Oblong or Lanceolate Leaves — Submerged leaves oval, oblong or lanceolate, as small as ½ inch or as long as 8 inches. *(See figures on pages 30 and 31.)*

Part One

Free-floating Plants

#1

Choose one of the following:

Plants small, between $\frac{1}{8}$ and $\frac{1}{2}$ inch in size, with flat, floating leaves and small, dangling roots (Figs. 3.1 - 3.3) . . . . **go to #2**

Plants round and very small, less than $\frac{1}{8}$ inch in size, with no roots (Figs. 3.4 and 3.5). *Wolffia* spp. (watermeal) . . . . **see Portrait 1**

#2

Choose one of the following:

Plants with round, flat leaves joined together at a common point (Fig 3.1) . . . . **go to #3**

Plants with spade-shaped leaves connected by narrow stalks (Fig 3.3). *Lemna trisulca* (star duckweed). . . . . **see Portrait 2**

#3

Choose one of the following:

Plant leaves red on the lower surface, more than 5 roots (Fig 3.2). *Spirodela polyrhiza* (big duckweed). . . . . **see Portrait 4**

Plant leaves green on the lower surface, a single root (Fig 3.1 and Plate 4). *Lemna minor* (lesser duckweed) . . . . **see Portrait 3**

Part One

Free-floating Plants

(Plants very small — drawings approximately 10 times larger than plant)

Fig. 3.1

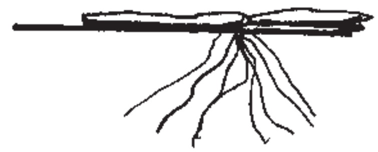


Fig. 3.2 *(actual size less than ¼ inch)*

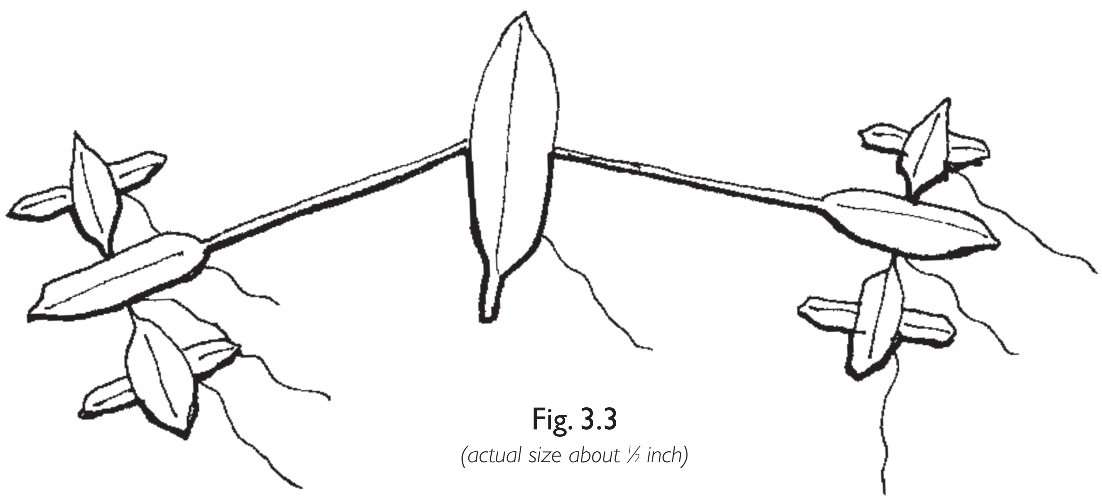


Fig. 3.3
(actual size about ½ inch)

Fig. 3.4

Fig. 3.5 *(actual size less than ⅛ inch)*

Fig. 3.1: *Lemna minor* (lesser duckweed), **Fig. 3.2**: *Spirodela polyrhiza* (big duckweed), **Fig. 3.3**: *Lemna trisulca* (star duckweed), **Figs. 3.4** and **3.5**: *Wolffia* spp. (watermeal).

Part Two

Plants with Leaves that Extend Above the Water

#1

Choose one of the following:

Leaves other than arrowhead-shaped (Figs. 3.6 - 3.11) .... **go to #2**

Leaves arrowhead-shaped (Figs. 3.12 - 3.17) .... **go to #4**

#2

Choose one of the following:

Leaves narrow and usually several feet long, extending well out of the water (Figs. 3.6 and 3.8) .... **go to #3**

Leaves oblong, usually less than 6 inches long. Plant may be growing erect in shallow water or as a limp vine with floating leaves trailing through the water (Fig. 3.10). Pale pink to red flower spike extends above the water (Fig. 3.11). *Polygonum* spp. (smartweeds) .... **see Portrait 11**

#3

Choose one of the following:

Leaves ribbon-shaped, approximately 1 inch wide. Flower, if present, borne on a long, cylindrical spike (Figs. 3.6 and 3.7). *Typha* spp. (cattails) .... **see Portrait 6**

Leaves cylindrical, about the diameter of a pencil. Flower, if present, borne near the tip of the leaf (Figs. 3.8 and 3.9). *Scirpus* spp. (bulrushes) .... **see Portrait 7**

#4

Choose one of the following:

Leaves with a network of veins branching from a strong midrib (Figs. 3.16 and 3.17). *Peltandra virginica* (arrow arum) .... **see Portrait 8**

Leaves with a network of veins not as above but generally radiating from a central point near the petiole attachment (Figs. 3.13 and 3.15) .... **go to #5**

#5

Choose one of the following:

Leaf veins generally radiating outward from the petiole attachment to the leaf margin (Fig. 3.13). Flower, if present, a small, simple flower with three white petals (Fig. 3.12). *Sagittaria* spp. (arrowheads) .... **see Portrait 9**

Leaf veins radiating parallel from the petiole attachment to the leaf tip (Fig. 3.15). Flower, if present, a bluish, dense spike (Fig. 3.14). *Pontederia cordata* (pickerelweed) .... **see Portrait 10**

Part Two

Plants with Leaves that Extend Above the Water

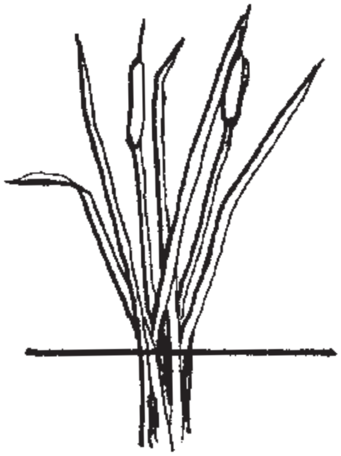


Fig. 3.6
(actual size 3 to 6 feet)

Fig. 3.7
Flower detail (actual size 6 to 8 inches)

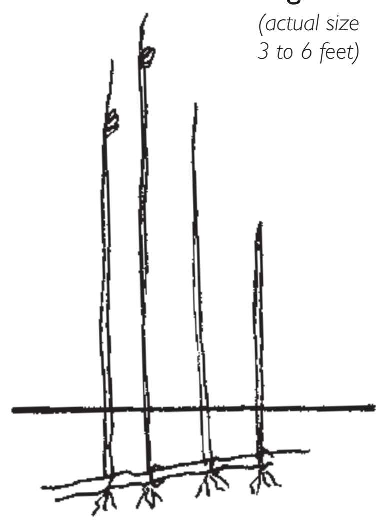


Fig. 3.8
(actual size 3 to 6 feet)

Fig. 3.9
(actual size 3 to 6 inches)

Fig. 3.10
(actual size 3 to 5 feet)

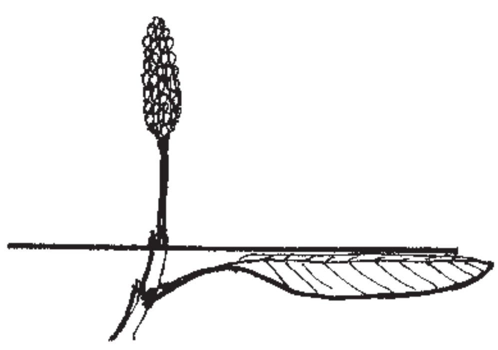


Fig. 3.11
Flower detail (actual size 3 to 5 inches)

Figs. 3.6 and **3.7**: *Typha* spp. (cattails), **Figs. 3.8** and **3.9**: *Scirpus* spp. (bulrushes), **Figs. 3.10** and **3.11**: *Polygonum* spp. (smartweeds), Part Two

Plants with Leaves that Extend Above the Water

Fig. 3.12

(actual size 1 to 3 feet)

Fig. 3.13

Leaf detail (actual size 5 to 9 inches)

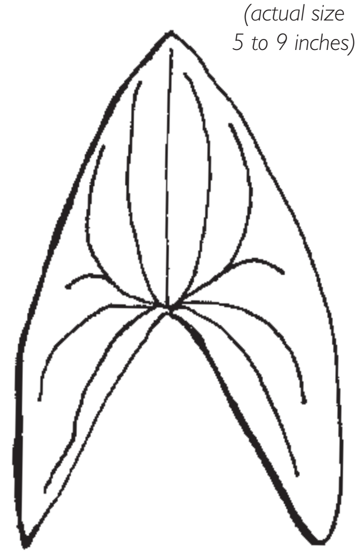


Fig. 3.14

(actual size 1 to 3 feet)

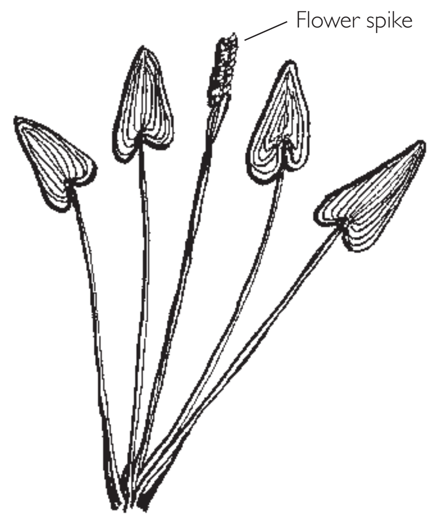


Fig. 3.15

Leaf detail

(actual size 5 to 9 inches)

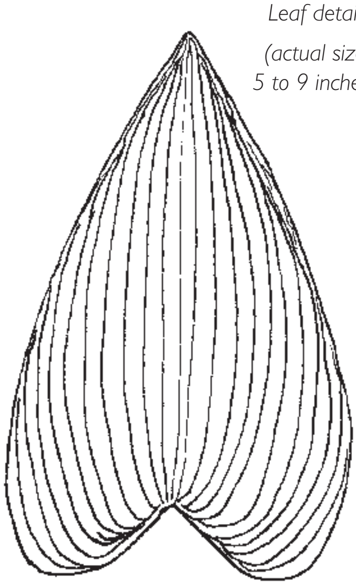
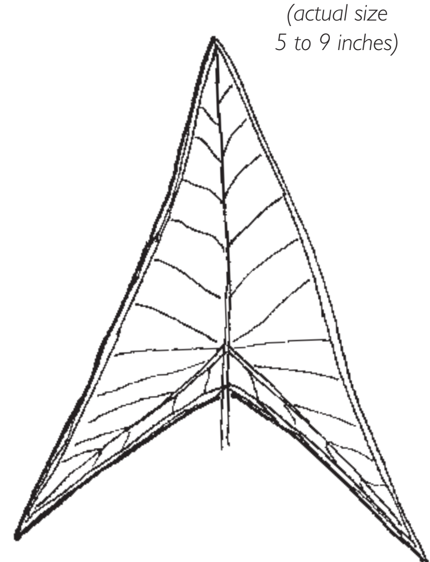


Fig. 3.16

(actual size 1 to 3 feet)

Fig. 3.17

Leaf detail (actual size 5 to 9 inches)



Figs. 3.12 and **3.13**: *Sagittaria* spp. (arrowheads), **Figs. 3.14** and **3.15**: *Pontederia cordata* (pickerelweed), **Figs. 3.16** and **3.17**: *Peltandra virginica* (arrow arum).

Part Three

Plants with Floating Leaves

#1

Choose one of the following:

Floating leaves with parallel veins arising at the base of the petiole and extending to the tip of the leaf (Figs. 3.18, 3.20 and 3.21) . . . . **go to #2**

Floating leaves with veins that are ***not*** parallel but form a net pattern of some type (Figs. 3.19, 3.22 and 3.23) . . . . **go to #4**

#2

Choose one of the following:

The plant's floating leaves heart-shaped at the base, where the leaf attaches to the petiole (Fig. 3.18). *Potamogeton natans* (floating-leaf pondweed) . . . . **see Portrait 43**

The plant's floating leaves ***not*** heart-shaped at base (Fig. 3.20) . . . . **go to #3**

#3

Choose one of the following:

Plant's submersed leaves large, 4 to 8 inches long and 1 to 3 inches wide; often curved or wavy (Fig. 3.20). *Potamogeton amplifolius* (large-leaf pondweed). . . . . **see Portrait 30**

Plant's submersed leaves small to moderate in size, 1 to 3 inches long, and generally flat (Fig. 3.21). *Potamogeton gramineus* (variable pondweed),. . . . . **see Portrait 31**

#4

Choose one of the following:

Petiole attached at the middle of the floating leaf (Fig. 3.22). *Brasenia schreberi* (water shield) . . . . **see Portrait 14**

Petiole attached at a notch in the floating leaf (Fig. 3.19 and 3.23). . . . . **go to #5**

#5

Choose one of the following:

Veins of the floating leaf radiate out from the notch in the leaf (Fig. 3.19). The flower is white, if present. *Nymphaea* spp. (white water lily) . . . . **see Portrait 12**

Veins of the floating leaf arise from a midrib vein running from the notch in the leaf to the tip (Fig. 3.23). The flower is yellow, if present. *Nuphar* spp. (yellow water lily) . . . . **see Portrait 13**

Part Three

Plants with Floating Leaves

Fig. 3.18

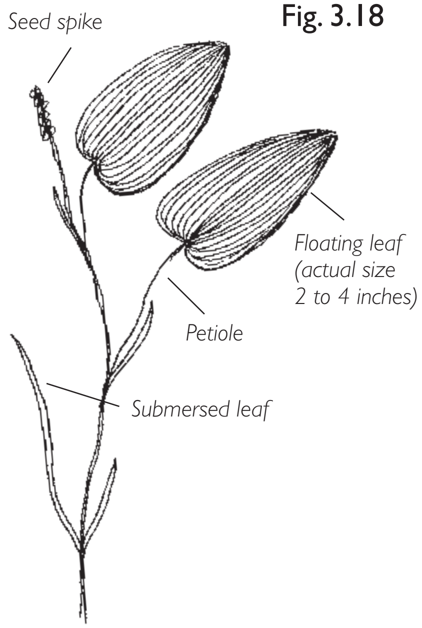


Fig. 3.19
(actual size 3 to 10 inches)

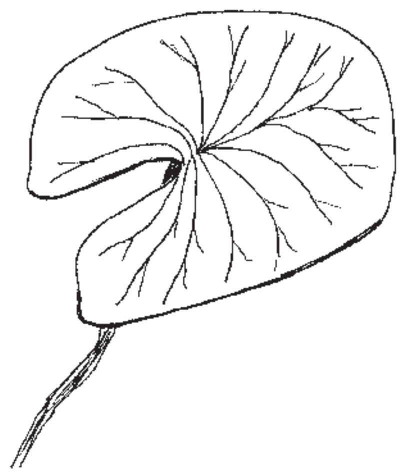


Fig. 3.20

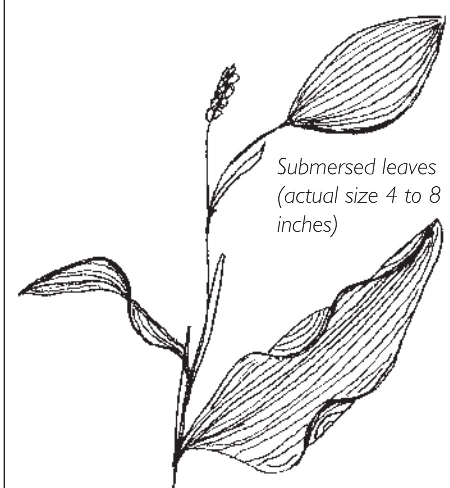


Fig. 3.21

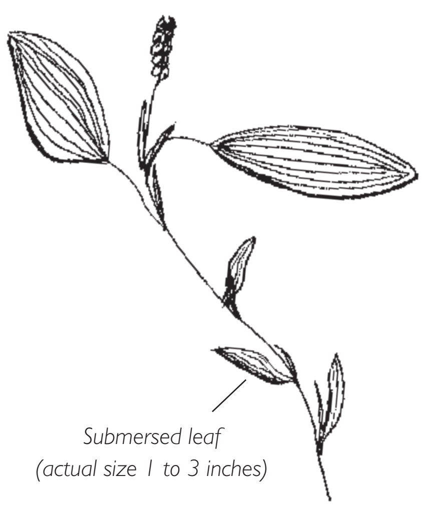


Fig. 3.22
(actual size 3 to 5 inches)

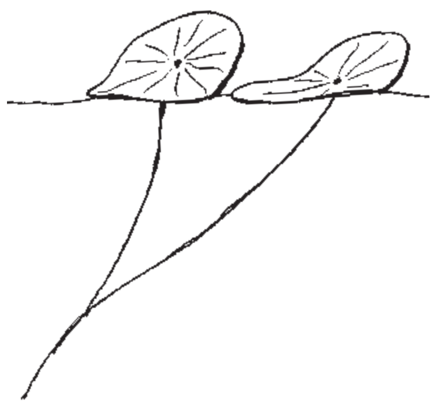


Fig. 3.23
(actual size 3 to 10 inches)

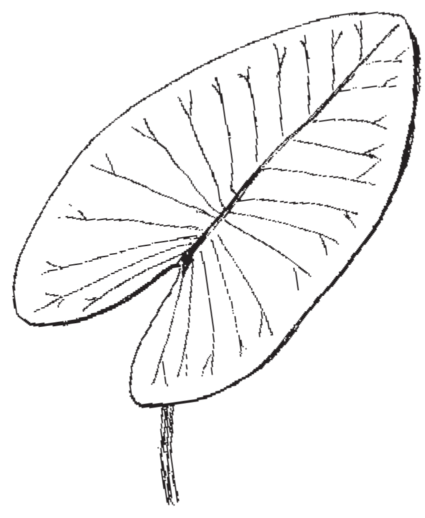


Fig. 3.18: *Potamogeton natans* (floating-leaf pondweed), **Fig. 3.19**: *Nymphaea* spp. (white water lily), **Fig. 3.20**: *Potamogeton amplifolius* (large-leaf pondweed), **Fig. 3.21**: *Potamogeton gramineus* (variable pondweed), **Fig. 3.22**: *Brasenia schreberi* (water shield), **Fig. 3.23**: *Nuphar* spp. (yellow water lily).

Part Four

Plants with Leaves Thread- or Needle-like

#1

Choose one of the following:

Leaves whorled (Figs. 3.28 - 3.30) or opposite along the stem (Fig. 3.27) . . . . **go to #2**

Leaves alternate along the stem (Figs. 3.24 and 3.25). . . . . **go to #4**

#2

Choose one of the following:

Leaves opposite but with bundles of other leaves at the base of each leaf giving the appearance of being whorled (Fig. 3.27 and Plate 4). *Najas* spp. (bushy pondweed) . . . . **see Portrait 21**

Leaves truly whorled, arising entirely around the stem (Figs. 3.29, 3.37 and 3.39) . . . . **go to #3**

#3

Choose one of the following:

Leaves with minute, spiny teeth along one side (Figs. 3.28 and 3.29 and Plate 1). Plant not brittle and without musk-like odor. *Ceratophyllum demersum* (coontail) . . . . **see Portrait 41**

Leaves usually very short and without minute, spiny teeth (Fig. 3.30 and Plate I). Plant sometimes encrusted with lime, brittle, and having a musk-like odor when crushed in hand. *Chara* spp. (stonewort or muskgrass) . . . . **see Portrait 20**

#4

Choose one of the following:

Leaf tips very pointed and leaf and stipule fused at the base forming a sheath at least ¼ inch long (Figs. 3.24 and 3.26). *Stuckenia pectinata* (sago pondweed) (formerly *Potamogeton pectinatus*) . . . . **see Portrait 52**

Leaf tips blunt or leaf and stipule not fused at the base or fused for less than ¼ inch (Fig. 3.25 and Plate 4). *Potamogeton* spp. (thin-leaf pondweed). . . . . **see Portrait 32**

Part Four

Plants with Leaves Thread- or Needle-like

Fig. 3.24
(actual size of leaves 2 to 3 inches)

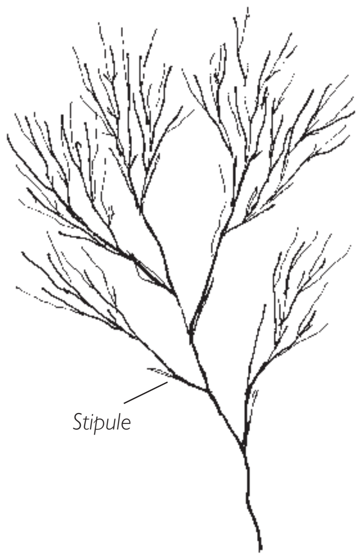


Fig. 3.25
(actual size of leaves 1 to 3 inches)

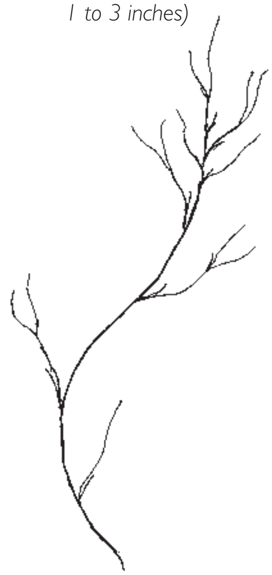


Fig. 3.26
(actual size 2 to 3 inches)

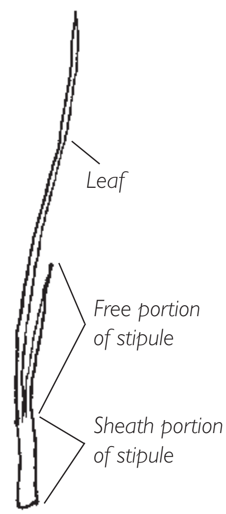


Fig. 3.27
(actual size of leaves ½ to 1½ inches)

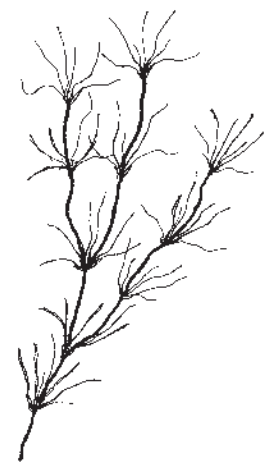


Fig. 3.28

Fig. 3.29
(actual size of leaves ½ to 1 inch)

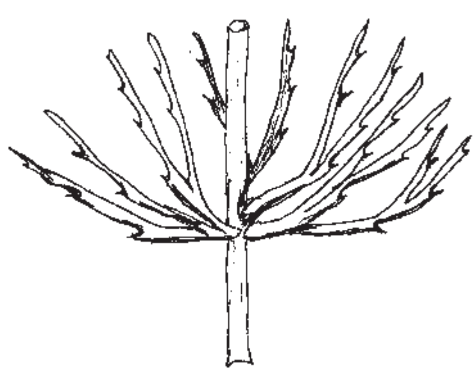


Fig. 3.30
(actual size of leaf-like structures ¼ to 1 inch)

Fig. 3.24: *Stuckenia pectinata* (sago pondweed), **Fig. 3.25**: *Potamogeton* spp. (thin-leaf pondweed), **Fig. 3.26**: Leaf with stipule, **Fig. 3.27**: *Najas* spp. (bushy pondweed), **Figs. 3.28** and **3.29**: *Ceratophyllum demersum* (coontail), **Fig. 3.30**: *Chara* spp. (stonewort/muskgrass).

