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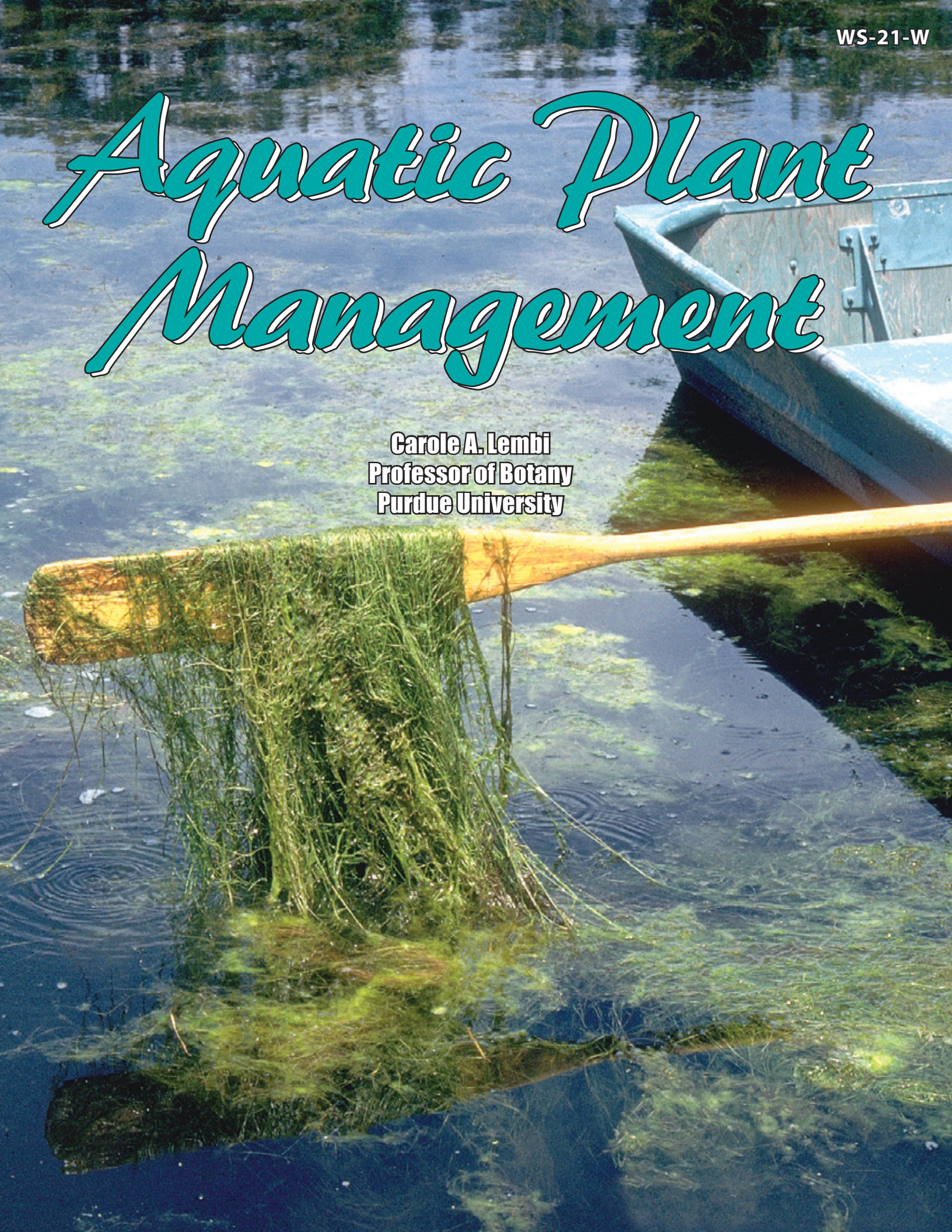
Aquatic Plant Management



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