Part Five

Plants with Long, Ribbon-like Leaves

#1

Choose one of the following:

All leaves arising from base of plant (Fig. 3.31and Plate 2).
Vallisneria americana (wild celery) . . . . **see Portrait 34**

Leaves arising from a stem (Figs. 3.32, 3.34 and 3.35). . . . . **go to #2**

#2

Choose one of the following:

Stem flat (Figs. 3.32 and 3.33 and Plate 2). *Potamogeton zosteriformis*
(flat-stemmed pondweed) . . . . **see Portrait 33**

Stem round . . . . **go to #3**

#3

Choose one of the following:

Leaves extending in nearly opposite directions in a single plane so
that the entire plant appears somewhat flat, forming the shape of a hand fan
or fern plant, particularly as seen in the water (Fig. 3.34 and Plate 2).
Potamogeton robbinsii (fern pondweed) . . . . **see Portrait 22**

Leaves of plant not arranged in a pattern to form the shape of a hand fan
or fern plant but scattered along the stem (Fig. 3.35 and Figs. 3.52 and 3.53
in Part Seven of the key, "Plants with Oval, Oblong or Lanceolate Leaves") . . . . **go to #4**

#4

Choose one of the following:

Leaves short, less than 4 inches long, and leaf margins finely toothed
(see Figs. 3.52 and 3.53 and Plate 3). *Potamogeton crispus* (curly-leaf pondweed) . . . . **see Portrait 51**

Leaves long and flexible and leaf margins not finely toothed (Fig. 3.35 and Plate 2).
Heteranthera dubia (water star grass) (also known as *Zosterella dubia*) . . . . **see Portrait 35**

Part Five

Plants with Long, Ribbon-like Leaves

Fig. 3.31
(actual size of leaves 1 to 3 feet)

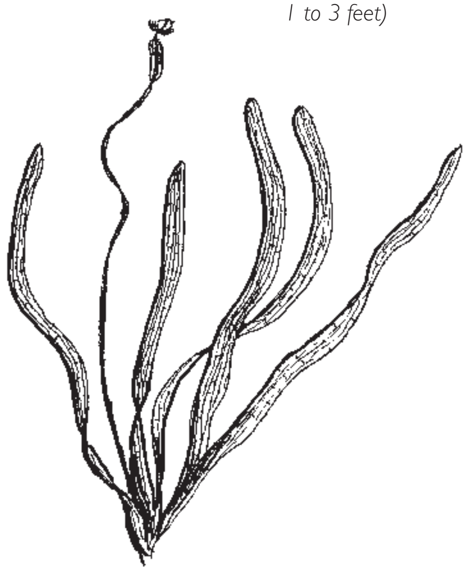


Fig. 3.33
(actual size of leaves 2 to 5 inches)

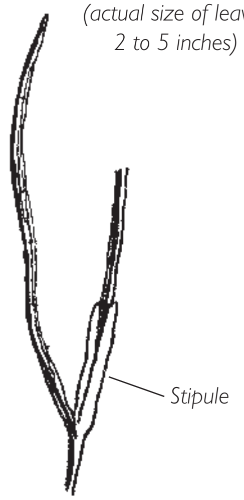


Fig. 3.32

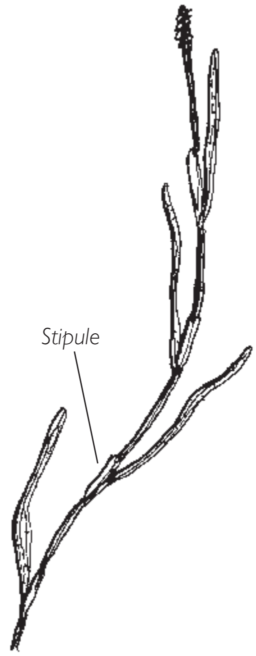


Fig. 3.34
(actual size of leaves 2 to 4 inches)

Fig. 3.35
(actual size of leaves 2 to 6 inches)

Fig. 3.31: *Vallisneria americana* (wild celery), **Figs. 3.32** and **3.33**: *Potamogeton zosteriformis* (flat-stemmed pondweed), **Fig. 3.34**: *Potamogeton robbinsii* (fern pondweed), **Fig. 3.35**: *Heteranthera dubia* (water star grass).

Part Six

Plants with Complex and Finely Divided Leaves

#1

Choose one of the following:

Leaves with a central axis (Figs. 3.37 and 3.39) . . . . **go to #2**

Leaves without a central axis (Figs. 3.42 - 3.46). . . . . **go to #3**

#2

Choose one of the following:

Number of leaflets on one side of central axis less than 12 to 14 (Figs. 3.36 and 3.37) or floral bracts long, usually extending to near or beyond the tip of the flower (Fig. 3.38 and Plate 1). *Myriophyllum* spp. (native milfoils) . . . . **see Portrait 40**

Number of leaflets on one side of central axis more than 12 to 14 (Figs. 3.39 and 3.40 and Plate 1) and floral bracts short, not reaching the tip of the flower (Fig. 3.41). *Myriophyllum spicatum* (Eurasian milfoil) . . . . **see Portrait 50**

#3

Choose one of the following:

Leaves alternate (Figs. 3.44 and 3.45) . . . . **go to #4**

Leaves opposite (Figs. 3.42 and 3.43). *Megalodonta beckii* (water marigold) . . . . **see Portrait 47**

#4

Choose one of the following:

Leaves with small bladders (Figs. 3.45 and 3.46). *Utricularia* spp. (bladderwort) . . . . . . **see Portrait 48**

Leaves without small bladders; a small white flower may be present (Fig. 3.44). *Ranunculus* spp. (buttercup) . . . . **see Portrait 49**

Part Six

Plants with Complex and Finely Divided Leaves

Fig. 3.36

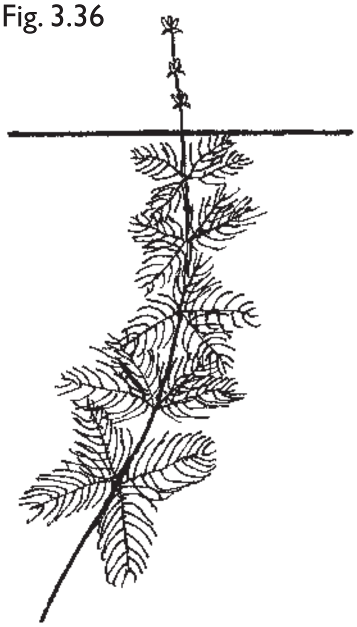


Fig. 3.37

(actual size of each leaf about 1 inch)

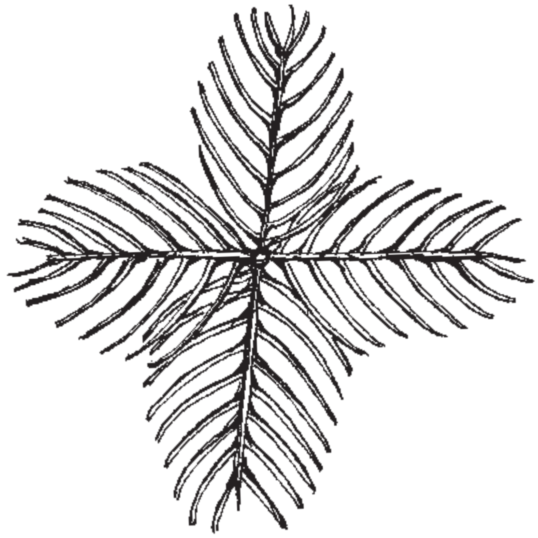


Fig. 3.38

(actual size less than ½ inch)

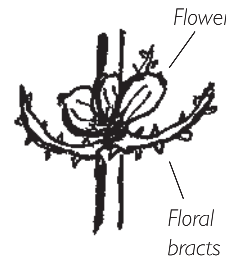


Fig. 3.40

Fig. 3.39

(actual size of each leaf about 1¼ inch)

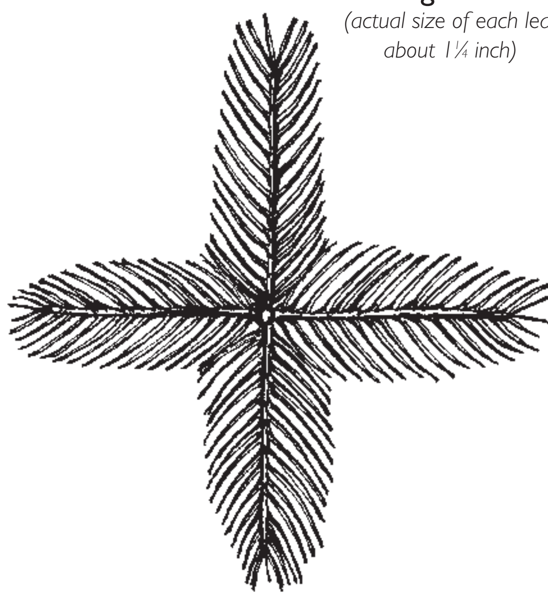


Fig. 3.41

(actual size of floral bracts less than ½ inch)

Figs. 3.36, **3.37** and **3.38**: *Myriophyllum* spp. (native milfoil), **Figs. 3.39**, **3.40** and **3.41**: *Myriophyllum spicatum* (Eurasian milfoil).

Part Six

Plants with Complex and Finely Divided Leaves

Fig. 3.42

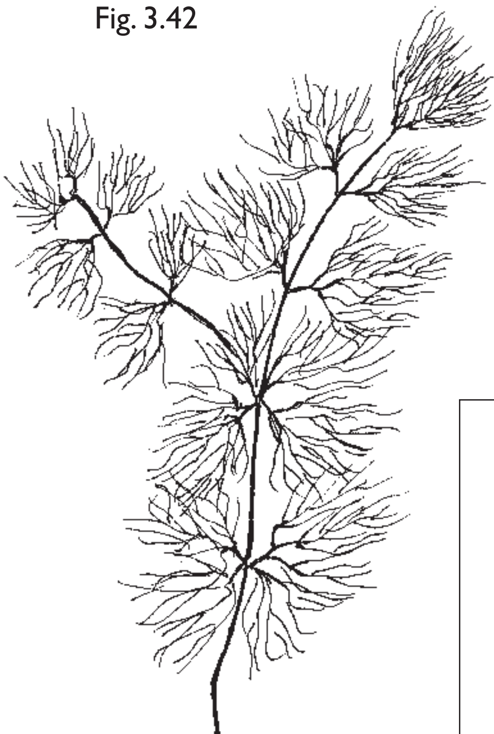


Fig. 3.45

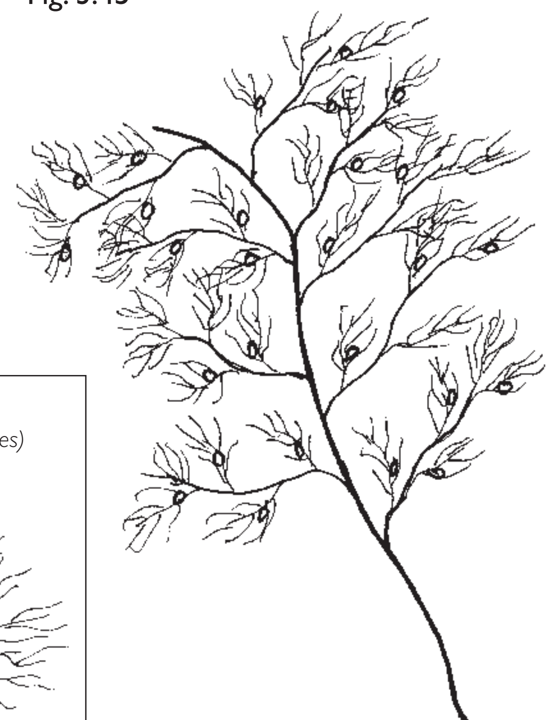


Fig. 3.43

(actual size about 1 to 3 inches)

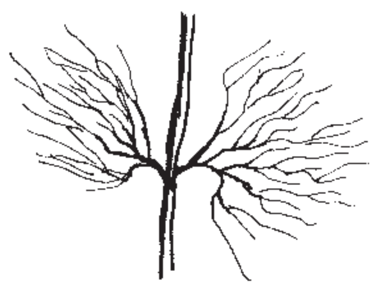


Fig. 3.44

(actual size of leaves 1 to 3 inches)

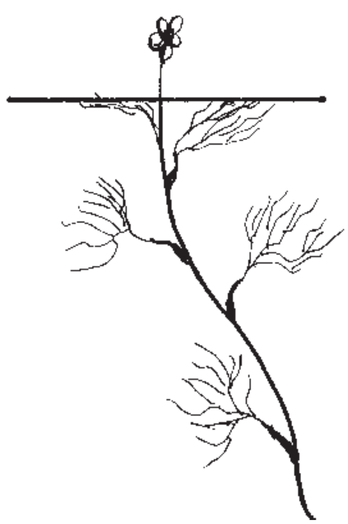
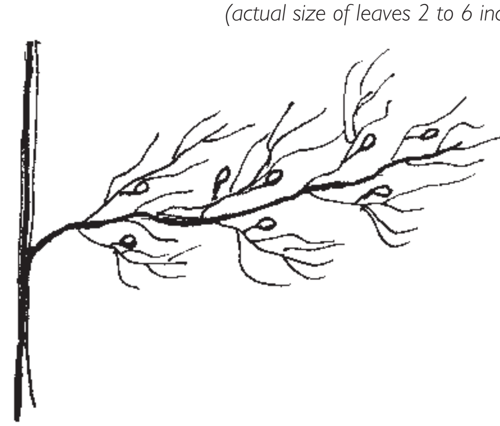


Fig. 3.46

(actual size of leaves 2 to 6 inches)



Figs. 3.42 and **3.43**: *Megalodonta beckii* (water marigold), **Fig. 3.44**: *Ranunculus* spp. (buttercup), **Figs. 3.45** and **3.46**: *Utricularia* spp. (bladderwort).

Part Seven

Plants with Oval, Oblong or Lanceolate Leaves

#1	***Choose one of the following:*** Leaves small, less than ¾ inch long, oblong or lanceolate, and whorled on stem (Fig. 3.47 a and b). . . . . **go to #2** Leaves larger than ¾ inch long, oval, oblong or lanceolate, and alternate on stem (Figs. 3.48 - 3.58) . . . . **go to #3**
#2	***Choose one of the following:*** Three leaves at each node, leaf edges appear smooth or very finely toothed, and midvein smooth (Fig 3.47a and Plate 4). *Elodea canadensis* (waterweed) . . . . **see Portrait 36** Four to 7 leaves at each node (usually 5), leaf edges with fine teeth, and midvein usually with spines (Fig. 3.47b). *Hydrilla verticillata* (hydrilla). . . . . **See Portrait 53**
#3	***Choose one of the following:*** Leaves large, 4 to 8 inches long, ¾ inch to 3 inches wide (Figs. 3.48 and 3.49) . . . . **go to #4** Leaves small to moderate size, usually less than 4 inches long (Figs. 3.52, 3.54, 3.56 and 3.57) . . . . **go to #5**
#4	***Choose one of the following:*** Leaves 1 to 3 inches wide, curved or wavy, tip pointed (Fig. 3.55) and with a short petiole (Fig. 3.48). *Potamogeton amplifolius* (large-leaf pondweed) . . . . **see Portrait 30** Leaves ¾ inch to 1¼ inches wide, tip of leaf boat-shaped (Fig. 3.50); clasping leaves with no petiole (Fig. 3.51). *Potamogeton praelongus* (whitestem pondweed, Fig. 3.49 and Plate 3) . . . . **see Portrait 44**
#5	***Choose one of the following:*** Leaf margins finely toothed (Fig. 3.53). *Potamogeton crispus* (curly-leaf pondweed, Fig. 3.52 and Plate 3) . . . . **see Portrait 51** Leaf margins not finely toothed. . . . . **go to #6**

(continued)

Part Seven (cont.)

Plants with Oval, Oblong or Lanceolate Leaves

#6	***Choose one of the following:*** Leaf clasping the stem (Fig. 3.51) and with wavy margins. *Potamogeton richardsonii* (clasping-leaf pondweed, Fig. 3.54 and Plate 3) . . . . **see Portrait 42** Leaf with a petiole (Fig. 3.57) or obscurely petioled (Figs. 3.53 or 3.58) but not clasping the stem . . . . **go to #7**
#7	***Choose one of the following:*** Leaves with a sharp-pointed tip (Fig. 3.55) . . . . **go to #8** Leaves with a round or boat-shaped tip (Fig. 3.50), obscurely petioled; leaf size can vary from small to moderate size. *Potamogeton gramineus* (variable pondweed, Fig. 3.56 and Plate 3) . . . . **see Portrait 31**
#8	***Choose one of the following:*** Upper submersed leaves definitely petioled. Floating leaves sometimes present. *Potamogeton nodosus* (American pondweed, Fig. 3.57) . . . . **see Portrait 45** Leaves obscurely petioled. *Potamogeton illinoensis* . . . . **see Portrait 46** (Illinois pondweed, Fig. 3.58)

Part Seven

Plants with Oval, Oblong or Lanceolate Leaves

Fig. 3.47a

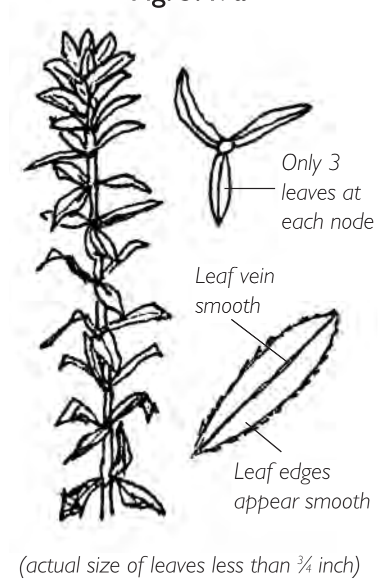


Fig. 3.48

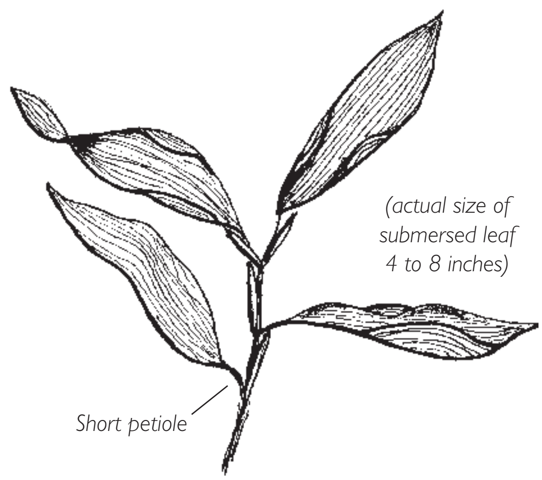


Fig. 3.49

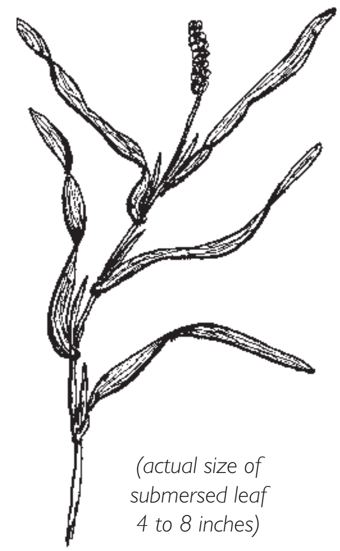


Fig. 3.47b

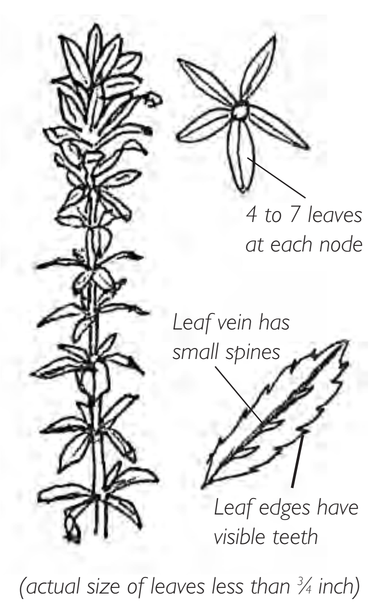


Fig. 3.52

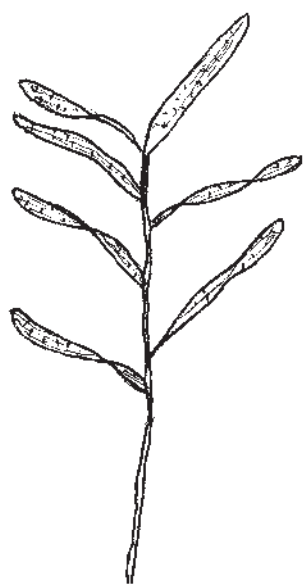


Fig. 3.50

Fig. 3.51

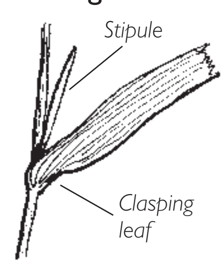


Fig. 3.53

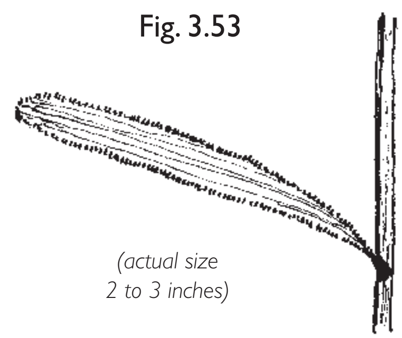
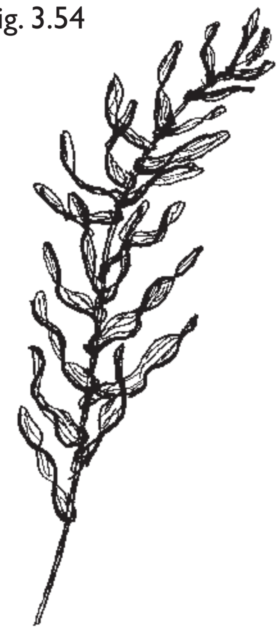


Fig. 3.47a: *Elodea canadensis* (waterweed), **Fig. 3.47b:** *Hydrilla verticillata* (hydrilla), **Fig. 3.48**: *Potamogeton amplifolius* (large-leaf pondweed), **Fig. 3.49**: *Potamogeton praelongus* (whitestem pondweed), **Fig. 3.50**: Boat-shaped leaf, **Fig. 3.51**: Clasping leaf, **Figs. 3.52** and **3.53**: *Potamogeton crispus* (curly-leaf pondweed).

Part Seven

Plants with Oval, Oblong or Lanceolate Leaves

Fig. 3.54



(actual size of leaves about 2 to 3 inches)

Fig. 3.56

(actual size of leaves 1 to 3 inches)

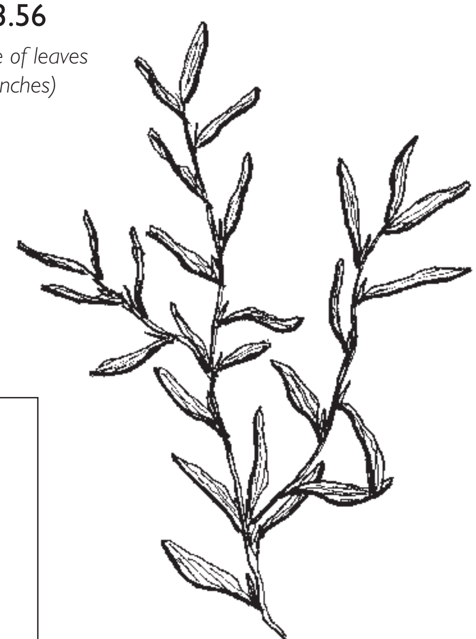
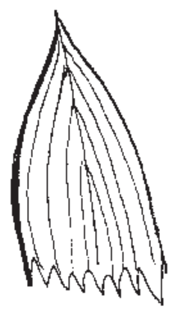


Fig. 3.55



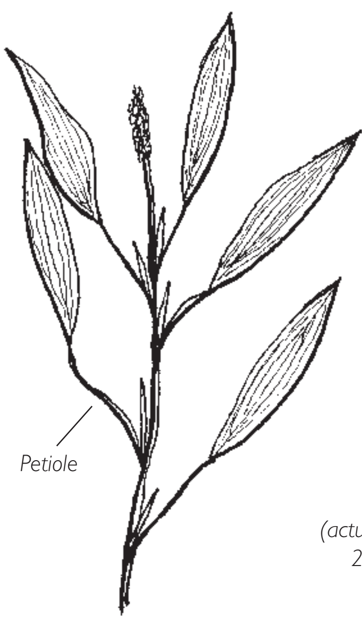


Fig. 3.57

(actual size of leaves 2 to 4 inches)

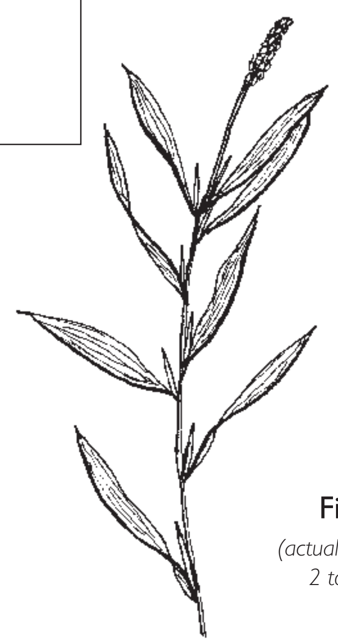
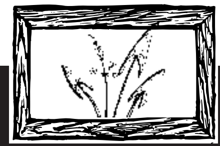


Fig. 3.58

(actual size of leaves 2 to 6 inches)

Fig. 3.54: *Potamogeton richardsonii* (clasping-leaf pondweed), **Fig. 3.55**: Sharp-tipped leaf, **Fig. 3.56**: *Potamogeton gramineus* (variable pondweed), **Fig. 3.57**: *Potamogeton nodosus* (American pondweed), **Fig. 3.58**: *Potamogeton illinoensis* (Illinois pondweed).



Portraits of the Common Rooted Aquatic Plants of Michigan Lakes

P o r t r a i t s

Portrait Number	Description of plants	*(+) = beneficial, (0) = neutral, (–) = nuisance*

1 to 4

Watermeal (*Wolffia* spp.), **star duckweed** (*Lemna trisulca*), **lesser duckweed** (*Lemna minor*) and **big duckweed** (*Spirodela polyrhiza*). All four duckweed species are described collectively. (0)

Growth characteristics Duckweed species are very small — usually less than ½ inch in size — free-floating plants. Their small size allows them to reproduce quickly. They can sometimes cover the entire surface of small lakes in a few days or quickly revegetate an area after application of plant controls.

Habitat These plants are found in quiet water areas such as ponds, small lakes, canals and protected bays of larger lakes. They do not grow well in flowing or wave-washed areas, but they are carried by currents and deposited in quiet backwaters. They are more common in fertile environments such as eutrophic lakes and ponds.

Beneficial traits Duckweed is an important food for waterfowl and other marsh birds.

Nuisance traits Under heavy growth conditions, duckweed can shade out other plants. Though not seriously hindering recreation, a heavy growth of the plant can be an annoyance to people.

Other details The duckweed watermeal (*Wolffia* spp.) is the world's smallest flowering plant. Duckweed can be difficult to control in many situations. Control is limited to herbicides, with highly variable results.

6

Cattails (*Typha* spp.) (+)

Growth characteristics Two species of cattails are found in Michigan. They grow from 3 to 8 feet tall. They may grow in small patches of a few plants or in large beds covering hundreds of acres.

Habitat Cattails are shallow-water plants, usually growing in 1 to 3 feet of water. One species can grow in deeper water to a depth of 5 to 6 feet.

Beneficial traits Cattails provide excellent habitat for many birds, aquatic and wetland animals, and some fish species. The leaves and roots are important food for muskrats. The matted roots, stem system and leaves diminish wave energy, hold sediments in place and protect shorelines from erosion. Positioned plants can screen development and provide a natural background.

Portraits

Portrait Number	Description of plants (+) = beneficial, (0) = neutral, (–) = nuisance
6	**Cattails** *(continued)*
	Nuisance traits Cattails are not acceptable in swimming beach areas. **Other details** Cattails are one of the first plants to colonize newly flooded areas. They often greatly expand their area of coverage following lake drawdown.
7	**Bulrushes** (*Scirpus* spp.) (+)
	Growth characteristics The bulrush's slender stem grows 3 to 6 feet tall. The stems arise from a buried stem (rhizome), giving the stems the appearance of growing in rows. **Habitat** Bulrush typically grows in narrow bands along the lake shoreline in water 1 to 2 feet deep. It rarely covers an extensive area, so conflict with most recreational activities is minimal. It may appear offshore growing from sunken islands. It can grow well on sandy and marl soils. **Beneficial traits** Bulrush provides excellent habitat for many birds and animals and furnishes shelter for young fish. Its seeds are an important waterfowl food. Bass and bluegill often build their spawning nests in bulrush areas. Its matted roots and stems diminish wave energy, hold sediments in place and protect shorelines from erosion. Positioned plants can screen development and provide a natural background. **Nuisance traits** Bulrushes are not acceptable in swimming beach areas. **Other details** Turn-of-the-century photographs of Michigan lakes show many with bands of bulrush along most of the shore.
8 to 10	**Arrow arum** (*Peltandra virginica*), **arrowheads** (*Sagittaria* spp.) and **pickerelweed** (*Pontederia cordata*). All three plants are described collectively. (+)
	Growth characteristics These three plants grow 2 to 3 feet tall in small beds usually less than ¼ acre in size. Consequently, they rarely conflict with most recreational activities. **Habitat** These are shallow-water plants growing in 1 to 2 feet of water. They are often found at the outer edge of emergent vegetation, giving way to water lilies and submerged plants as the water deepens. **Beneficial traits** These three plants afford habitat for many aquatic and wetland birds and animals and shelter for young fish. Their seeds and root tubers are food for waterfowl and some wetland mammals. As transition plants from the upland to the deep water environment, they help diminish wave energy, hold sediments in place and protect shorelines from erosion.

Portraits

Portrait Number	Description of plants (+) = beneficial, (0) = neutral, (–) = nuisance
8 to 10	**Arrow arum, arrowheads, pickerelweed** (*continued*) **Nuisance traits** These plants are not acceptable in swimming beach areas. **Other details** Arrowhead species take on many forms. Some grow entirely submersed and have ribbon-shaped leaves instead of arrow-shaped leaves. The flower of pickerelweed is a large blue spike, very colorful in mid- to late summer.
11	**Smartweed** (*Polygonum* spp.) (+) **Growth characteristics** There are several species of smartweed. These plants may be flat on the water surface or grow erect 2 to 3 feet out of the water. They can form thick, tangled brushy beds. **Habitat** Smartweed is a marsh plant found along organic lakeshores in water less than a foot deep. It is typically found where a wetland habitat transitions into the lake. **Beneficial traits** The plant's seeds are highly prized for food by many birds and mammals. It provides cover for marsh wildlife and young fish. It and other transition plants protect the wetland from wave erosion and hold light organic sediments in place, reducing sediment turbidity. **Nuisance traits** The plant is found primarily in marsh areas, so it does not conflict with most recreation except where development has intruded into wetland habitat. **Other details** Smartweed is often one of the first plants to colonize an area after a lake drawdown.
12 to 14	**White water lily** (*Nymphaea* spp.), **yellow water lily** (*Nuphar* spp.) and **water shield** (*Brasenia schreberi*). All three species are described collectively. (+) **Growth characteristics** These are floating-leaf plants with no submersed leaves. A single floating leaf grows at the end of each leaf stalk. Leaves grow from a large root (rhizome) buried in the lake sediments. **Habitat** Lilies and water shield are more commonly found growing on organic soils. Consequently, they are often but not exclusively associated with wetland areas. They may grow as one or two isolated plants or cover several acres of water. In some lakes with organic bottoms, lilies may ring the entire shoreline or cover much of the surface if the lake is shallow. Lilies grow in water 2 to 4 feet deep; water shield may grow out to the 6-foot depth.

P o r t r a i t s

Portrait Number	Description of plants *(+) = beneficial, (0) = neutral, (–) = nuisance*
12 to 14	**White water lily, yellow water lily, water shield** (*continued*) **Beneficial traits** Lily seeds are eaten by waterfowl, and leaves and tubers by some aquatic mammals. Lilies provide habitat for fish and attract waterfowl and marsh birds. As transition zone plants, they help diminish wave energy, hold sediments in place and protect shorelines from erosion. **Nuisance traits** In dense stands, lilies may shade out other plants and hinder navigation in shallow water areas. **Other details** Water lilies have one of the most commonly recognized aquatic plant flowers.
20	**Stonewort/Muskgrass** (*Chara* spp.) (+) **Growth characteristics** Stonewort is actually algae. It grows in low mats, which can cover extensive area in some lakes. Eight to 12 inches is the maximum height for stonewort species. **Habitat** Stonewort occurs in hard water, which includes most Michigan lakes except the Precambrian shield area of the western Upper Peninsula. Stonewort can be found growing in shallow water or in very clear lakes at depths of 30 feet or more. Being an alga, it can grow deeper than rooted vascular plants. **Beneficial traits** Stonewort is an alga, so it has no roots. It obtains its nutrients from the water, competing with other algae for the available supply. A low-growing mat of stonewort impairs other algae and enhances water clarity. It also competes with and retards taller rooted plants, reducing recreational conflicts. The heavily branched stonewort provides excellent habitat for small aquatic invertebrates. The plant itself and the abundant animal life associated with it make stonewort an excellent waterfowl food and food provider for fish. **Nuisance traits** Stonewort has few negative qualities. Normally, it should be encouraged wherever found. Only heavy growth in active swimming beaches is a problem. **Other details** Stonewort when crushed in the hand has a strong musk odor. It is also commonly referred to as muskgrass. It is often covered with marl (crusty material).
21	**Bushy pondweed** (*Najas* spp.) (+) **Growth characteristics** Bushy pondweed is in the naiad genus, *Najas*, not the pondweed genus, *Potamogeton*. It is usually a low-growing plant reaching 2 to 4 feet in height. In rare situations, it may grow to 8 feet. It germinates late, reaching full growth in July or August. Normally, it doesn't form large beds except in lakes where other plants have been reduced by early summer control programs. The bare sediments allow the late blooming bushy pondweed to expand and replace the controlled species.

Portraits

Portrait Number	Description of plants	(+) = beneficial, (0) = neutral, (–) = nuisance

21 — **Bushy pondweed** (*continued*)

Habitat It is found throughout the littoral zone.

Beneficial traits Its low-growing nature minimizes most recreational impacts. Being bushy, it harbors abundant aquatic invertebrate life and so is one of the most important waterfowl food and fish food providers. Growing higher in the water column than stonewort, it affords better habitat for fish, particularly shelter for young fish.

Nuisance trait In lakes heavily managed for aquatic plants, bushy pondweed can become overabundant.

Other details Drawdowns enhance bushy pondweed populations.

22 — **Fern pondweed** (*Potamogeton robbinsii*) (+)

Growth characteristics Fern pondweed normally grows to a height of 3 to 4 feet.

Habitat This plant is usually found in brown water lakes, which appear tea-colored because of organic material dissolved in the water. Such lakes are usually associated with wetland areas.

Beneficial traits Its low-growing nature minimizes most recreational impacts. It provides a good habitat for fish.

Nuisance traits In some brown water lakes, it can become the dominant plant and be dense.

30 — **Large-leaf pondweed** (*Potamogeton amplifolius*) (+)

Growth characteristics Large-leaf pondweed usually grows to a height of 4 to 6 feet. It may produce floating leaves. It grows in an open, scattered pattern, almost never forming dense colonies, and is usually associated with other plants in diverse communities.

Habitat Typically it is found growing between the 4- and 8-foot depth contours.

Beneficial traits Like most members of the *Potamogeton* (pondweed) genus, large-leaf pondweed is an important waterfowl food. Its characteristic of growing mixed with other plants in a diverse community makes it a valuable fish habitat plant. It only occasionally reaches the surface, so conflict with most recreational uses is minimal.

Portraits

Portrait Number	Description of plants (+) = beneficial, (0) = neutral, (–) = nuisance
30	**Large-leaf pondweed** *(continued)* **Nuisance traits** The plant has few negative qualities and, like most native pondweeds, should usually be encouraged.
31	**Variable pondweed** (*Potamogeton gramineus*) (+) **Growth characteristics** Variable pondweed usually grows to a height of 3 to 5 feet. It may put out floating leaves. Its submersed leaves can vary in size and shape, thus its common name. It grows in an open, scattered pattern, almost never forming dense colonies, and is usually associated with other plants in diverse communities. **Habitat** Typically it is found growing between the 4- and 8-foot depth contours. **Beneficial traits** Like most members of the *Potamogeton* (pondweed) genus, variable pondweed is an important waterfowl food. Its characteristic of growing mixed with other plants in a diverse community provides good fish habitat. It only occasionally reaches the surface, so conflict with most recreational uses is minimal. **Nuisance traits** The plant has few negative qualities and, like most pondweeds, should usually be encouraged.
32	**Thin-leaf pondweed** (*Potamogeton* spp.) (+) **Growth characteristics** Many species make up the group identified as thin-leaf pondweed. Most grow to a height of 3 to 5 feet, sometimes putting out floating leaves. Their submersed leaves are thin, thread-like and very fragile-looking. They rarely form dense colonies and are usually associated with other plants in diverse communities. **Habitat** Typically these species are found growing between the 4- and 8-foot depth contours. **Beneficial traits** Like most members of the *Potamogeton* (pondweed) genus, thin-leaf pondweeds are an important waterfowl food. Their characteristic of growing mixed with other plants in a diverse community provides good fish habitat. They only occasionally reach the surface, so conflict with most recreational uses is minimal. **Nuisance traits** These plants have few negative qualities.

Portraits

Portrait Number	Description of plants (+) = beneficial, (0) = neutral, (–) = nuisance

33 **Flat-stemmed pondweed** (*Potamogeton zosteriformis*) (+)

Growth characteristics Flat-stemmed pondweed usually grows to a height of 3 to 5 feet. It rarely forms dense colonies and is usually associated with other plants in diverse communities.

Habitat It is found growing out to a depth of 8 feet.

Beneficial traits Like most members of the *Potamogeton* (pondweed) genus, flat-stemmed pondweed is an important waterfowl food. Its minimal branching supports fewer insects and other invertebrates, and therefore less fish food than other pondweeds. Its characteristic of growing mixed with other plants in a diverse community provides good fish habitat. It only occasionally reaches the surface, so conflict with most recreational uses is minimal.

Nuisance traits The plant has few negative qualities.

Other details Its flat stem makes it easily identifiable.

34 **Wild celery** (*Vallisneria americana*) (+)

Growth characteristics Wild celery is a low-growing plant attaining 2 to 4 feet in height; in rare situations it may grow to a height of 6 feet. In late summer, the plant puts out a spiraling flower stalk that grows to the water surface. It germinates late, not reaching full growth until July or August. This plant usually does not form large beds except in lakes where other plants have been reduced by early summer control programs. The bare sediments allow the late-blooming wild celery to expand to replace the controlled plants.

Habitat It is found throughout the littoral zone, sometimes as deep as 15 feet.

Beneficial traits Its low-growing nature minimizes most recreational impacts. This plant is one of the most important waterfowl foods. All parts of the plant are eaten. Having few branches, it harbors less aquatic invertebrate life than bushier plants and so provides less fish food. The plant does furnish good habitat for young fish, however.

Nuisance traits In lakes heavily managed for other aquatic plants, wild celery can become overabundant and a problem. It is difficult to harvest and is resistant to most herbicides.

Portraits

Portrait Number	Description of plants (+) = beneficial, (0) = neutral, (–) = nuisance

34 Wild celery *(continued)*

Other details There are other plants similar in appearance to wild celery, such as bur reed (*Sparganium* spp.), water star grass (*Heteranthera dubia*) and some forms of arrowhead (*Sagittaria* spp.). It is necessary to look at the vein structure of the leaves for a positive identification. Wild celery has leaves with a broad central vein region with many longitudinal veins between the outer regions of the leaf, which have few veins. See wild celery's color plate (Plate 2) for an example of this venation. Wild celery also grows well in rivers and streams.

35 Water star grass (*Heteranthera dubia*) (also known as *Zosterella dubia*) (+)

Growth characteristics Water star grass usually grows to a height of 3 to 5 feet. It rarely forms dense colonies and is usually found associated with other plants in diverse communities.

Habitat It is typically found growing in less than 8 feet of water.

Beneficial traits Its characteristic of growing mixed with other plants in a diverse community provides good fish habitat. However, its minimal branching means few invertebrates live on it, so it produces less fish food than other plant species. It only occasionally reaches the surface, so conflict with most recreational uses is minimal.

Nuisance traits The plant has few negative qualities.

Other details It looks similar to flat-stemmed pondweed but has a round stem.

36 Waterweed (*Elodea canadensis*) (+)

Growth characteristics Waterweed is usually a low-growing plant attaining 3 to 5 feet in height. In rare situations, it can grow much taller. This plant usually does not form large beds but may in certain situations cover several acres. The plant can fragment and drift in floating mats of tangled plants that eventually sink to form new colonies.

Habitat It is found throughout the littoral zone.

Beneficial traits Its low-growing nature minimizes most recreational impacts. Being bushy, it harbors abundant aquatic invertebrate life that makes it a good waterfowl food and fish food provider. It also provides habitat for fish, especially young of the year.

Portraits

Portrait Number	Description of plants (+) = beneficial, (0) = neutral, (–) = nuisance
36	**Waterweed** *(continued)*
	Nuisance traits It can become abundant and a problem in localized areas. Floating mats of waterweed are a problem on beaches where they are windblown. **Other details** It is used extensively as an ornamental plant in aquaria. When introduced into Europe, waterweed became a serious problem on that continent.
40	**Native milfoil** (*Myriophyllum* spp.) (0/–)
	Growth characteristics Native milfoil is a tall, indigenous aquatic plant capable of reaching the surface in 10 to 12 feet of water in clear lakes. Its growth pattern allows it to grow over other plants and reach the surface from greater water depths than most other native species. Consequently, it can form dense colonies covering many acres. As a native species, it has natural biological control agents that diminish large colonies in time. Control of other aquatic plants reduces competition and allows native milfoil to maintain a greater coverage. **Habitat** Native milfoil may be found throughout the littoral zone out to a depth of 15 to 20 feet. **Beneficial traits** Its highly branched or bushy nature is excellent habitat for small aquatic invertebrates, so it is a good fish food provider. When not in dense conditions, it is excellent fish habitat, especially in deeper water areas. **Nuisance traits** Its tall growth pattern conflicts with many recreational activities. In dense conditions, it can be a serious localized problem. It is not a significant food for waterfowl or aquatic mammals. **Other details** It can regenerate from detached fragments but not as prolifically as Eurasian milfoil.
41	**Coontail** (*Ceratophyllum demersum*) (0/–)
	Growth characteristics Coontail is a tall, highly branched indigenous species without roots. Its growth pattern allows it to outcompete many other species and cover many acres. As a native species, it has natural biological control agents that diminish large colonies in time. Control of other aquatic plants reduces competition and allows coontail to maintain a greater area of coverage. **Habitat** Coontail may be found throughout the littoral zone. **Beneficial traits** Its highly branched or bushy nature is excellent habitat for small aquatic insects and other invertebrates, so it is a good fish food provider. When not in dense conditions, it provides exceptional fish habitat, especially in deeper water areas. It is also a preferred waterfowl food plant.

P o r t r a i t s

Portrait Number | **Description of plants** — (+) = beneficial, (0) = neutral, (–) = nuisance

41 — Coontail *(continued)*

Nuisance traits Its tall growth pattern conflicts with many recreational activities. In dense conditions, it can be a localized problem.

Other details This plant has no root system. Its hold on the bottom is simply a portion of the stem covered with thin sediments. Even minor wave energy can dislodge large masses of a bed, which float to another part of the lake, sink and start a new colony. Large, thick floating mats of coontail can be a recreational hindrance.

42 & 44 — Clasping-leaf pondweed (*Potamogeton richardsonii*) and whitestem pondweed (*Potamogeton praelongus*). Both species are described collectively. (0)

Growth characteristics These pondweeds are large, leafy plants. They sometimes reach a height of 8 feet and have a more luxuriant growth than many members of the pondweed genus. Though they are usually not problem plants, in certain situations they can form dense colonies.

Habitat These plants may be found throughout the littoral zone.

Beneficial traits The tall, leafy nature of these plants provides excellent habitat for aquatic invertebrates, so they are a good fish food provider. When not in dense conditions, they are exceptional fish habitat, especially in deeper water areas. They are also preferred waterfowl food plants.

Nuisance traits The tall, leafy growth pattern of these plants can conflict with some recreational activities. In dense conditions, they can be a localized problem.

43 — Floating-leaf pondweed (*Potamogeton natans*) (+)

Growth characteristics Floating-leaf pondweed usually grows to a height of 5 to 8 feet. It grows in an open, scattered pattern, rarely forming dense colonies, and is usually found associated with other plants in diverse communities.

Habitat It is typically found growing between the 4- and 8-foot depth contours.

Beneficial traits Like most members of the *Potamogeton* (pondweed) genus, floating-leaf pondweed is an important waterfowl food. Its characteristic of growing mixed with other plants in a diverse community makes it a good fish habitat plant. Its minimal branching yields few aquatic invertebrates, so it produces less fish food than other plant species.

Nuisance traits The plant has few negative qualities.

P o r t r a i t s

Portrait Number	Description of plants (+) = beneficial, (0) = neutral, (–) = nuisance
45 to 46	**American pondweed** (*Potamogeton nodosus*) and **Illinois pondweed** (*Potamogeton illinoensis*). Both species are described collectively. (+)
	Growth characteristics These pondweeds usually grow to a height of 5 to 8 feet. They rarely form dense colonies and are usually associated with other plants in diverse communities. **Habitat** They are typically found growing between the 4- and 8-foot depth contours. **Beneficial traits** Like most members of the *Potamogeton* (pondweed) genus, these pondweeds are important waterfowl food. Their characteristic of growing mixed with other plants in a diverse community makes them good fish habitat plants. Their open architecture growth pattern minimizes conflict with most recreational activities. **Nuisance traits** These plants have few negative qualities.
47 to 49	**Water marigold** (*Megalodonta beckii*), **bladderwort** (*Utricularia* spp.) and **buttercup** (*Ranunculus* spp.). All three species are described collectively. (0)
	Growth characteristics These plants are highly branched with finely divided leaves giving them the appearance of milfoil, with which they are often confused. They grow to a height of 6 to 8 feet. Though they can form dense colonies, these colonies rarely cover more than a few acres. **Habitat** They are usually found out to the 8-foot depth contour (buttercup somewhat shallower). **Beneficial traits** The bushy nature of these plants provides excellent habitat for small aquatic invertebrates, so they are good fish food providers. They are good fish habitat and fair waterfowl food plants. **Nuisance traits** The bushy growth pattern of these plants can conflict with some recreational activities. In small areas, they can be a localized problem. **Other details** Bladderwort is a carnivorous plant. Its bladders trap microscopic animals found in the water.

Portraits

Portrait Number | **Description of plants** — *(+) = beneficial, (0) = neutral, (–) = nuisance*

50 — Eurasian milfoil (*Myriophyllum spicatum*) (–)

Growth characteristics Eurasian milfoil is an aggressive, tall-growing exotic aquatic plant from Europe and Asia. It is capable of growing to the surface in 12 to 15 feet of water. At the surface, it forms a dense canopy of vegetation over other plants. Many native plants may be reduced in abundance by the Eurasian milfoil canopy. Consequently, this plant can form dense colonies covering much of a lake's littoral zone. Being an exotic, it has few natural biological control agents, so it can dominate a lake for many years. A few biological control agents have been found. Some lakes have seen significant declines in Eurasian milfoil after 10 to 20 years. Control of other aquatic plants reduces competition and appears to allow Eurasian milfoil to maintain a greater coverage for a longer period.

Habitat Eurasian milfoil may be found throughout the littoral zone, out to a depth of 20 feet.

Beneficial traits Its bushy nature provides excellent habitat for aquatic insects and invertebrates, making it a good fish food provider.

Nuisance traits Its tall growth pattern conflicts with many recreational activities. In dense conditions, it is a serious localized and lakewide problem. It is not a significant food crop for waterfowl, other birds or aquatic mammals.

Other details It readily regenerates from detached fragments and spreads rapidly.

51 — Curly-leaf pondweed (*Potamogeton crispus*) (–)

Growth characteristics Curly-leaf pondweed is an aggressively growing exotic aquatic plant from Europe and Asia. It is capable of growing to the surface in 8 to 10 feet of water. At the surface, it forms a canopy of vegetation. It is one of the first plants to begin growing in the spring, reaching the surface before many native plants germinate from the sediments. Consequently, it can form dense colonies covering much of a lake's littoral zone by early summer. It usually dies back dramatically to minimal levels by mid-July. Curly-leaf pondweed can produce special reproductive pine cone-like structures called "turions", which are highly resistant to herbicidal damage and help spread the plant.

Habitat It may be found throughout the littoral zone out to a depth of about 12 feet.

Beneficial traits It is a fair fish food provider and is used by waterfowl for food.

Nuisance traits It conflicts with many recreational uses and can be a serious localized and lakewide problem.

Other details Curly-leaf pondweed seems to do particularly well in disturbed habitats. In lakes where large-scale aquatic plant control is conducted, this plant can quickly become a serious nuisance.

Portraits

Portrait Number	Description of plants (+) = beneficial, (0) = neutral, (–) = nuisance

52 Sago pondweed *(Stuckenia pectinata)* (formerly *Potamogeton pectinatus*) (0/–)

Growth characteristics Sago pondweed is one of the taller, highly branched native aquatic plants. It can grow over other native species and form colonies covering many acres. A native species, it has natural biological control agents that diminish large colonies in time. However, control of other aquatic plants reduces competition and can allow sago pondweed to maintain a greater coverage for longer.

Habitat Sago pondweed may be found throughout the littoral zone to a depth of 10 feet.

Beneficial traits Its bushy nature provides excellent habitat for small aquatic invertebrates, so it is a good fish food provider. When not in dense conditions, it is exceptional fish habitat, especially in deeper water areas. It is also a preferred waterfowl food plant.

Nuisance traits Its tall, dense growth pattern conflicts with many recreational activities. In dense conditions, it can be a localized and lakewide problem.

Other details In lakes with major aquatic plant control projects, sago pondweed can expand its coverage and become a problem.

53 Hydrilla *(Hydrilla verticillata)* (–)

Growth characteristics Hydrilla is a submersed aquatic plant native to much of Asia. Taxonomically, it is a member of the Hydrocharitaceae (frog's bit) family, the same family as Michigan's native plant *Elodea canadensis* (waterweed), which it closely resembles. It can grow in lakes, ponds, slow-flowing streams, drains and deepwater marshes. Under good conditions it can grow an inch a day and reach a length of 30 feet. It can reproduce by seeds, turions that form at the bases of leaves, tubers or stem fragments. It forms a dense canopy at the water surface, limiting the growth of native species and driving many to local extinction. It usually outcompetes even Eurasian milfoil to be the dominant plant in a lake.

Habitat Hydrilla may be found throughout the littoral zone to a depth of 20 feet or more.

Beneficial traits Its bushy nature provides excellent habitat for aquatic insects and invertebrates, making it a good fish food provider.

Nuisance traits One Florida researcher referred to hydrilla as the "perfect aquatic weed." It typically invades a new environment by colonizing an area, such as deepwater sediments or other sites not colonized by native species, and then spreading to dominate the environment. Where it becomes established, it is a serious recreational and economic problem.

Other details At the time of this writing, hydrilla is not in Michigan, but it has been found in northern Indiana and will likely invade Michigan.

Chapter 4

Creating a Plant Collection

Introduction

The creation of a plant collection has several values, including:

- Helping volunteer monitors learn to recognize various aquatic plants.
- Serving as a reference for collectors.
- Providing a long-term record.
- Allowing quality control checks by an aquatic ecologist.
- Serving as a program display to acquaint property owners with aquatic plants.

There are several plant collection methods. The use of herbarium procedures produces a mounted specimen that will last a long time if stored in climate-controlled cabinets. Unfortunately, these mounted specimens are fragile and not easily handled or transported. Procedures for producing herbarium specimens are available in many botanical texts and are not presented here. Instead, this reference provides a procedure for producing a more functional collection with the obvious tradeoff in longevity.

Materials Needed

A **rake**, **cooler**, **ice**, **tape** and **zip-lock bags** are needed to collect and transport the plants. Inscribe the collection location on each bag with a **waterproof marker**. The home work area will need **a shallow pan**, **a plant press**, **newspaper**, **matte board**, **clear contact paper**, **self-adhesive labels**, **clear packaging tape**, and **toothpicks** or a **similar pointed tool**.

Procedures

A thorough search assures representation of the lake's common plant species in a collection. Survey both developed and undeveloped shorelines and all depths of water out to at least 10 feet. Collection of plants in deep water will require a rake and line. Chapter 5, "Mapping Aquatic Plants in the Lake," provides suggestions for rakes and their use.

Aquatic plants grow and bloom at various times of the year, just like land plants, so creating a good collection requires sampling at least twice during the summer. The best collection dates for Michigan are early to mid-June and late August.

After harvesting the plants, select the best specimens. Choose plants that are in bloom or fruiting, green and vigorous, and unbroken and undamaged. Retain three good examples to guarantee one good mount. Gently place gathered plants in zip-lock bags marked with location, depth and date, keep cool and press within 12 hours. Use tape to keep zip-lock bags closed, if necessary.

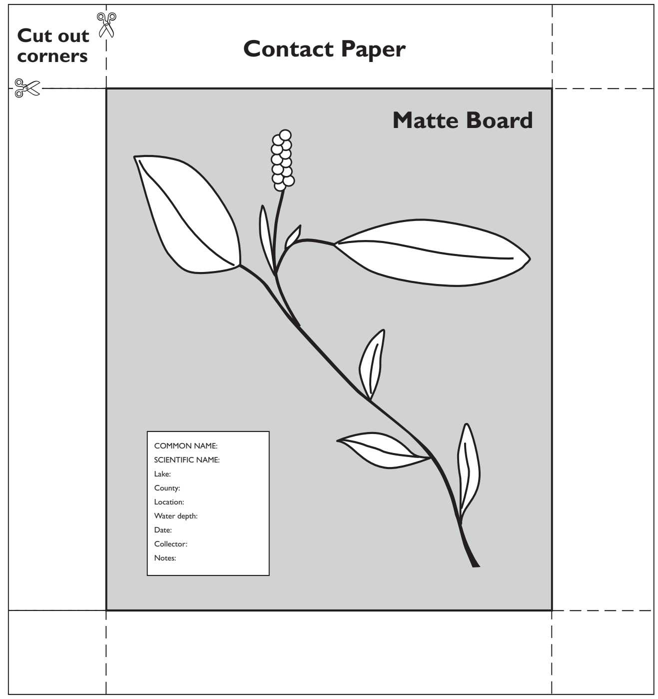
At the home work station, identify the plants using the Citizen's Key to Common Aquatic Plants of Michigan Lakes in Chapter 3. Keep the plants damp in a shallow pan while identifying. Press and mount unidentified plants for later identification by an aquatic ecologist or other expert.

On a newspaper, lay out a plant. Use a toothpick or other pointed tool to spread the plant so all important features are apparent. Bend the plant so it will fit onto a matte board 11 by 14 inches or larger. Fold very long plants into a **W** shape. If the plant has too many leaves, remove a few so the remaining leaves clearly display patterns and shapes. Sometimes individually mounting leaves, flowers, nutlets or other important features greatly assists identification.

Once the plant is properly spread, lay a newspaper over the plant and place it in the press. Insert a spacer board and repeat the process for the next plant. Press the plants for 6 to 8 weeks. Figure 4.1 presents a simple homemade plant press. If no plant press is available, spread the plants in newspaper and press between large heavy books, such as old phone books.

After pressing, very carefully remove a plant from the newspapers and lay it out on a matte board. The matte board should already have a completed label attached in a corner. Box 4.1 provides an example label. Wrap the plant and matte board with clear contact paper. Cut squares out of the contact paper corners to allow the contact paper to fold easily around the matte board without crumpling. Small pieces of clear tape help hold the plant down when placing the contact paper. On the backside of the matte board, use clear packaging tape to secure the edges of the contact paper.

Securely store the mounted plants to avoid damaging the collection. Large file folders are available that hold 11- by 14-inch matte boards.



Training

Reviewing these procedures with an aquatic ecologist will minimize problems and provide a quality product. Michigan Lake and Stream Associations, Inc., annual meetings and Michigan State University Extension training often provide instruction in aquatic plant management. These are excellent settings to obtain information and share problems and suggestions with other citizen volunteer monitors.

Box 4.1 **Example Label**

COMMON NAME: ____________________

SCIENTIFIC NAME: ____________________

Lake: ____________________

County: ____________________

Location: ____________________

Water depth: ____________________

Date: ____________________

Collector: ____________________

Notes: ____________________

Collection Verification

Periodic review of the collection by an aquatic ecologist to verify plant identification is essential. Have the collection verified by a knowledgeable professional or in an aquatic plant workshop.

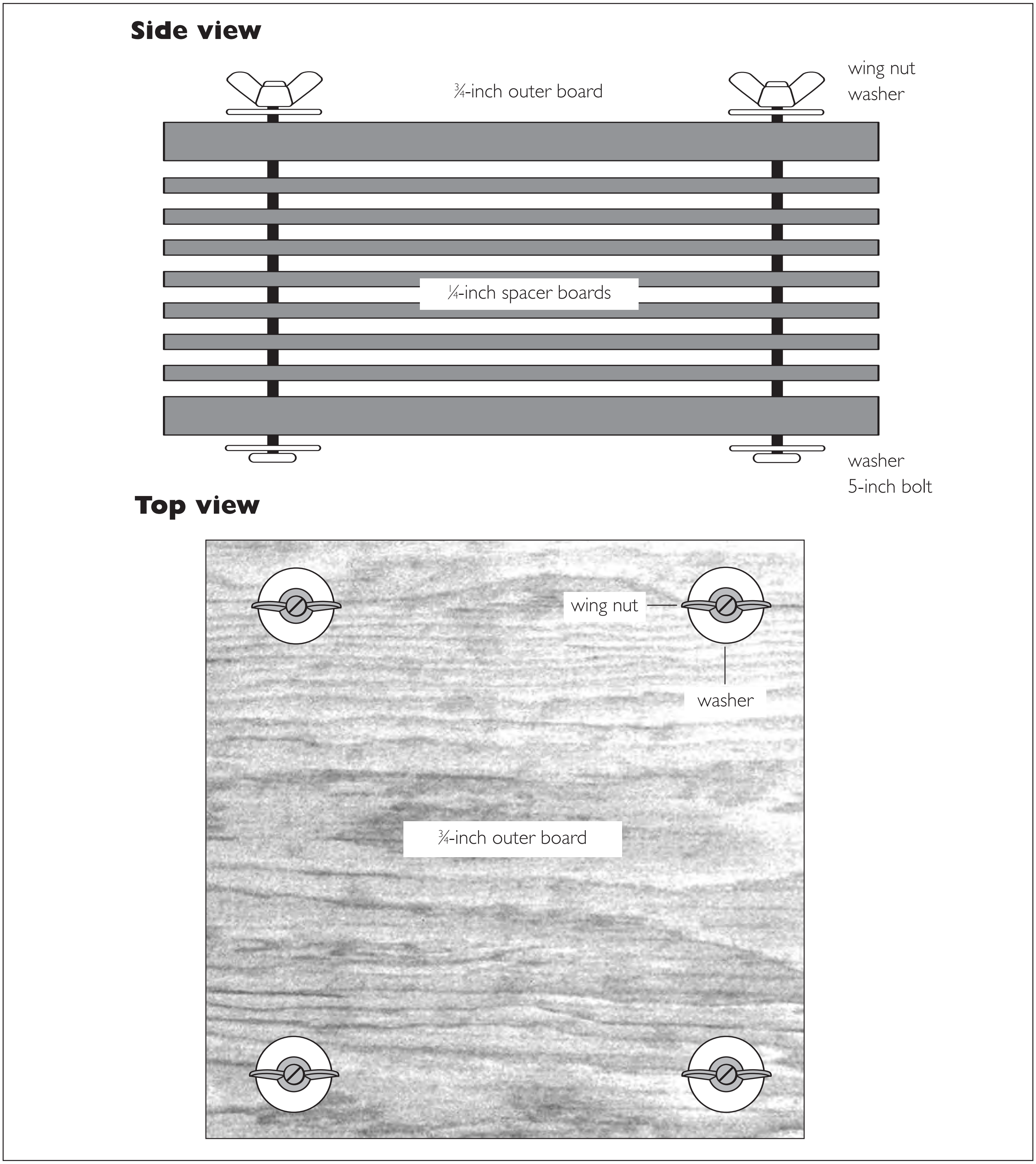
References

References on aquatic plant collections:

Temte, J. (no date). **Aquatic Plant Monitoring Procedures - Self-Help Lake Volunteer Training Manual**. Madison, Wis.: Wisconsin Department of Natural Resources.

Hellquist, C.B. 1993. **Taxonomic Considerations in Aquatic Vegetation Assessment**. Lake and Reservoir Management 7 (2) 175 - 183. Alachua, Fla.: North American Lake Management Society.

Fig. 4.1 **Homemade plant press.**



Chapter 5

Mapping Aquatic Plants in the Lake

Introduction

There are no easy methods to map aquatic plants. People working on the water surface sometimes can't even see the plants below. With some effort and a consistent sampling program, however, a citizen monitor can do a general assessment of a lake's plants. This general assessment is a snapshot of existing conditions. This manual provides a sampling program that volunteer monitors can use to produce an aquatic plant map and data sheet. The program may be used as presented or modified, with assistance from a water quality professional, to meet individual lake needs. Sampling could be limited to critical species, such as the exotics Eurasian milfoil and curly-leaf pondweed. Color codes could be used instead of numbers and letters to produce visual products for citizens. Whatever sampling program is used, it should produce good, reliable information and have procedures that can be duplicated in subsequent years.

The sampling program suggested in this manual is time consuming. Several teams of volunteers may be needed to complete the sampling in a timely manner. On large lakes, several days of sampling may be needed. Required equipment and supplies are generally available. A critical component is the volunteer's time and willingness to learn. Collecting the data needed to create an aquatic plant map and data sheet is much more efficient if the volunteer is already familiar with and able to identify the plants growing in the lake. It is essential to spend some time, maybe even the first year, creating a plant collection and learning to recognize the plants. A lake-specific plant collection, verified by an aquatic ecologist, can be an invaluable tool to help volunteers construct the lake's aquatic plant map and data sheet.

The numbers generated by the sampling methods in this manual are for comparative purposes, not quantitative scientific data usable in statistical analysis. Changes in plant density scores can be the result of the procedures used or the interpretation of the data collector. Even substantial differences in density scores need to be interpreted carefully. Cautious use of this information, along with facts on shoreline land uses, watershed characteristics, nutrient concentrations and recreational goals, allows development of an aquatic plant management plan.

Many lake associations will find it beneficial to hire a professional aquatic ecologist to assess the plant populations of their lake. If they do, the association should still have individuals familiar with aquatic plant identification and assessment methods to communicate with consultants, contractors and governmental units.

Materials Needed

Boating equipment (**boat, motor, gasoline, repair kit, anchor and oars**) provides transportation and a working platform. Safety equipment (**a life vest for each person and a first-aid kit**) is very important and should not be left on shore. Always sample with two people in the boat in case an emergency should arise. Sampling equipment consists of: a sampling map, ideally a depth map of the lake, if available; **extra maps of the lake; field recording sheets; weighted sounding line**, marked for measuring water depth; **weighted rake and retrieving line**; **zip-lock bags**; **clipboard**; **pencils**; and **waterproof marker**.

When to Monitor

Aquatic plant species grow and bloom at various times of the year. Ideally, two aquatic plant maps should be created during the summer. The best data collection dates are early to mid-June and late August. If plant populations are stable and exotic nuisance species are not present, annual mapping is not necessary. Mapping every 3 to 5 years is adequate. Inspections for introduction of undesirable species are still done every year. Annual mapping is recommended if plant populations are expanding, if nuisance species are present or if plant populations are managed.

Preparations

Before mapping begins, the monitoring team(s) prepares for sampling. One monitoring team of two volunteers may process about 10 to 15 sampling transects per day. With experience and thorough preparations, sampling efficiency will improve. Some pre-sampling preparations are suggested.

The sampling map

Aquatic plant collection sites are identified on a sampling map, ideally a depth map of the lake. An example is provided in Figure 5.1. Draw sampling transect lines on the map perpendicular from the shore out to the 10-foot depth contour. Place an "X" on the transect line at approximately the 1-foot, 4-foot and 8-foot depths. Each "X" represents a plant collection site. Recording a description of the shoreline at the transect starting point permits locating this same spot again later. GPS units may also be used to identify the location. Number each transect line and record the number on the map. This number simplifies data recording.

The transect lines are regularly distributed around the lake, with two exceptions. Position one at a boat launching site and another at the major stream inlet. These sites are places of plant introductions. Sampling these sites facilitates early detection of exotic plant introductions and aquatic plant community changes in the lake.

How many sampling transect lines to create is a function of the lake's size and the number of monitors available. Box 5.1 suggests the minimum number of transect lines for lakes of three size ranges. Smaller lakes need fewer transects; larger lakes, more.

Box 5.1

Suggested Minimum Number of Transects

Lake size in acres	Number of sampling transect lines
less than 100	5 to 15
100 to 500	15 to 30
over 500	30 to 50

Field recording sheets

The field recording sheet is the most important item in the aquatic plant mapping effort. The data recorded on these sheets are the foundation for future management decisions. They should be completed accurately and retained for future reference. Each transect line has three sampling sites (1-, 4- and 8-foot depths), so each monitoring effort needs three recording sheets for each transect line. Completing the information sections of the field recording sheets before going on the lake will save time and confusion once sampling begins. Figure 5.2 is a suggested field recording sheet. It is a modification of the recording sheet in *Volunteer Lake Monitoring: A Methods Manual*, published by the U.S. Environmental Protection Agency.

Weighted sounding line

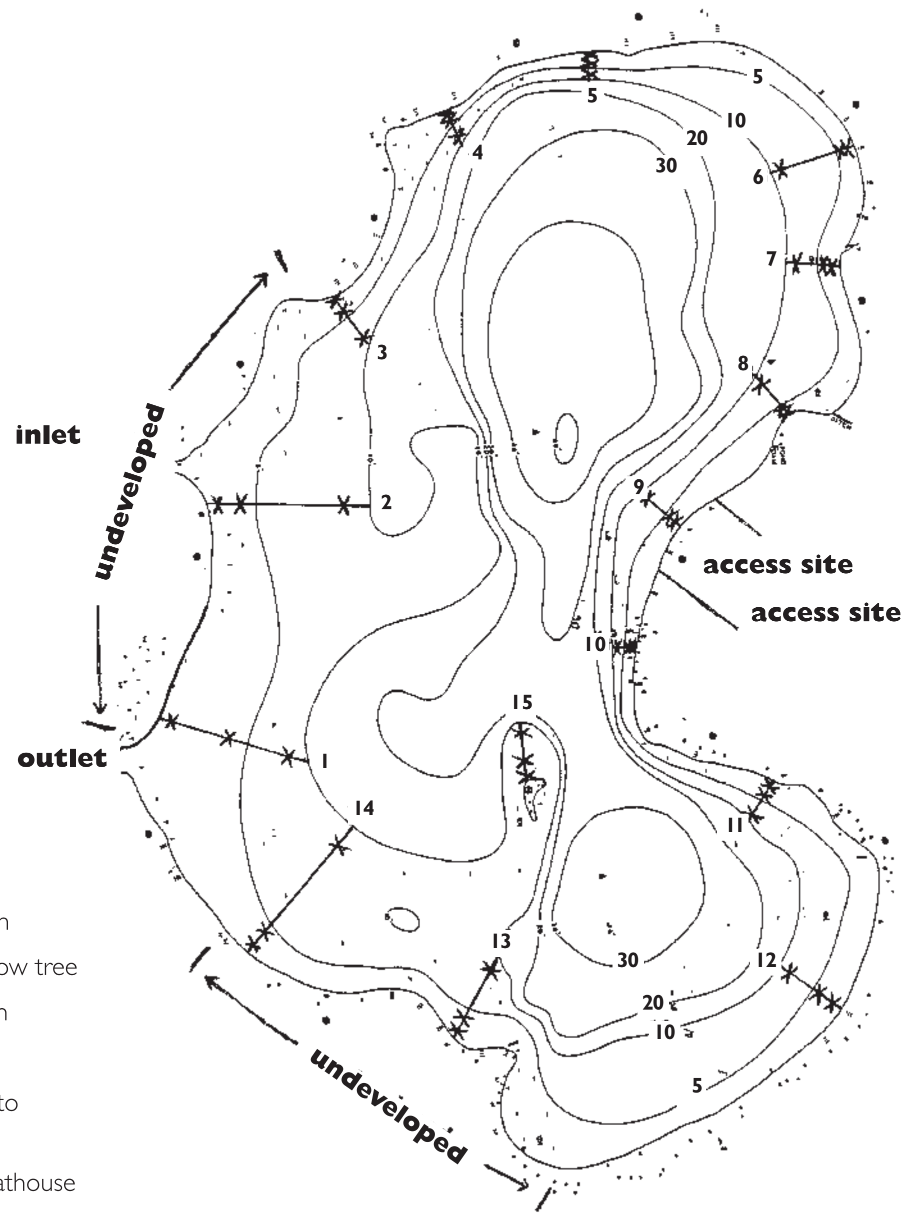
The weighted sounding line is a strong rope with a flat or disk-shaped weight attached to the end. The disk-shaped weight will not sink into organic mucky bottoms as much as more compact weights. The sounding line should be marked so the 1-, 4- and 8-foot sampling depths can be located quickly and easily.

Weighted rake and retrieving line

To collect plants, a strong rake or other harvesting device is needed. Sampling in water 8 feet deep requires a heavy or weighted rake. A long telescoping pole, at least 15 feet long, may be used for retrieval. However, a rope line usually works more efficiently. A wide landscape rake with the handle removed or cut short and secured to a strong line works well. A tool that works especially proficiently is a

Fig. 5.1. **Example of field sampling map and sampling site descriptions.**

Ideal Lake
area 135 acres



Example of transect line location descriptions.

Transect line number	Location description
1	50 feet north of outlet
2	25 feet south of inlet
3	100 feet south of the first house on northwest shore
4	Starts at slide at Camp Sunrise
5	In front of white house with green roof
6	Road end between yellow house and brown pole barn
7	Storm drain near large willow tree
8	50 feet west of Smith Drain
9	Park boat launch site
10	At base of steep hill, stairs to brown house
11	To right (east) of white boathouse
12	25 feet south of permanent dock in front of white house
13	Only group of cedar trees along this beach
14	White house with blue shed
15	North end of island

Fig. 5.2. **Example field recording sheet.**

Lake name:	County name:
Sampling date:	
Names of volunteers:	

Density rating chart	
Rake recovery of aquatic plant	Density rating
Taken in all 4 casts (teeth of rake full)	Dense (D)
Taken in 4 casts	Heavy (H)
Taken in 3 casts	Moderate (M)
Taken in 2 casts	Sparse (S)
Taken in 1 cast	Found (F)

Transect line no.

____

Position on transect line

- 1 foot ❑
- 4 foot ❑
- 8 foot ❑

Plant name or identification number, if known	Collected in 12 o'clock position	Collected in 3 o'clock position	Collected in 6 o'clock position	Collected in 9 o'clock position	Density rating

12- to 14-inch-wide lawn thatcher, again with the handle removed or cut short and a strong rope attached. Lines attached to the rake or thatching tool must be strong and bolted securely. Heavy plant growth creates considerable resistance when the rake is being retrieved.

Materials for identifying unknown plants

Use zip-lock bags and waterproof markers to collect unknown plant species for later identification.

Safety considerations

Before sampling starts: confirm weather conditions; ensure that all safety equipment is on board and in good condition; review safety procedures with all participating volunteers.

Field Procedures

During the week of scheduled plant sampling, take a tour of the lake to locate major aquatic plant beds. On an extra lake map, mark out the location of floating plants (Plant Key, Part 1), emergent plants (Plant Key, Parts 2 and 3) and submergent plants (Plant Key, Parts 4 - 7). This map is the plant location map for the lake. Figure 5.3 is an example. It provides a very general overview of the distribution of plants around the lake. The more detailed aquatic plant map is constructed by replacing the general plant categories (floating, emergent and submergent) of the plant location map, with actual plant species names and densities from data collected in the sampling program.

If volunteers are not available to undertake plant sampling, a plant location map may be completed as a first step in plant mapping for the lake. Finding and recording on the map the location of large beds of exotic species, such as Eurasian milfoil and curly-leaf pondweed, can enhance the simple plant location map. The enhanced plant location map may be used as a prototype aquatic plant map until more accurate information can be collected using the manual procedures.

On the day chosen for plant sampling, activities proceed as follows:

- Go to the first sampling transect.
- Using the weighted sounding line, locate 1 foot of water.
- Anchor the boat facing shore. This will be the 12 o'clock position (see Figure 5.4).
- Pitch the weighted rake toward shore and retrieve.
- Remove all vegetation collected and sort into piles for each known and unknown species.
- Place three specimens of each unknown species in a zip-lock bag to be mounted for later identification.
- Record the presence of each species on the field recording sheet.
- Repeat the procedures at the 3, 6 and 9 o'clock positions.
- After completing all four clock positions, give each plant a density rating, using the rating system in Box 5.2.
- Lift anchor and move directly offshore to the 4-foot depth and anchor.
- Repeat the procedure as at the 1-foot depth site.
- After collecting at the 4-foot depth site, move to the 8-foot depth site and repeat the procedure.
- After completing the first sampling transect, move on to the next and repeat until all are completed.

With the rake, collection of floating plants is nearly impossible and emergent shoreline plants difficult. To account for this deficiency, visually check for these plants in each of the clock positions. If they are present in sufficient quantities to appear in the path of an imaginary rake tow, record their presence.

After all transects are completed, the plant data are combined with the plant location map to produce the aquatic plant map.

Fig. 5.3. **Example of a plant location map.**

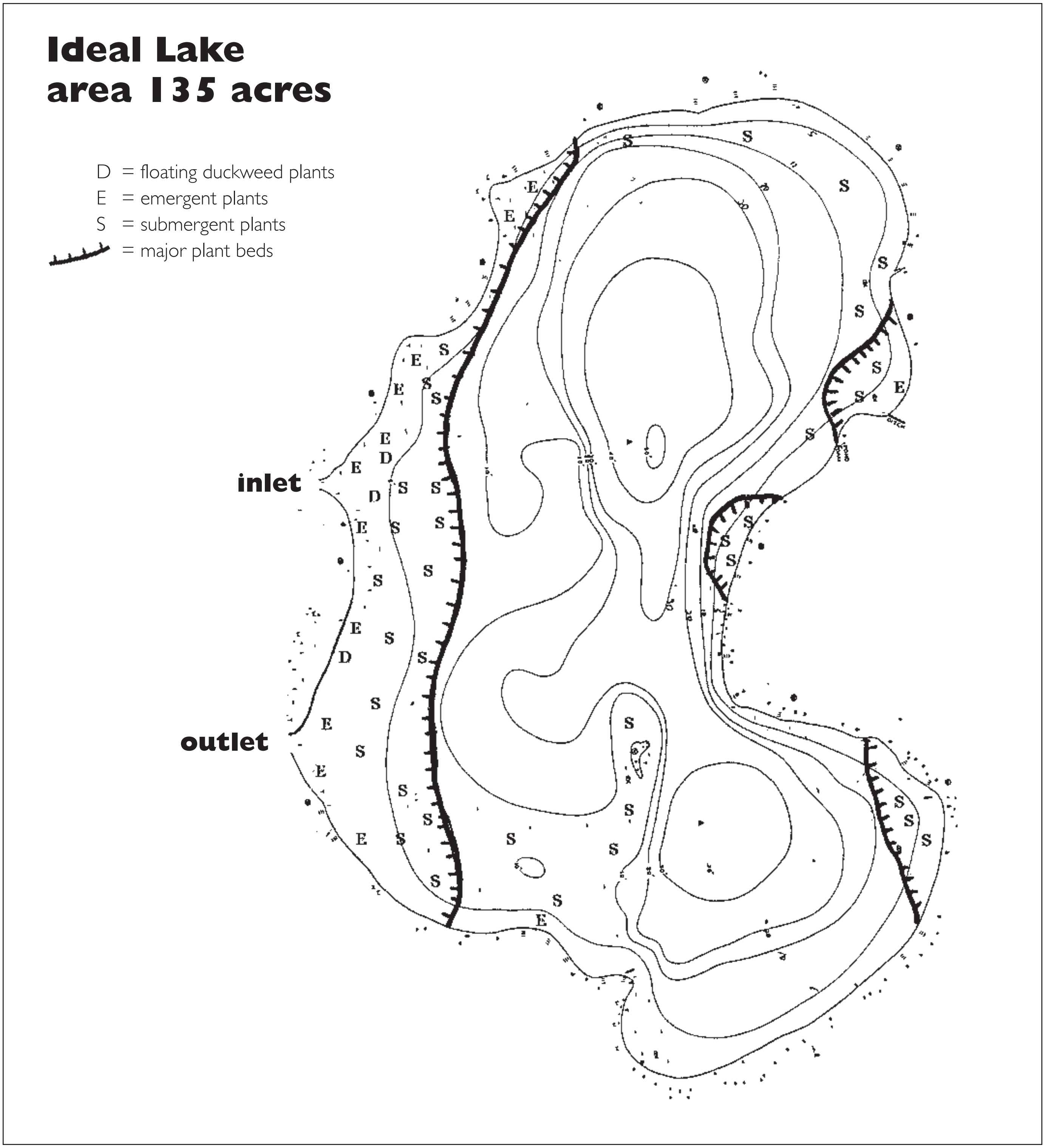
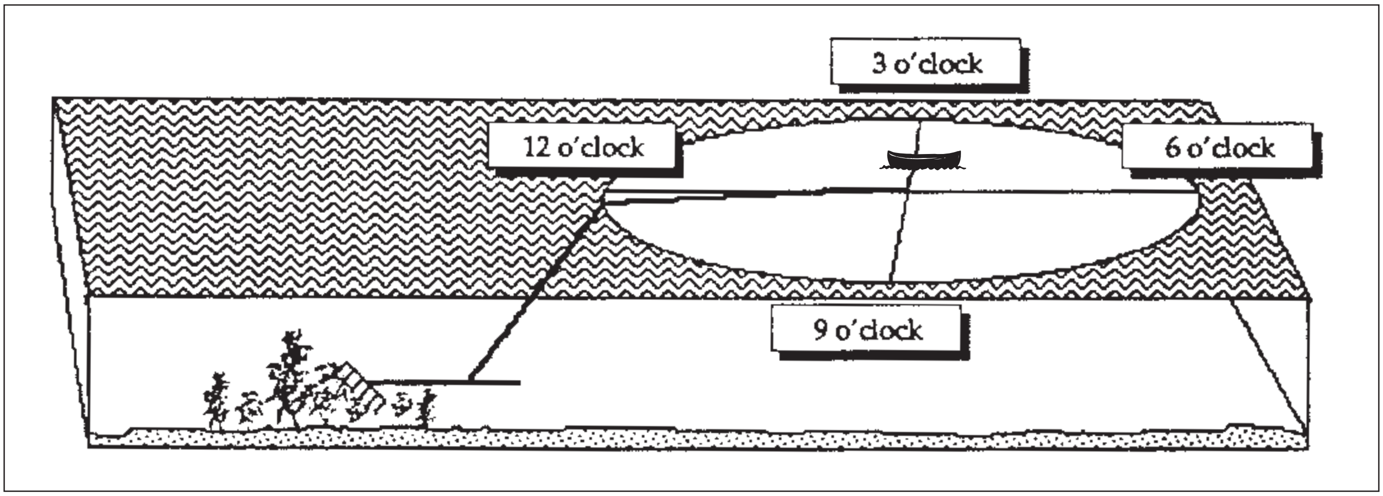


Fig. 5.4.



A rake is pitched at each clock position and then dragged along the lake bottom. The rake is then hauled back into the boat, and the collected vegetation is sorted into plant types. A*dapted from: Simpson, J.T. 1991. Volunteer Lake Monitoring: A Methods Manual. EPA 440/4-91-002.*

Box 5.2. A**quatic Plant Density Rating**

Dense (D)	Species fills the rake in all four casts (12, 3, 6 and 9 o'clock).
Heavy (H)	Species found mixed with other plants in all four cast of the rake.
Moderate (M)	Species found in three of the four rake casts.
Sparse (S)	Species found in two of the four rake casts.
Found (F)	Species found in one of the four rake casts.

Producing the Aquatic Plant Map

To present the plant data on a map, a number code and a letter for its density symbolize each species. Any number code may be used, but the code in Box 5.3 is recommended. If each volunteer monitor uses the same code, sharing information is easier. The plants are ordered according to the portrait numbers given them in Chapter 3 for their growth characteristics. Numbering by growth characteristics will allow citizens to more clearly visualize the distribution of desirable low- and mid-growing species and the location of nuisance canopy species. As an example, the lake's management plan may generally encourage plants with portrait numbers in the 20s and 30s, but plants with portrait numbers in the 50s would be controlled wherever found. Plants with portrait numbers in the 40s may be controlled only where they directly conflict with recreational uses.

The classification of aquatic plants into the growth patterns shown in Box 5.3 is a generalization and should not be strictly interpreted. The classification is based on a large number of observations by the author and colleagues. Under different environmental conditions, plant growth patterns can vary greatly. Low-growing plants such as bushy pondweed can reach the surface in 8 feet of water if conditions are right. Plants usually seen in scattered patches, such as coontail and native milfoil, can sometimes grow in large, dense beds.

To create the aquatic plant map, combine the numbers in Box 5.3 for each plant found at each sampling site with the density rating in Box 5.2 for the plant at that site. As an example, if coontail was found on three rake tows, its map symbol is 41M. On a copy of the lake map showing major plant beds, locate the map symbols for each plant found at each sampling site. A completed aquatic plant map provides a graphical description of what plants are growing in the lake, where and at what densities. Figure 5.5 is an example aquatic plant map.

Box 5.3. A**quatic Plants Numbered by Growth Pattern.**

Free floating

1 -	Watermeal	(0)
2 -	Star duckweed	(0)
3 -	Lesser duckweed	(0)
4 -	Big duckweed	(0)

Shoreline (emergent)

6 -	Cattail	(+)
7 -	Bulrush	(+)
8 -	Arrow arum	(+)
9 -	Arrowhead	(+)
10 -	Pickerelweed	(+)
11 -	Smartweed	(+)
12 -	White water lily	(+)
13 -	Yellow water lily	(+)
14 -	Water shield	(+)

Low growing (1 to 3 feet)

20 -	Stonewort	(+)
21 -	Bushy pondweed	(+)
22 -	Fern pondweed	(+)

Mid-water growing (2 to 5 feet)

30 -	Large-leaf pondweed	(+)
31 -	Variable pondweed	(+)
32 -	Thin-leaf pondweed	(+)
33 -	Flat-stemmed pondweed	(+)
34 -	Wild celery	(+)
35 -	Water star grass	(+)
36 -	Waterweed	(+)

Tall growing (4 to 10 feet); open scattered growth pattern

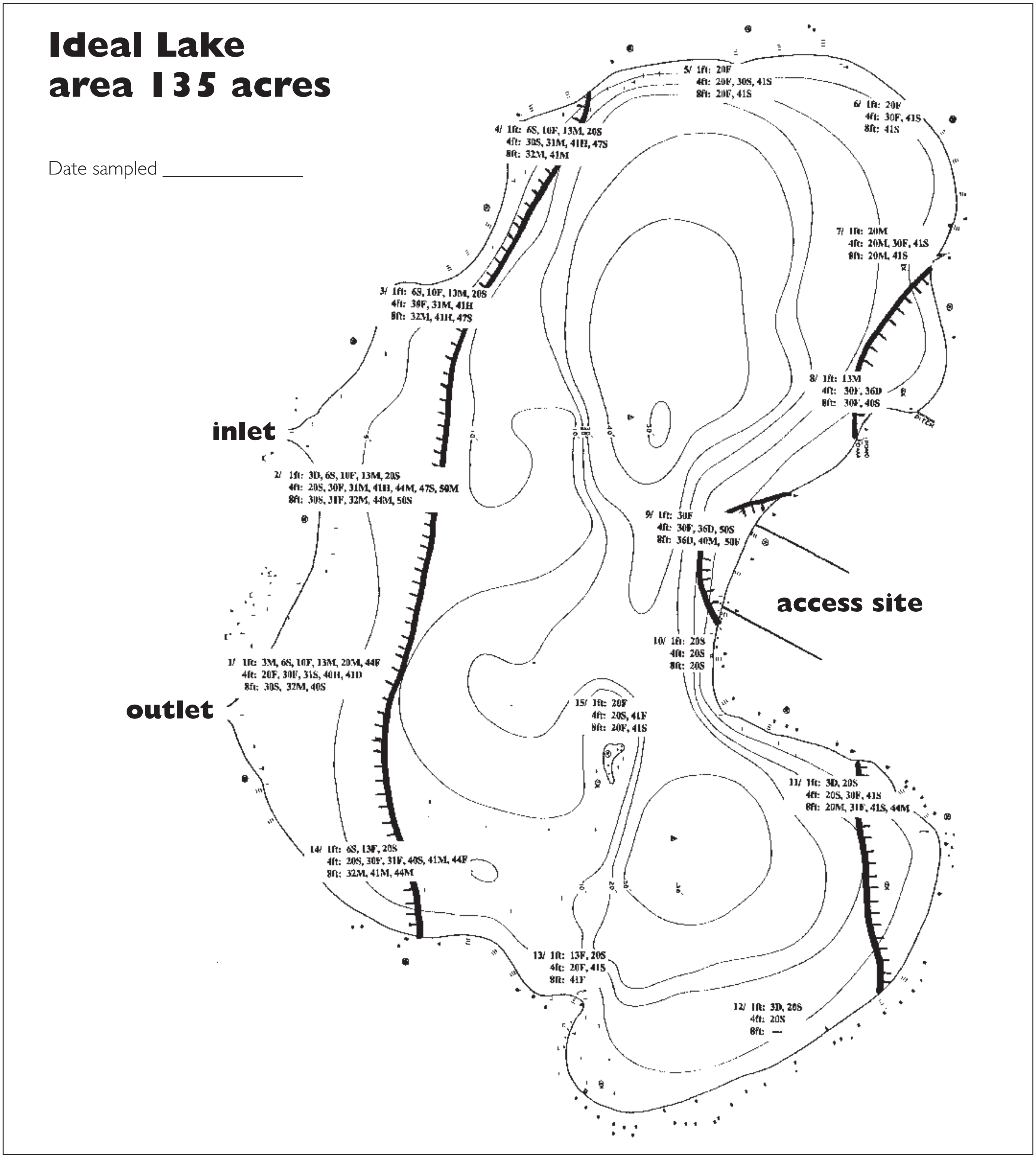
40 -	Native milfoil	(0/–)
41 -	Coontail	(0/–)
42 -	Clasping-leaf pondweed	(0)
43 -	Floating-leaf pondweed	(+)
44 -	Whitestem pondweed	(0)
45 -	American pondweed	(+)
46 -	Illinois pondweed	(+)
47 -	Water marigold	(0)
48 -	Bladderwort	(0)
49 -	Buttercup	(0)

Tall growing (4 to 10 feet); dense canopy growth pattern

50 -	Eurasian milfoil	(–)
51 -	Curly-leaf pondweed	(–)
52 -	Sago pondweed	(0/–)
53 -	Hydrilla	(–)

(+) = generally beneficial, (0) = generally neutral, (–) generally a nuisance

Fig. 5.5. **Example of aquatic plant map.**



Producing the Data Sheet

In addition to the aquatic plant map, the information from the field recording sheets can be summarized onto a data sheet. Figure 5.6 provides an example data sheet. Summarize the data for the lake by tallying all the recorded observations for a plant and calculating its average density. This is done by assigning a number to each of the density ratings: 1 for "found"; 2 for "sparse"; 3 for "moderate"; 4 for "heavy" and 5 for "dense". Total the plant's density numbers and divide by the number of sampling sites used. An example calculation is presented in Box 5.4.

In the example in Box 5.4, coontail is present in only 20 of 45 sample sites. At most sites, it is absent or present in low densities, giving an overall lakewide density rating of 1.1. Only at a few sites does it reach dense conditions that could be a problem. Completing the calculations for each plant species establishes the relative dominance and distribution of plants throughout the lake. The same calculations can be performed, if helpful, for the near-shore sample sites (1-foot-deep sampling station), the mid-depth sampling sites (4-foot-deep sampling sites) and the deep-water sampling sites (8-foot-deep sampling sites). In the example in Box 5.4, with 15 sampling transects there are 15 sampling sites for each water depth zone. The completed data sheet and aquatic plant map provide a good description of the general location and dominance of each plant species in the lake.

Having compiled a good database on the lake's plant population, the volunteer monitor may use the information in Chapters 6-8 to prepare a management plan.

Box 5.4. **Example Data Sheet Calculation.**

There were 15 sampling transects in the lake, giving 45 sampling sites. Coontail was present at 20 sites in the densities identified below.

Density	Number of observations	Multiplication factor	Total density points
Found	2	1	2
Sparse	10	2	20
Moderate	3	3	9
Heavy	3	4	12
Dense	2	5	10
TOTAL	20		50

50 (total density points) / 45 (sampling sites)
= 1.1 (lakewide density rating)

An average lakewide density rating of 1.1 is slightly above the "found" level.

Record observations (20) and average lakewide density rating (1.1) on the data sheet.

Training and Review

Reviewing procedures and completed work with an aquatic ecologist is beneficial. Michigan Lake and Stream Associations, Inc., Michigan State University Extension and others have aquatic ecologists available at regional aquatic plant workshops and conferences. The plant data could be reviewed with one of these individuals or with a professional ecologist from a consulting firm.

References

Other references on the subject of plant mapping include:

Madsen, J.D., and J.A. Bloomfield. 1992. A**quatic Vegetation Monitoring and Assessment Protocol Manual**. Albany, N.Y.: A Report to the Finger Lakes Water Resources Board.

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North American Lake Management Society. 1993. A**quatic Vegetation Quantification Symposium**. In Lake and Reservoir Management, Volume 7, No. 2.

Phillips, E.A. 1959. **Methods of Vegetation Study**. New York: Henry Holt & Co.

Simpson, J.T. 1991. **Volunteer Lake Monitoring: A Methods Manual**. EPA 440/4-91-002. Washington, D.C.: U.S. Environmental Protection Agency.

Temte, J. No date. A**quatic Plant Monitoring Procedures - Self-Help Lake Volunteer Training Manual**. Madison, Wis.: Wisconsin Department of Natural Resources.

Fig. 5.6. **Example data sheet.**

Lake name/county			Sampling date	
Data sheet for:	Whole lake	Near shore	Mid-depth	Deep water
Number of transects			Number of sampling sites	

Plant number	Plant name	Distribution (number of sites where observed)	Average density

Other plants known to be in the lake at the time of the survey but not collected in the survey.

Chapter 6

Securing Public Input

Introduction

The management of aquatic plants requires not only a knowledge of the lake's plant community but information from the lake's citizens. It is important to understand how the citizens perceive the lake and its condition, their comprehension of lake ecology and plant communities, and their recreational aspirations. Do the citizens have realistic expectations, and are they willing to commit to comprehensive management of the lake resource? If the plan does not address the citizens' concerns and issues, it is likely to be rejected, even if it is environmentally and technically correct.

It is impossible to make good decisions without knowledge or practical information. Most lake citizens have never had a class or training session on lake ecology or read a book or manual on managing lake resources. It is unfair to expect them to make decisions regarding a multimillion dollar resource without adequate information. Citizens want to make appropriate decisions and desire the information needed for that purpose but may not know where to obtain it. Facts and reference materials should be made available for those citizens wishing more information.

In many cases, an informational program should precede completion of the management plan to prepare citizens for receipt of the plan. It may even be desirable to conduct the informational program before initiating a citizen survey. This allows them to formulate opinions on the issues with facts before they are requested to provide input to plan development. Introductory materials for an informational program are provided in this chapter. Additional information on lake ecology and aquatic plants for distribution to citizens may be assembled from the documents listed in the reference section at the end of the chapter.

Acquiring citizen input to plan development might be accomplished in several ways, including receipt of written comments, survey forms and public meetings. Depending on the circumstances, the management plan developers may use one or more of these procedures to secure citizen input. One of the most frequently used methods is the survey questionnaire form. An example form is provided in this chapter.

Information Program

To facilitate the information process, two introductory information sheets are included in this manual. Box 6.1 provides information on lake ecology; Box 6.2 includes facts on aquatic plant communities. These information sheets may be used or modified to address a specific situation. The best information program would incorporate lake conditions for the specific lake into the information documents. This allows the citizens to relate directly to the facts provided for their lake.

Survey of Citizens

Box 6.3 provides an example of an aquatic plant survey questionnaire for obtaining the opinions and concerns of citizens living on or using the lake. This survey form may be used as is or modified to address the specific situation. The form may also be improved by incorporating lake data for the particular lake into the questions. This allows the citizens to relate directly to the issues.

Each question on the survey form is included for a distinct purpose. An individual's response to each question informs those developing the management plan how that individual defines the issues, problems and needs. The purpose for each question is as follows:

- **Question 1** – This question provides a perspective on how long the respondent has been familiar with the lake's conditions.
- **Question 2** – The response to this question identifies the disposition the individual may have for aquatic plants. Generally, those who fish will have a greater tolerance for aquatic plants. Those who only water ski and/or swim may have a low tolerance for aquatic plants.

(continued on p. 63)

Box 6.1

The Nature of Lakes

The last glacial period, about 10,000 years ago, left Michigan with a diverse arrangement of soils and topography. Depressions filled with water, creating Michigan's approximately 11,000 lakes larger than 5 surface acres. In regions where nutrient-rich soils were deposited, primarily the southern part of the Lower Peninsula, the land and the lakes are fertile. These nutrient-rich soils produce an abundance of plants and animals, both on the land and in the water. Scientists labeled these fertile lakes with abundant plants "**eutrophic**". In regions of the state where nutrient-poor soils were deposited, the lakes are less fertile and produce fewer plants and animals. Scientists classified these lakes as "**mesotrophic**", lakes of moderate fertility, and "**oligotrophic**", lakes of low fertility. These three classes of lakes are referred to as **trophic states** or levels of fertility.

Lakes are a temporary feature of the landscape. Over time, soil particles and nutrients are washed into the lake from the land around it. This drainage area is called the lake's watershed. Gradually the lake becomes shallower and more fertile, producing more plants. Eventually the lake becomes a wetland and then part of the forest. This process of aging is called **natural eutrophication** and takes thousands of years even in small, shallow lakes. The development of human civilization increases the fertility of the land and the movement of sediments and nutrients into the lakes. The eutrophication process is greatly accelerated, dramatically increasing plant growth in the lakes. This accelerated process is termed **cultural eutrophication**.

The qualities or characteristics of a lake can be changed in two ways: **short-term in-lake management** and **long-term watershed management**. In-lake management is directed at the effects of cultural eutrophication. Tools and techniques include the use of herbicides, harvesters and drawdown to reduce aquatic plant populations. These management activities do not change the environmental conditions that caused the plants to grow, so their benefits are short-term. The plants quickly return or are replaced by more aggressive plants or by algae. The only way to change the characteristics of a lake over the long term is to address the cause of cultural eutrophication, which is the loading of the lake with sediments and nutrients from the watershed. It is possible to retard or even reverse the effects of cultural eutrophication with watershed management.

The natural trophic state of a lake is the base level of fertility, which neither short-term nor long-term management is likely to alter. A lake that is naturally eutrophic produces an abundance of plants and/or algae. Management may shift productivity from one plant to another, but it doesn't change the basic fertility of the lake. Drastically altering the characteristics of a naturally eutrophic lake is possible but not sustainable without continual application of controls. Tremendous energy and cost must be perpetually expended to maintain the artificial conditions created. Relaxing efforts even slightly allows aggressive species to colonize the highly disturbed and unnatural environment. The impacts on native plant and animal communities under such conditions are major and negative. It is important to know a lake's trophic state and the consequences of management controls before applying them.

For a list of additional references on lake ecology, please contact: (List the name, address and phone number of your lake association's contact person below.)

Box 6.2

Plants that Grow in Lakes

Plants are a natural part of the aquatic environment, just as grasses, shrubs and trees are part of the land. They are essential to lakes and the animals that live in or near the water. Their roots are a fabric that holds sediments in place, reduces erosion and maintains bottom stability. They serve to cycle nutrients through the environment and enrich the lake with oxygen. Plants provide habitat for every life stage of fish, including spawning and nursery areas as well as habitat for foraging and predator avoidance. Waterfowl, shorebirds and birds of the marsh habitat use aquatic plants for food, as nesting materials and as cover from predators. Aquatic animals such as fish, frogs, turtles, muskrats, beavers and otters, as well as water-dependent animals such as minks, martens and shrews, use these plants for similar purposes.

Plants are important to lakes, but they can become overabundant in some situations and cause negative impacts on fish populations, fishing and the recreational activities of lake users. When plants become a problem, controls should be implemented to improve environmental and recreational conditions while maintaining the proper vegetative balance for the lake's natural trophic state. The lake should be subtly changed to enhance habitat and recreational uses, not drastically altered. The use of aquatic plant controls will not change a lake's trophic state and, if misused, can negatively affect the plants and the animals that depend on them. Persistent overuse of any control tool can result in a shift to aggressive "weed" species taking advantage of disrupted natural conditions.

One hundred or more common aquatic plant species grow in Michigan lakes. Most of these species are desirable plants that conflict only minimally with recreational uses. A few, however, form dense beds that create major recreational problems. The two worst offenders are **exotic species** unintentionally imported from Europe and Asia – **Eurasian milfoil** and **curly-leaf pondweed**. These two invaders can take over a lake, crowding out native species and creating a recreational nightmare. Excessive control of native plants can facilitate the spread and dominance of these exotic pests. Additionally, a few native plants, such as **sago pondweed** and **coontail**, may become a nuisance if competition from other plants is reduced by a plant control project.

The direct management of plants, whether in the water or on the land, generally falls into five broad options: **promotion, no intervention, selective maintenance, small-scale site maintenance** and **large-scale continual maintenance**. The introduction or planting of desirable species can increase plant variety, improve habitat for animals and add competition for undesirable species. In many lakes, the plants are well distributed and do not interfere with recreational uses. No management is needed in these lakes except monitoring to identify introductions of exotic species. Selective maintenance uses a control to remove one or two species from the lake and maintain all others, and so minimizes environmental impacts. Small-scale site maintenance removes all plants from a very small area, such as a swimming beach, leaving the remainder of the plant community intact. Large-scale continual maintenance is the removal of most plants from a large area of the lake. An analogy in the terrestrial environment would be a farm field. Once cleared, the field must be continually managed to maintain the artificial vegetative state.

Plants may also be managed indirectly by **environmental manipulation**, which often provides long-term control of the plants. Manipulating the environment discourages plant reproduction, distribution and/or colonization. The long-term control of aquatic plants in lakes usually entails reducing the amounts of nutrients and sediments entering the lake from the watershed.

For a list of additional references on aquatic plants and their management contact: (List the name, address and phone number of your lake association's contact person.)

Box 6.3

Aquatic Plant Survey Questionnaire

1. How long have you had the opportunity to observe the lake? ________ Years

2. What uses do you make of the lake? (Select all that apply.)
____ Swimming ____Fishing ____Boating ____Water skiing ____Viewing ____Hunting ____Personal watercraft

3. How would you rank the quality of the lake? (Select all that apply.)
____Very good ____Good ____ Average ____Poor ____Bad

4. What aquatic plant problems exist in the lake? (You may choose more than one.)
____There are not enough plants for the fish and wildlife.
____ Plants are not a problem.
____ Plants are not a problem except in certain areas.
____The plants are unsightly.
____ Plants are excessive and hinder recreation.
____ Algae blooms are a problem.
____Other plant problems (please explain):

5. What kinds of plants are causing a problem? (Select all that apply.)
____ Shoreline plants ____ Underwater plants ____ Floating plants ____Algae

6. Do aquatic plants interfere with any of the following activities? (You may choose more than one.)
____ Swimming ____Navigation ____Offshore boating ____ Fishing ____ Viewing

7. In your opinion, how much of the lake's vegetation should be controlled?
____ None ____ Only problem plants ____Only in problem areas ____ As much as permitted ____All plants

8. If the lake's vegetation should be reduced, which control method do you favor?
____ Drawdown ____ Harvesting ____ Herbicides ____ Hand raking ____ No preference (use what's best)
____ Other (please specify):

9. What do you think are the sources of pollution to the lake? (You may choose more than one.)
____ Agricultural runoff ____ Residential runoff ____ Urban runoff ____ Septic seepage ____Storm sewers
____ Other (please specify):

10. Do you fertilize your lawn? ____Yes ____ No

11. Would you support a voluntary program that promotes good septic system maintenance? ____Yes ____ No

Please use the back of the questionnaire to present your ideas, ask questions and make comments.

(continued from p. 59)

- **Question 3** – This question provides an overall assessment of lake conditions as seen by the citizens.
- **Questions 4, 5 & 6** – The purpose of these questions is to characterize citizens' perspectives on the aquatic plant community of the lake and the problems that exist.
- **Question 7** – This question addresses the need for plant management and the citizens' viewpoint on the level of control needed. If many respondents indicate "as much as permitted" or "all plants," an educational program is probably needed before the management plan is finalized.
- **Question 8** – The response to this question may identify a clear preference of the citizens for a particular control tool, which may or may not be appropriate for the conditions that exist.
- **Question 9** – The purpose of this question is to identify sources contributing to an aquatic plant problem and gauge the citizens' understanding of watershed impacts on the lake.
- **Question 10** – This question will identify possible problem areas and watershed management issues and determine whether an educational program on riparian stewardship would be beneficial.
- **Question 11** – This question will help determine citizens' interest in shoreline and watershed management as a long-term control of aquatic plants.

References

The references listed below may help citizens understand lake ecology and aquatic plants.

Holdren, C., *et al.* 2001. **Managing Lakes and Reservoirs**. Madison, Wis.: North American Lake Management Society and Terrene Institute. In cooperation with the Office of Water Assessment Watershed Protection Division, U.S. Environmental Protection Agency. (Copies available from North American Lake Management Society, www.nalms.org.)

Michigan Department of Environmental Quality. No date. **Management of Aquatic Plants**. Lansing, Mich.: Michigan Department of Environmental Quality.

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New York State Department of Environmental Conservation and Federation of Lake Associations, Inc. 1990. **Diet for a Small Lake.** (Available from New York State Federation of Lake Associations, Inc., www.nysfola.org.)

Vigmostad, K.E. No date. **Your Lake and You**. Madison, Wis.: North American Lake Management Society.

Warbach, J., *et al*. 1990. **Protecting Inland Lakes – You Can Make A Difference**. Lansing, Mich.: Michigan Department of Environment Quality.

Chapter 7

Management Options and Control Tools

Introduction

Aquatic plants are essential for maintaining a balanced, healthy lake, but any plant that creates a nuisance is a weed. The essence of aquatic plant management is suppressing undesirable species and plants that restrict essential uses while encouraging desirable species in important habitat areas. True management has both a controlling and a promoting aspect. Undesirable conditions are controlled, and essential conditions are promoted. Very often, lake plants are controlled but not promoted. This chapter and the following chapter suggest ways to use both controlling and promoting aspects of management.

There are various ways of applying management. Controls can be applied directly to the target plant, temporarily reducing its population. Because environmental conditions that favored the plant are not altered, it eventually returns. Consequently, such direct controls are known as short-term controls. Long-term controls are directed at the environmental conditions that permit the plant to grow and flourish. Altering environmental conditions needed by the plant greatly reduces its ability to reproduce and attain nuisance levels, and thus provides long-term control.

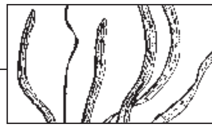
Short-term and long-term concepts can also be applied to promoting plants. Short-term promotion introduces a plant to the lake. Long-term promotion changes the environment to improve plant growth. Most lake communities are involved in the long-term promotion of aquatic plants. Because little or no watershed management is done to abate the increasing supply of nutrients and sediments reaching the lake from expanding agricultural and residential development, plant growth is promoted.

Long-term promotion or control of aquatic plants involves manipulation of the lake and its watershed to change the conditions that favor plant growth. Long-term management is primarily watershed management, which reduces or increases nutrient loading to the lake and therefore the supply of nutrients available for plant growth. Additionally, dredging to change lake depth and sediment fertility may have some long-term benefits if properly designed and implemented. Biological control tools may also be long-term controls, depending on the herbivore/plant interactions.

This chapter discusses management options, which are basic management philosophies, and control tools, which are methods available to manipulate plants. Only in-lake or direct management options and control tools are discussed. Watershed management or long-term control strategies are briefly presented in Chapter 1. The references suggested in Chapter 1 should be consulted for assistance with watershed management. It is important to properly assess and relate any control option and tool with the specific lake conditions present at the time. No control option or tool will work in every situation. It may be best to consult a professional — who is knowledgeable regarding lake ecology and aquatic plant biology before finalizing any control program. Necessary permits should also be secured from the Michigan Department of Environmental Quality. A Department of Natural Resources (DNR) permit may be necessary if threatened and/or endangered species will be harmed. Also, use permits may be necessary if you are using DNR property for commercial purposes. It may also be necessary to consult with the local units of government for permits, approvals or compliance with local ordinances.

Management Options

Direct management of plants, whether in water or on land, generally falls into five broad options, each with advantages and disadvantages. Each should be considered carefully before being incorporated into the lake's management plan. The five options are: plant promotion, no intervention, selective maintenance, small-scale site maintenance and large-scale continual maintenance.



Plant promotion

For the first 50 years of the 1900s, the primary objective of most aquatic plant management programs in Michigan was promoting plant growth, particularly species favorable to fish and wildlife. Research agencies conducted fertilization studies of lakes to formulate procedures for increasing plant growth. Conservation and lake groups spent considerable money planting desired species. The most commonly cultivated plants included cattails, bulrushes, wild rice, water lilies, pondweeds (particularly sago and floating leaf), wild celery and bushy pondweed.

Today so much effort is expended curtailing plant growth that the idea of encouraging vegetation seems abnormal. This shift in plant management philosophy is no doubt linked to the development of large outboard motors and the building of lakefront homes following World War II. Before 1950, the lake experience consisted of challenging the wild environment, swimming, fishing and hunting. A large outboard motor was 10 horsepower. A place on the lake was a rustic cottage, with few or no modern amenities. Since 1950, pleasure boating and high-speed water sports have become significant lake use activities, and a modern second home and suburban concepts of environmental order have replaced the primitive cottage.

Controlling aquatic plants may be necessary to maintain modern recreational uses. What should not be lost from the first 50 years of plant management is the value of plants to the whole lake ecosystem and the concept of encouraging desirable species. Physically planting vegetation is probably not the best promotion of desirable species but may be necessary as a last resort. Management plans should identify desirable species, map their location, avoid using controls in important habitat areas and keep aggressive species suppressed with maintenance control strategies described in the section on selective maintenance. A healthy population of desirable species is the best defense against the spread of exotic nuisances such as Eurasian milfoil.

Advantages:

- Promotes good fish and wildlife habitat.
- Encourages native species.
- Protects against the invasion of nuisance species.
- Low or no cost.

Disadvantages:

- May conflict with some recreational uses, such as swimming and boating.

No intervention

In this management option, plants are intentionally not controlled or manipulated but allowed to grow as environmental conditions dictate. This option is used most often in higher quality (oligotrophic or mesotrophic) lakes where rooted plants and algae are not naturally abundant. The plants create no or only minor recreational conflict, so they are allowed to grow without any controls.

Even in eutrophic lakes that naturally have abundant plant and algae growth, this option should be considered in the management plan development process. If desirable plant species are growing in a good habitat arrangement and if recreation is not seriously hindered, manipulating the plants has little value and could result in a shift to less desirable species and create the need for additional control and added cost. Such action ignores the promoting aspect of management, focusing only on the control aspect. In some lakes, it may be more advantageous to slightly adjust recreational uses to the lake's natural characteristics than to attempt to alter the lake to fulfill every recreational aspiration.

Even if the no-intervention management option is used, the lake should still be monitored for the introduction of exotic nuisance species. It is easier to control these invaders in small areas rather than waiting until they have created a major problem.

Advantages:

- No cost or labor required.
- No environmental disruption.

Disadvantages:

- Certain recreational uses may be impeded.

Selective maintenance

This management option uses a control tool that removes only one or two species and maintains all others. The controlled species are usually troublesome native plants or exotics creating serious problems. Desirable species are not injured by the treatment, so they can fill the habitat opened by the reduction in undesirable species. A healthy population of desirable plants will deter the reintroduction and spread of the controlled undesirable plants. Because this option minimally affects the total plant population, it can be used in small or large areas without drastically altering the plant community and opening it for disruptive changes.

An important aspect of selective harvest in pest, parasite and disease management programs is the practice of **maintenance control**. It is extremely difficult to eradicate disease and pest organisms. Consequently, the practice of maintenance control is used to minimize the impact of troublesome pests and diseases on human culture. Maintenance control uses continual monitoring to identify the location and density of a target nuisance organism. Once it's identified, selective control techniques are immediately employed to check the pest before it can spread and cause major damage. This practice keeps the pest organism at low levels and minimizes the amount of pesticide or other control agent needed. Because the pest organism is never functionally eradicated, this practice must be employed repeatedly, thus the term "maintenance control".

Maintenance control may seem expensive and unnecessary when nuisance plants such as Eurasian milfoil or curly-leaf pondweed are only a minor problem in a lake. Exploding populations of these plants can cause major problems, however, and at high densities, control may be difficult and expensive.

Depending upon environmental conditions, some possible selective control tools may include:

- Careful hand or rake removal of small areas of recently introduced nuisance species.
- Eurasian milfoil control with the herbicide 2,4-D or triclopyr.
- Eurasian milfoil control with very low concentrations of the herbicide fluridone.
- Early-season treatment with fluridone.
- Curly-leaf pondweed control prior to about May 20 with contact herbicides.
- Mechanical harvesting of curly-leaf pondweed prior to about May 20.

The selectivity of these tools is continually being researched and improved.

Advantages:

- Controls the plants primarily responsible for recreational hindrance.
- Maintains and promotes good populations of desirable plants in the treated environment.
- Minimizes environmental impacts.
- Reduces costs.

Disadvantages:

- Some recreational uses may still be impaired.
- Water use restriction is possible.

Small-scale site maintenance

This management option controls most or all plants in a small area intensively used for recreation. Because the area of plant control is a very small part of the entire plant community, overall integrity is maintained. An example would be the complete removal of all vegetation in a swimming area. The total treated areas should be less than 20 percent of the lake's vegetation.

The size of the plant control site is key for this option to function appropriately and not cause undesirable shifts in the plant community. The complete removal of all vegetation customarily means the controlled plants are replaced by aggressive undesirable species. If the overall integrity of the plant community is sustained, however, intensively managing small sites may have minimal impact. Treated sites should be monitored to ensure that troublesome species do not use the disturbed area for invasion and spread.

Because the plant treatment site is small, the plant control tools most frequently used for this management option are small harvesting devices. They may include hand-held rakes and chains or small mechanized rakes and rolling devices or bottom barriers. All are labor-intensive. These activities may also require permits from the state (DEQ) or local units of government.

Advantages:

- Low cost.
- Maximum use of small areas.
- Minimal environmental disruption.

Disadvantages:

- Usually labor-intensive.
- Recreational uses requiring a large area, such as boating, may still be hindered in some lakes.

Large-scale continual maintenance

This management option involves large-scale manipulation of the plant community, both in area and number of species controlled. A major reduction in plants occurs during the efficacy period of the plant control tool used. This option is environmentally disruptive and can produce substantial changes in the lake's plant and animal communities. Very careful consideration and planning should be undertaken before implementing large-scale continual maintenance.

Persistent use of this management option may cause an undesirable shift in plant species. Large treatments leave much of the littoral zone devoid of vegetation. The exposed treated area is susceptible to colonization by aggressively growing "weed" species, which can quickly dominate the ecosystem. Low-growing, non-aggressive native plant species can be greatly reduced by the control tool used and by competition from the invading weed species. Ultimately two or three tall-growing, canopy-forming plants can dominate the lake.

Once started, use of this option is difficult to stop. If the plants are left uncontrolled after a number of years, the lake will reestablish a diverse plant community, with the weed species being a minor component. However, many citizens will want the lake treated every year. Consequently, recurrent management becomes a necessity. This option should be started only with this understanding and a commitment to finance continual control. An analogy in the terrestrial environment would be a farm field. Once cleared, the field must be continually managed. If left unmanaged, even for one year, weed species proliferate. If left unmanaged over time, the field reverts once again to a forest.

Advantages:

- Beneficial to recreational uses requiring a large area.

Disadvantages:

- High cost.
- Commitment to continual management.
- Usually disruptive to fish and wildlife populations.
- Encourages "weed" species.

Farm field undergoing plant succession.

Control Tools

The purpose of this publication is to aid riparian property owners in the identification and mapping of aquatic plants and in the development of an appropriate plant management plan for their lake. Part of the plan includes selection of control tools, which may target the plants directly or the environmental conditions that promote plant growth.

The abundance of aquatic plants largely depends on the amount of nutrients available to support their growth, so long-term management of aquatic plants involves the control of nutrients and sediments moving from the watershed into the lake. Therefore, watershed or nutrient management should be one of the control strategies used in most plant management plans. Chapter 1 provides a brief introduction to the subject and refers the reader to other references that will aid in development of this phase of the management plan.

Control tools that more directly manipulate plant populations are profiled in this section. Most of these tools are short-term, providing only temporary control of the plants. The profiles are not meant to be comprehensive, only introductions to their advantages and disadvantages. More information on the control tools may be found in the references listed at the end of this chapter.

A permit from the Michigan Department of Environmental Quality (DEQ) will usually be required to use any of the control tools discussed. Contact the DEQ for permitting information before implementing any plant management project.

Dredging

Management options: long-term control (in certain situations) and plant promotion (in certain situations).

Dredging may provide long-term plant control benefits, depending on plan design and lake conditions. Removal of bottom sediments and the deepening of a lake can control aquatic plants in two ways. Plants must have sufficient light to germinate and grow. Water depth and turbidity diminish the amount of light reaching the sediments. Dredging a lake to a depth of 12 to 15 feet will prohibit most plants from germinating and reaching the surface in sufficient density to cause recreational problems. Dredging nutrient-rich sediments to expose nutrient-poor glaciated sediments, particularly sands, can diminish plant density by reducing nutrient availability and increasing sediment abrasiveness. If sources of sediment and nutrient inputs are not controlled, however, lake improvements may be short-term.

A dredging plan that does not achieve one or both of these goals usually brings about little change in the plant community. In shallow canals or shorelines, dredging to promote navigability may advance recreational use but not diminish the need for plant management.

Dredging can also be used to promote plant growth by altering environmental conditions such as depth, sediment type and degree of slope. Dredging based on knowledge of the environmental requirements of a desired plant can shape an area to promote that plant's colonization. Additional management options such as control of undesired species can improve colonization of the desired species.

The two primary types of dredging are hydraulic and bucket. Hydraulic dredging utilizes lake water to pump sediments to a disposal site some distance from the lake. This type of dredging is expensive but more practical and cost-effective on large projects. Bucket dredging using backhoe-type equipment is limited to near-shore work where spoils can be sidecast or placed on trucks and transported off-site.

All forms of dredging are extremely expensive. The cost of dredging a major area of even a small lake is probably prohibitive in most situations. A good study addressing dredging feasibility can itself cost tens of thousands of dollars. If dredging is being considered for a lake, it may be advantageous to first conduct a preliminary study to consider its technical and financial feasibility.

Advantages:

- Possible long-term control of aquatic plants.
- Improved recreational use.

Disadvantages:

- Very expensive.
- Loss of lake use during dredging.
- Increased turbidity and/or algal problems during dredging.
- Possible contaminated sediments, increasing disposal costs and affecting the environment.
- Placement of spoils.
- Environmental issues regarding placement of sediments.
- If there has been no reduction of sediment and nutrient loading, dredging may only shift the lake's vegetation from rooted plants to algae.

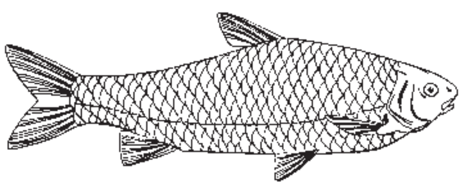
Biological

Management options: long-term control, selective maintenance (in certain situations) and large-scale continual maintenance (in certain situations).

Biological control uses an agent such as a predator, herbivore, parasite, fungus or disease to control a target organism. If successful, biological agents furnish long-term suppression. In most situations, however, the nuisance is not eradicated. Successful biological control agents do not eradicate their host. To do so means extinction for them. Instead, the populations of host and control agent fluctuate about an optimum level determined by environmental conditions and their interaction with each other. Permits may be required from the DNR for the introduction of non-native species into Michigan waters.

At this time, biological control agents for aquatic plant management programs in lakes are limited. Two possibilities have been or are being considered: the grass carp (*Ctenopharyngodon idella*) and an aquatic weevil (*Euhrychiopsis lecontei*).

Some southern states are using the grass carp in aquatic plant control programs; most northern states are not. Many concerns still remain regarding this fish's impacts on higher quality northern lakes and associated fish and waterfowl populations. At this time it is illegal to import the grass carp into Michigan. One of the major problems with the grass carp is its food preference. It prefers many of the plants that should be encouraged and avoids many of the nuisance species. Eurasian milfoil is one of the last plants the fish consumes. Most stocking rates recommended for the fish promote Eurasian milfoil expansion. At very high stocking rates, the grass carp will eat the Eurasian milfoil and any plant material it can find. The lake is stripped of all rooted vegetation; sport fish and waterfowl populations are negatively impacted, and the lake becomes dominated by blue-green algae.



Grass carp.

Researchers are also evaluating the use of insects for Eurasian milfoil control. An aquatic weevil may have some potential. *E. lecontei* is native to North America. It lives most of its life cycle on native milfoil, feeding on the tips and stem. Research has shown that it will also use Eurasian milfoil and may prefer this species if hatched from eggs deposited on Eurasian milfoil. More research, including in-lake evaluations, is needed to determine the efficacy of this weevil to control Eurasian milfoil.

Advantages:

- Long-term control.
- Potential low cost.

Disadvantages:

- Potential for significant environmental damage.
- Results may take years to manifest.
- The level of plant control may not meet lake user expectations.
- Initial cost can be high.

Drawdown

Management options: plant promotion, large-scale continual maintenance (in certain situations) and selective maintenance (in certain situations).

Drawdown or water level manipulation is a control tool for certain types of aquatic vegetation. Exposing lake sediments to drying and freezing kills the plant tissues and roots of some species. Other plants resist desiccation and freezing and proliferate after drawdown. Additionally, drawdown results have been highly variable, so it is impossible to determine definitively which species are controlled and which are favored. This variability is probably due to environmental conditions such as air temperatures, lake sediment types, groundwater influence, snow cover, length of drawdown and time of year. The best that can be suggested at this time is which plants generally decrease and which generally increase (see Box 7.1).

Because drawdown encourages some plant species, annual use of this control tool may result in a dramatic shift toward these species. Greater plant diversity may be maintained by alternating drawdown years, thus avoiding the creation of preferential conditions for a few species.

Advantages:

- Low cost.
- Eurasian milfoil generally decreases.
- May allow for certain beach maintenance activities.

Disadvantages:

- Not practical in lakes without a water level control structure.
- Can seriously reduce fish populations, particularly northern pike.
- May damage contiguous wetlands.
- Can seriously injure hibernating wetland animals.
- May result in increased algal blooms.

Box 7.1

Generalized Response of Plants to Overwinter Drawdown

Plant species	Generally decrease	Generally increase	Variable or unclear
Milfoil	X		
Coontail	X		
Water lilies	X		
Waterweed	X		
Bladderwort	X		
Bushy pondweed		X	
Thin-leaf pondweed		X	
Cattails		X	
Most pondweeds			X
Water stargrass			X
Curly-leaf pondweed			X
Most emergent species			X

Bottom barriers

Management options: small-scale site maintenance.

It is possible to treat small areas by placing a gas-permeable bottom barrier over the lake sediments. Plants growing beneath the barrier are unable to photosynthesize and die. The barrier can then be removed or left in place, though there are problems with both actions. Removing the barrier is labor-intensive, and the plants will immediately begin to grow from seeds or surviving root or underground tissues. If the barrier is left in place, algae can grow on it, creating a slippery condition. Over time, sediments accumulating on the barrier allow plants to grow on top of it. Sometimes the barrier material is covered or weighed down with sand or a sand gravel mix.

It is important that a gas-permeable material be used as the barrier. If not, decomposition gases from the sediments will accumulate under the barrier and dislodge it.

Advantages:

- A good treatment for small, defined areas.
- Can be used in areas close to shore where other control tools may not work as well.

Disadvantages:

- Cost per area treated is very high.
- Labor-intensive.
- May become slippery.
- Dislodged barriers can be a boating hazard.

Aeration and nutrient inactivation

Depending upon environmental conditions, aeration of lakes and use of alum or other precipitants to remove phosphorus from the water column may reduce algal blooms. Their value as control tools for rooted plants is not adequately documented at this time.

Mechanical harvesting

Management options: large-scale continual maintenance and selective maintenance (in certain situations).

Mechanical harvesting involves the use of specially designed and constructed machines to cut and remove plant material from a lake. The machines vary in size and cost, from small, boat-mounted devices to large, expensive, combine-type machines especially designed to harvest aquatic plants.

Harvesting does not kill the aquatic plants – it only reduces their height in the water column. Plants continue to grow, usually reaching full height again in approximately four to eight weeks. Harvesting twice during the summer, once in early June and again in mid-July, provides the most control of the plants and advantage for recreational uses. If funds

Plant harvester.

are limited, harvesting once in late June affords good control during the peak of the summer use period. Some studies suggest that harvesting more than twice per year may improve the control of some plants and slightly reduce nutrient levels in the lake.

Plants vary in their response to harvesting. The nuisance exotic Eurasian milfoil's stem is capable of yielding a new plant from a cut fragment. Harvesting and other activities that encourage fragmentation may facilitate the spread of this troublesome plant. Coontail and waterweed can also reproduce from cut or broken fragments. On the other hand, plants that rely more on sexual reproduction may be suppressed by the harvesting of flowers and seeds. Pondweeds, the *Potamogeton* genus, may be particularly susceptible to harvesting because of their dependence on sexual reproduction.

A shift in a plant community from pondweeds to Eurasian milfoil and coontail is not a positive change for most recreational uses. The potential of this shift occurring can be reduced by careful application of the harvesting tool. Variations in use can include the number of harvest cuttings, the timing of cuttings, the location of cuttings, and the use of harvesting in conjunction with other selective tools to increase control of milfoil and coontail and reduce impacts on pondweeds.

The cutting and removal of plant material from the lake has advantages over other control tools that leave the plants in the lake. Removing the cut plants reduces decomposing matter and thus accumulation of organic material on the lake bottom. Some nutrients are removed with the cut plants. If nutrient loading from the watershed is low, there may be some restorative value in removing the plants.

Advantages:

- Cost competitive with chemical controls.
- Removes nutrients from the lake but may be minimal compared with input.
- Removes organic material from the lake.
- May provide some selective control.

Disadvantages:

- Undesirable plants may fragment, spread and colonize new areas.
- Desirable plants such as pondweeds may be suppressed.
- Limited operation in shallow water and around docks and rafts.
- Machine breakdowns can disrupt operations.
- Drifting plant fragments may accumulate at nuisance levels in quiet water areas.

Hand harvesting

Management options: small-scale site maintenance.

Plants must produce sufficient food in their leaves to maintain their root systems. Periodic cutting of the leaves or their destruction by wading and swimming will eventually kill the root system and the plant. On a small site, such as a cottage swimming beach, rakes, chains, bedsprings and other devices may be pulled through the area to clear vegetation. Once plants are removed, active swimming and wading can keep the site weed free. Clearing the site can be very labor-intensive and require several hours of work.

To facilitate this type of plant control, power rakes and mechanized rolling devices have been developed. This equipment speeds the cleaning process and reduces the labor needed but still requires some installation or handling to complete the task.

If plant debris is removed from the lake, hand harvesting has many of the same advantages of nutrient and organic material removal as mechanical harvesting. Because the site harvested is small relative to the entire littoral zone, disruption to the entire plant community as well as fish and wildlife populations is minimal.

Advantages:

- Low cost.
- Excellent control in small areas.
- Low environmental impact.

Disadvantages:

- Labor-intensive.
- Not suitable for large areas.

Herbicides

Management options: large-scale continual maintenance (in certain situations), selective maintenance (in certain situations), small-scale site maintenance (in certain situations) and plant promotion (in certain situations).

The most frequently used control tool in aquatic plant management is herbicides registered by the U.S. Environmental Protection Agency and the Michigan Department of Agriculture for aquatic uses. There are many products available in various formulations, with various efficacy rates and toxicities to non-target organisms. They can be used individually or in various combinations and applied to large or small areas. Their use can also be controversial.

The herbicide's product label is a legal document. To use a herbicide contrary to its label is a violation of federal and state laws. Only herbicides registered for aquatic use should be applied to a lake. The label should be read carefully and all directions and precautions followed. It is often best to hire a commercial applicator, licensed by the Michigan Department of Agriculture, who is familiar with pesticide regulations to apply the herbicides to the lake.

Comprehensively addressing the topic of aquatic herbicides would require extensive writing, beyond the scope of this manual. The presentation here is of limited focus and introductory. No discussion will be devoted to product registration, efficacy rates, toxicity, water use restrictions or application procedures. The references provided at the end of the chapter offer additional reading.

Herbicide application.

In this manual, herbicides are discussed in the context of aquatic plant community structure and management. Herbicides can be divided into **selective** and **broad-spectrum**, reflecting their scope of impact on plant species. Selective herbicides control a limited number of species; broad-spectrum herbicides control a wide range of species. Also, herbicides can be referred to as **systemic** or **contact**. Systemic herbicides are taken up by the plant and transported throughout the plant's vascular system, killing the entire plant, including the roots. Contact herbicides act externally upon the plant, destroying tissues in contact with the chemical. Root systems are not destroyed, so plants can resprout. Depending on the plant species and environmental conditions, complete regrowth may occur within four to eight weeks.

Selective herbicides

Selective herbicides control only a limited number of plant species, leaving most uninjured. This characteristic is highly beneficial if the controlled species are ones that frequently create a nuisance. The nuisance species is controlled with minimal to no disruption to the rest of the plant community. This allows even large areas to be treated without serious negative impacts.

- **2,4-D** (systemic) – This herbicide is available in liquid and granular forms. Liquid forms control emergent species such as cattails, bulrushes and lilies. At this time, liquid forms are not available for submergent plant species. Granular forms may be used on both emergent and submergent plants. The most common granular form of 2,4-D used in products registered for aquatic uses is the butoxyethanolester (BEE). At low rates, BEE forms of 2,4-D are used to selectively control Eurasian and native milfoils. Higher rates will control coontail in addition to many emergent species. In certain situations, 2,4-D has been successfully used to bring milfoil under control and maintain it at low levels in a maintenance control program. Its ability to maintain control of milfoil appears to diminish in lakes with high flushing rates, upstream milfoil infestations or where other plants are also heavily controlled.
- **Fluridone** (systemic) – Fluridone is sold in liquid and granular forms. When the liquid form is used, the entire lake must be treated. At normal label rates, it is not a selective herbicide but very broad-spectrum. Only at concentrations of about 5 to 8 parts per billion (ppb) does it appear to have selective control qualities. At these low concentrations, it controls Eurasian milfoil and curly-leaf pondweed as well as native plants such as coontail, waterweed, bushy pondweed and native milfoil. Fluridone treatments are usually done in two applications. The initial application of herbicide is followed by a second treatment several weeks later to maintain the concentration of fluridone in the water. At treatment concentrations above 5 to 8 ppb, aquatic plant communities can be greatly reduced during the year of treatment. The following year, curly-leaf pondweed sometimes returns at nuisance levels. In many lakes treated with fluridone, Eurasian milfoil is curtailed for two and sometimes three years. If there is no maintenance control program to keep it suppressed, it usually returns to nuisance levels by the third or fourth year.

Broad-spectrum herbicides

Broad-spectrum herbicides control many but not all plant species. Consequently, it is still necessary to know what plants are growing in a treatment area to ensure adequate control with the chosen herbicide. If the goal is to remove all plants from an area, such as a swimming beach, it may be necessary to use a combination of herbicides. Employing two compatible broad-spectrum herbicides in combination provides a greater spectrum of plant control in the treatment area than using one herbicide alone.

In other situations, it may be desirable to use a broad-spectrum herbicide to control select problem plant species. In these situations, strategies are needed to restrict and target the broad-spectrum herbicide's range of control. Research is being done with these broad-spectrum herbicides to improve their selectivity. It may be possible that low concentrations applied at select times will allow targeting of specific nuisance species.

- **Copper** (contact) – Copper is available as copper sulfate, a granule, and as copper complexes in liquid or granular form. Copper sulfate is used to suppress algae and the macroalga stonewort. Copper complexes are used on algae and certain rooted plants, particularly bushy pondweed, waterweed and some pondweeds. Copper products are often mixed with diquat to improve plant control. Copper sulfate can be very toxic to some fish, such as trout. Most copper complexes are somewhat less toxic to fish.
- **Diquat** (contact) – Diquat is marketed only in liquid form. It is a restricted-use product available only to state-licensed applicators. It binds rapidly with the aquatic plants and other organic material in the lake, so drift from the treated area can be minimal. In turbid water, diquat will bind with the organic particles in the water. This may reduce its effectiveness and result in a failed treatment. Diquat is often mixed with a copper product to increase its spectrum of plants controlled, including some species of algae, and increase its toxicity to the plants, allowing application at lower concentrations. It is also mixed with endothall products to produce a very broad-spectrum combination capable of controlling most submergent aquatic plant species. Aquatic plants usually controlled by diquat include duckweed, coontail, milfoil, waterweed, bushy pondweed, buttercup, and curly-leaf, floating leaf and sago pondweeds.
- **Endothall** dipotassium salt (contact) – The dipotassium salt of endothall is available in liquid and granular forms. Endothall is particularly effective on pondweed species, most of which are susceptible. In addition to pondweeds, it may also control coontail, milfoil and bushy pondweed.

It may be mixed with diquat to increase the spectrum of plants controlled. This mixture may be used in the large-scale continual maintenance management option or carefully used in very small areas in the small-scale site maintenance option. Repeated use of this mixture may result in shifts in plant communities.

- **Endothall** mono (N, N-dimethylalkylamine) salt (contact) – This salt of endothall is available in liquid and granular forms. It is fairly broad-spectrum, controlling waterweed and wild celery in addition to the species controlled by the dipotassium salt. It is one of the few herbicide products that suppress wild celery. It may be used in the large-scale continual maintenance management option or the small-scale site maintenance option on very small areas. In addition to rooted plants at low concentrations, it controls many forms of algae. At the higher rooted plant dosages, fish kills are possible if the product is used improperly.
- **Glyphosate** (systemic) – Glyphosate is available only in liquid form. It is extremely broad-spectrum and is used extensively in agriculture. Few land plants are not injured by glyphosate. The applied product is inactivated by water, so glyphosate is ineffective on plants growing below the water surface. In the aquatic environment, it is used on emergent species and on plants with large floating leaves, such as water lilies. Water lily treatments must be done carefully to ensure adequate contact time between the product and plant. Because of the extreme broad-spectrum qualities of glyphosate, care must be exercised to avoid excessive damage to wetland and shore zone plant communities.
- **Imazapyr** (systemic) – Imazapyr is a broad-spectrum herbicide used to control a broad range of terrestrial and aquatic plants. Imazapyr may be applied by broadcast application to aquatic sites to control floating or emergent aquatic vegetation such as water lilies, pickerelweed, cattails and duckweed. It is not used for controlling submersed aquatic plants. Because it affects many plant species, ecological concerns are associated with the use of imazapyr and its impact on non-target terrestrial and aquatic plants. Therefore, care must be taken to avoid drift of imazapyr into non-target treatment areas.
- **Triclopyr** (systemic) – Triclopyr is available in liquid and granular forms. It is recommended for control of emergent and submersed aquatic plants in lakes and ponds that have little or no continuous outflow. It is fairly selective for dicotyledon plants such as Eurasian milfoil, native milfoil and coontail. It is also used along the shoreline of aquatic sites for control of shrubs and other vegetation such as water lilies, pickerelweed and purple loosestrife. For control of Eurasian milfoil, the herbicide should be applied in the spring or early summer when Eurasian milfoil is actively growing.

Advantages:

- Costs are reasonable in many situations.
- Range of products and combinations available provides flexibility in management options.
- Some products are highly selective for nuisance species.
- Can provide complete control of plants for swimming beaches.

Disadvantages:

- Involves the introduction of pesticides into shared water resources.
- Potential for misuse exists.
- May contribute to the buildup of organic material.
- Algal blooms are possible following large herbicide treatments.
- Large treatments may encourage shifts in plant communities.
- Fish kills may occur with misuse of certain products.
- Water use restrictions may need to be imposed.
- Does not address the causes of cultural eutrophication.

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Chapter 8

The Management Plan

Introduction

Plants are an essential part of a lake, but sometimes it is advantageous to alter a lake's plant community. When this is necessary, the most appropriate process is the development of a comprehensive management plan. Even the smallest lake can be a multimillion dollar resource. To initiate control practices without a well developed guidance document may be very costly in the long run. Additionally, lakes, like humans, are unique individuals. No two are exactly alike. Each management plan should be unique to the lake and the citizens for which it is developed, a compromise of many desires. Management is a continual process, so the management plan must be a living document, evolving as the lake and the riparian community change.

A lake is a complex interaction of physical, chemical and biological components. Development of an appropriate management document will require the input of an aquatic ecologist and possibly other trained professionals. It is impossible to transfer years of college and practical training into this manual. It is also impossible to relay information on every environmental, social and economic circumstance that may evolve during development of a management plan. Consequently, the advice of appropriate consultants will probably be helpful to complete and effectively implement the management plan.

There is no one right way to develop an aquatic plant management plan. This chapter offers a process that may be used or modified to address the unique conditions present at each lake community. The process comprises six steps from initial concerns to project evaluation:

- Getting started.
- Data and information collection.
- Plan development.
- Community decision.
- Implementation.
- Evaluation and feedback.

Step One – Getting Started

Interest in lake management usually begins as talk between neighbors. "There are too many plants in the lake." "There are too few plants in the lake." "Fishing isn't as good as it once was." "When is somebody going to do something about the problem?" If enough interest is generated, eventually the topic is raised at a lake association or local government board meeting. At this stage, there is much concern but few facts. The lake association or government board may hire a consultant to do a study of the lake, or an aquatic plant evaluation committee of lake residents may be appointed to gather data and develop a recommendation.

If the committee process is used, the selected committee members should not be expected to do all the work. Volunteers will be needed to conduct plant studies, mail out citizen surveys, contact local and state resource agencies, and gather basic information. Additionally, the committee should have access to trained professionals and contractors to address technical issues as they arise during development of the management plan. The committee's responsibility is to facilitate the development of the plan, not to personally complete each work element.

Step Two – Data and Information Collection

To manage a natural resource, the manager must understand and be familiar with the resource. Superficially, things may appear very simple; in the environment, they rarely are. Only by gathering data and information about the resource can managers make competent decisions and adjust them as conditions evolve. The purpose of Step Two is to collect needed information about the lake, its plants, the watershed and the interests of the citizens. (The DEQ guidance for collecting data for a lake management plan may be found on the Web site www.deq.state.mi.us/documents/deq-wd-illm–lakeplanform.doc.)

General characteristics of the lake

Information on the following characteristics is helpful and often necessary for selecting management options and control tools, calculating areas to be managed and completing permits from state agencies. Generally, this information may be available from hydrographic and topographic maps, state and local agencies, previous reports and local observation.

- **Lake area (in acres)** – The area of a lake is shown on hydrographic maps, if one has been constructed.
- **Littoral zone area (in acres)** – The littoral zone is the shallow-water area where aquatic plants grow. For practical purposes, it may be considered to be the 10-foot contour in most lakes and the 15-foot contour in very clear lakes. This area may be calculated from hydrographic maps using a planimeter or with a computer program. An estimate of the area may also be obtained by cutting the map of the lake into two pieces, the shore to the 10-foot contour and the rest of the lake. Weigh the 10-foot contour piece and then the two pieces together on a good scale and determine the percent by weight of the 10-foot contour. Multiply the area of the lake by the percent by weight of the 10-foot contour to estimate the area of the littoral zone.
- **Littoral zone area vegetated (in acres)** – This is the area of the lake's littoral zone in which plants are actually growing. The area may be estimated from the total littoral zone calculated above and the plant location map constructed for the work done in Chapter 5 (Figure 5.3).
- **Hydraulic retention time (in days)** – The hydraulic retention time is the length of time the lake needs to replace all the water with new water. A rough idea of the lake's hydraulic retention time will be helpful in selecting certain control tools. An exact calculation of retention time will require an engineering professional or may be available from an earlier report for the lake. As an example, lakes with very short retention times (less than seven days) may not be appropriate for herbicide treatment because the chemical may not remain in the treatment area long enough to work but could damage plants and crops downstream.
- **Shoreline land uses** – Mapping shoreline land uses aids in the identification of important habitat areas, residential zones and high use regions. The DNR Forest, Mineral and Fire Management Division can provide aerial photography for an area, possibly a lake's entire watershed, for minimal cost. Alternatively, a team of volunteers with a map of the lake can survey the lakeshore. Important land uses to identify include forested, undeveloped non-forested, wetlands, agriculture, low-density residential (lots wider than 150 feet), high-density residential (lots narrower than 150 feet), recreation (parks and access sites), commercial and industrial. Aerial maps and land use information can also be obtained from the Michigan Department of Information Technology or from Web sites such as TopoZone (www.topozone.com) and Google Earth (earth.google.com).
- **Inlets and outlets** – Inlets and outlets are areas of high water exchange as well as points where nutrients, sediments and biological species enter and leave the lake.
- **Endangered species** – To avoid impacts on endangered species, the management plan should identify their critical habitat. The Department of Natural Resources Wildlife Division or Michigan Natural Features Inventory can provide information on the possible presence of endangered species.

Aerial photo of lake.

Trophic state of the lake

Most of the controls presented in this manual directly manipulate plants — they do not alter the trophic state of the lake. The controls temporarily suppress the plants; the fertility of the lake is not reduced. Knowing a lake's trophic state allows development of a realistic management plan that manipulates the plants to improve recreation while retaining the lake's natural character. Excessive use of direct manipulation or short-term controls will not reduce lake fertility but will alter biological systems, usually with serious negative ecological and recreational impacts.

Box 1.1 in Chapter 1 (page 2) provides a general characterization of the three lake trophic states: oligotrophic, mesotrophic and eutrophic. The DEQ's Water Bureau has sampled more than 700 public lakes in Michigan. These data are available for distribution. The division has also classified all 700 plus lakes by their trophic state on the basis of the data collected. Additionally, the Water Bureau operates a citizen volunteer monitoring program in cooperation with Michigan Lake & Stream Associations, Inc. This program assists citizens with the collection of water quality data for their lake. These data can help with the determination of a lake's trophic state.

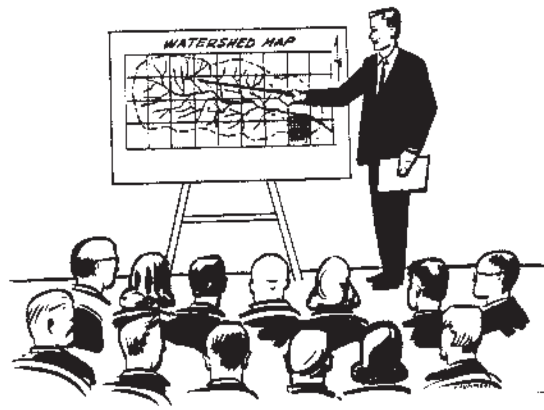
Collecting data.

Importance of watershed management

The citizens of each lake community must decide if the aquatic plant management program will include only short-term controls or both short-term and long-term controls. The long-term management of lakes is watershed management. Chapter 1 briefly addresses this issue. Box 1.2 (page 4) suggests the value of watershed management for lakes of various characteristics.

Citizen input

The ideas and concerns of all citizens living at or using the lake are important and should be solicited and synthesized in the development of a management plan that the public can support. Chapter 6 provides a citizen survey form that may be used or modified to address specific conditions.



Citizen involvement.

Current plant community

Delineation of the current plant community identifies species, their locations and densities. Chapter 5 outlines procedures for creating a map of the existing plant population and tables for analyzing the data collected. These are critical data for development of the management plan. Many lake associations initiate plant control programs without any idea of the true character of the lake's plant community.

The current plant community data, along with the information collected on the lake's general characteristics and citizen input, allow formulation of a plant management goal map and a plant control map. It is particularly important to identify desirable species that should be encouraged. Chapter 3 introduces portraits of the aquatic plants aiding in the identification of species that should be promoted and those that should be discouraged.

The current plant community map and data are also a benchmark for evaluating the success of the controls used and identifying positive and negative changes in the plant community resulting from the control program. Using this information allows the management plan to be adjusted to address changing lake conditions. The map and data become a valuable record that should be kept for future reference.

Step Three - Plan Development

Following collection and analysis of all available data and information, development of the management plan begins. The following process is offered as a system for preparing the plan. The system requires implementation of seven decisions and the preparation of a report to the citizens.

Decision one – define the problem

If done properly, with an openness to all the evidence and options, defining the problem may be one of the more difficult decisions the consultant or committee will make. The remaining decisions hinge on it. It requires careful thought, consideration and discussion, and it may not be arrived at quickly or easily. It must be supported by the evidence and presented to the citizens clearly and concisely. It is possible that the decision may be contrary to the prevailing opinion of most citizens. It may be necessary to prepare educational materials to explain how the decision was arrived at and present the evidence supporting it.

It is impossible to present every conceivable problem definition that may be put forth. However, as an aid to the discovery and discussion process, the following scenarios are presented. In certain situations, two or three of these scenarios may be recommended for a lake.

- There are too few aquatic plants in the lake for the lake's trophic state, possibly as a result of prior control efforts. Desirable species need to be encouraged, using the plant promotion option in areas where they will not conflict with recreation.
- Plants in the lake are abundant, but diversity is reduced to fewer than five species, possibly as a result of prior control efforts. Control options, selective maintenance and/or small-scale site maintenance are used to control problem plants and areas. The plant promotion option is used to increase species diversity and improve stability in the environment.
- Citizens have a significant misunderstanding of the value of aquatic plants and their relative abundance in the lake. An educational program is needed to share information with the citizens.
- Recreational desires are not consistent with the reality of lake conditions. Some adjustment in recreational aspirations is needed to make realistic use of the resource.
- The lake has a well balanced aquatic plant community that does not hinder recreation. Nothing needs to be done, except to continue to monitor the lake and plants for future problems.
- The lake does not have an aquatic plant problem. In fact, it's oligotrophic or mesotrophic with few plants. Watershed management is recommended to protect current conditions.
- Nutrient and sediment loading from the watershed are significant and stimulating plant growth. Watershed management controls are recommended to provide long-term control of plant populations.
- The lake has a minor problem with native plants in small, localized areas. These problem areas need control using the small-scale site maintenance option and appropriate control tools.
- An exotic plant species has invaded the lake or an aggressive native species is creating minor to serious problems. The selective maintenance option and appropriate control tools and a maintenance control plan are recommended to carefully control these nuisance plants without significant negative impacts on the rest of the plant community.
- The lake has a diverse population of native plants, but they are abundant and hinder recreation. The selective maintenance and small-scale site maintenance options are recommended to enhance recreational uses without significantly altering the plant community. Or, the large-scale continual maintenance option may be used to reduce the plant population to the DNR's suggested minimal plant community. The recommendation is highly disruptive to the natural plant community, so a long-term (continual) funding source will be needed to maintain this artificial condition.

Once the problem has been defined, the remaining decisions can be made.

Decision two – define the desired plant community

Once a decision is made that requires altering the plant community, either to promote additional vegetation or to reduce the existing population, another map needs to be created depicting the goal – the plant community that the management plan will bring into being. This is an important decision in the planning process. It distills all the ecological data and public opinion into a goal that all actions will strive to achieve. It is the standard against which implementation efforts will be measured for success or failure. It is modified over time to incorporate new data and information, and to maintain the living quality of the management plan.

The goal map may look similar to the current vegetation map (see Figure 5.5 in Chapter 5), but it reflects the future plant community rather than the existing population. The current vegetation map may serve as a basis for constructing the goal map. Plant species may be whited out or added to areas to produce the new map.

Unfortunately, many plant control efforts are initiated without any defined goal. No one is certain what the lake should look like except that there will be fewer plants. There is no standard by which to measure success or failure. Such efforts usually continue indefinitely with no final product to produce.

Decision three – define the control area

The difference between the current vegetation map and the vegetation goal map is the map of vegetation to be controlled and/or promoted. Construction of this map will assist with calculating treatment dimensions and areas, as well as securing cost estimates from contractors.

Decision four – select the management option

Chapter 7 introduced the five direct manipulation management options: plant promotion, no intervention, selective maintenance, small-scale site maintenance and large-scale continual maintenance. The management option selected determines the level of vegetation control applied and the impacts on the plant community and lake ecosystem. For certain lakes, two and possibly three management options may be used during the same year.

It must also be decided if watershed management will be a part of the management plan. Box 1.2 in Chapter 1 and the references at the end of the chapter furnish some assistance with this decision.

Decision five – select control tools

The second part of Chapter 7 described the most commonly used control tools. The most applicable management options are listed for each control tool. The control tools used and the scope of their use will largely dictate the cost of the project.

Decision six – define monitoring program

Annual monitoring of the plant community is recommended if control practices are implemented. Monitoring is the only way to determine if goals are achieved and to screen for undesired responses. Monitoring procedures adopted should be the same as those employed to create baseline vegetation maps (see Chapter 5), and the data collected should be recorded and saved for future application. These data are essential for adjusting the management plan to meet changes in the plant community and to plan subsequent control programs.

Decision seven – define funding

The decision on funding has two parts: implementation cost and funding sources. Implementation cost may be determined by securing formal bids from contractors. A contingency amount should be added to ensure that sufficient funds are collected to complete the project. Additionally, any cost for monitoring, public information, meetings and publication notices should be included. Once a reasonable cost estimate is arrived at, methods for paying for the project can be explored. There are basically two strategies for generating revenue: volunteer contributions from citizens participating in the project and establishment of a tax special assessment district for all properties benefiting from the project. Tax special assessment districts may be instituted under Part 309 (Inland Lake Improvements) of the Natural Resource and

Environmental Protection Act (P.A. 451 of 1994, as amended) and the Township Improvement Act (P.A. 188 of 1954, as amended).

Even if the no intervention management option is recommended, it may still be desirable to secure funding for the aquatic plant management program. Annual monitoring, particularly for exotic species, is highly recommended. An emergency treatment program should be in place ready to control these plants within days of identification of their presence. This monitor and control strategy will be far more cost-effective than waiting until everyone knows the exotic plants are in the lake.

Report to the citizens

Having worked through the seven decisions, the consultant or committee prepares a brief (approximately two-page) report, which is distributed to the public for review and reaction. The report should delineate the problem, possible solutions, the recommended plan, cost and funding alternatives. The report should be provided to the lake association's board or local government, which decides the best way to secure public comment on the report. If a public meeting is held, the consultant or members of the committee should be present to explain the decision process and answer questions.

If time and funds allow, a more complete report should be prepared, including all the data, maps, tables, calculations, literature references, procedures used, cost estimates and contacts made. The more complete report will be extremely valuable for documenting the entire management plan development process and as a future reference. Such reports are usually a requirement for projects funded by a tax special assessment district established by a local government.

Step Four – Community Decision

Upon receipt of the report from the consultant or committee, the lake association or local government board must decide how best to acquire endorsement by the citizenry. Methods used may include mailings, written comments, surveys or public meetings, which are often the most commonly employed and are required under certain laws. The public may accept, reject or request modifications to the plan. If accepted, the plan moves forward to Step Five - Implementation. If it's rejected or modifications are requested, the plan returns to the planning process for additional work.

Public meeting.

Step Five – Implementation

After acceptance of the management plan, implementation of the aquatic plant enhancement/control project begins. It is usually necessary to hire a contractor to complete phases of the project. It is worthwhile and under certain laws required that bids be secured for the work to be completed by the contractor. Bid documents and contracts must be prepared. The contractor should be required to demonstrate licensing, bonding and adequate insurance. In certain situations, it is appropriate to request the contractor to expand insurance to cover the lake association or local government board.

Most projects will require a permit from the DEQ or other state or local agency. The contractor may agree to secure the needed permits. Copies of the permits should be provided to the lake association or local government board.

If, as recommended in Step Three - Decision six, the plan includes a monitoring element, preparations for this work must be arranged. Proper data collection procedures and timing are essential to secure good data that will be useful in documenting the success of the program and in planning future projects.

Step Six – Evaluation and Feedback

Collection of monitoring data provides information back to the consultant or committee. With these data, the consultant or committee can return to the planning process to redefine the problem and reevaluate goals, management options, control tools and funding for the next year and beyond. If the program changes significantly, a new report and community decision should be completed.

This feedback step is critical to the management process and maintaining the written plan as a living document. It is not only the results of past work but a link to future needs. Continuing careful management of the lake resource will secure a quality recreational experience for this and future generations.

References

Below are references on the development of aquatic plant management plans.

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Hoyer, M.V., and D.E. Canfield, Jr. (eds.). 1997. A**quatic Plant Management in Lakes and Reservoirs.** Washington, D.C.: North American Lake Management Society and the Aquatic Plant Management Society for the U.S. Environmental Protection Agency.

Madsen, J.D., and J.A. Bloomfield. 1992. A**quatic Vegetation Monitoring and Assessment Protocol Manual**. Albany, N.Y.: A Report to the Finger Lakes Water Resources Board.

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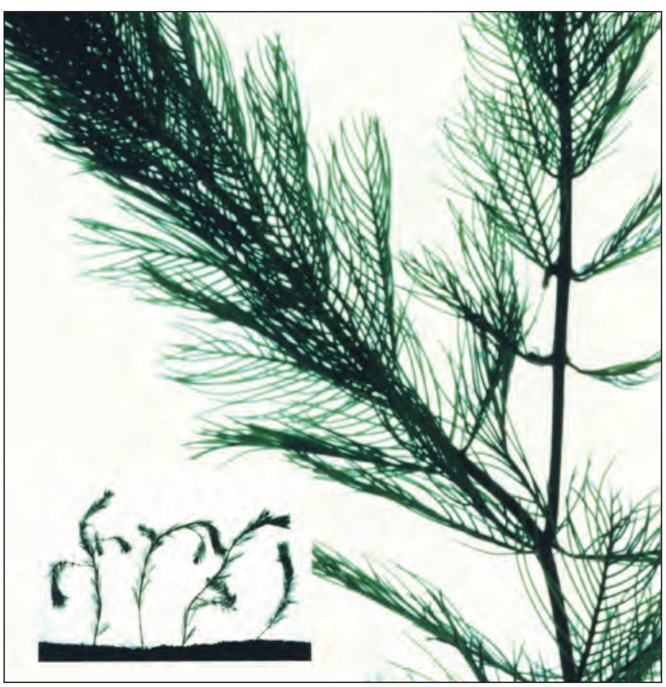
O'Neal, R.P., and G.J. Soulliere. 2006. **Conservation Guidelines for Michigan Lakes and Associated Natural Resources**. MDNR Fisheries Division Special Report 38. (Available online at: www.michigandnr.com/publications/pdfs/ifr/ifrlibra/special/reports/SR38.pdf.)

Chara spp. (stonewort)

Ceratophyllum demersum (coontail)

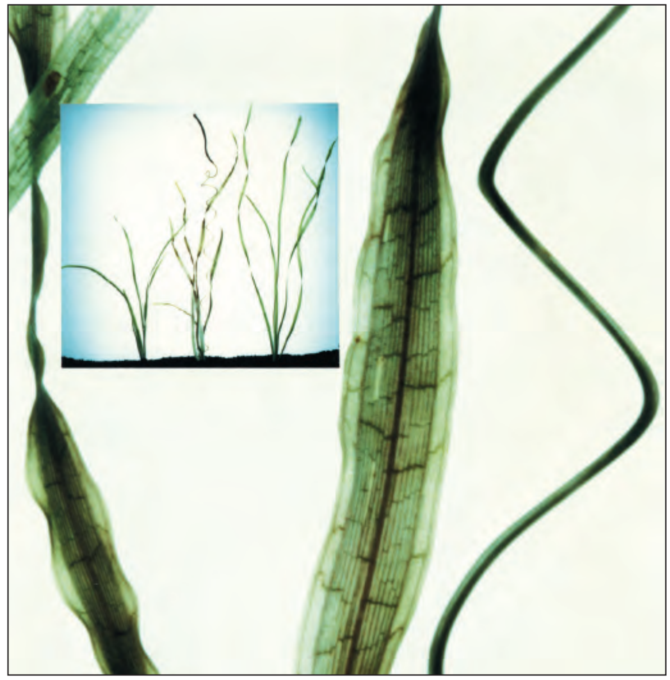


Myriophyllum spicatum (Eurasian milfoil)

Myriophyllum spp. (native milfoil)

Plate 2

Heteranthera dubia (water star grass)



Vallisneria americana (wild celery)

Potamogeton robbinsii (fern pondweed)

Potamogeton zosteriformis (flat-stemmed pondweed)

Potamogeton praelongus (whitestem pondweed)

Potamogeton gramineus (variable pondweed)

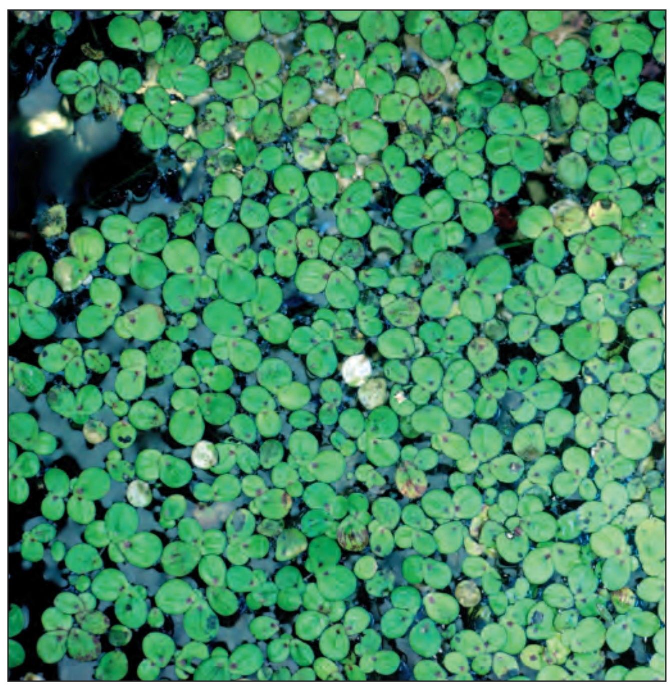
Potamogeton richardsonii (clasping-leaf pondweed)

Potamogeton crispus (curly-leaf pondweed)

Najas spp. (bushy pondweed)

Elodea canadensis (waterweed)

Potamogeton spp. (thin-leaf pondweed)



Lemna spp. (duckweed)

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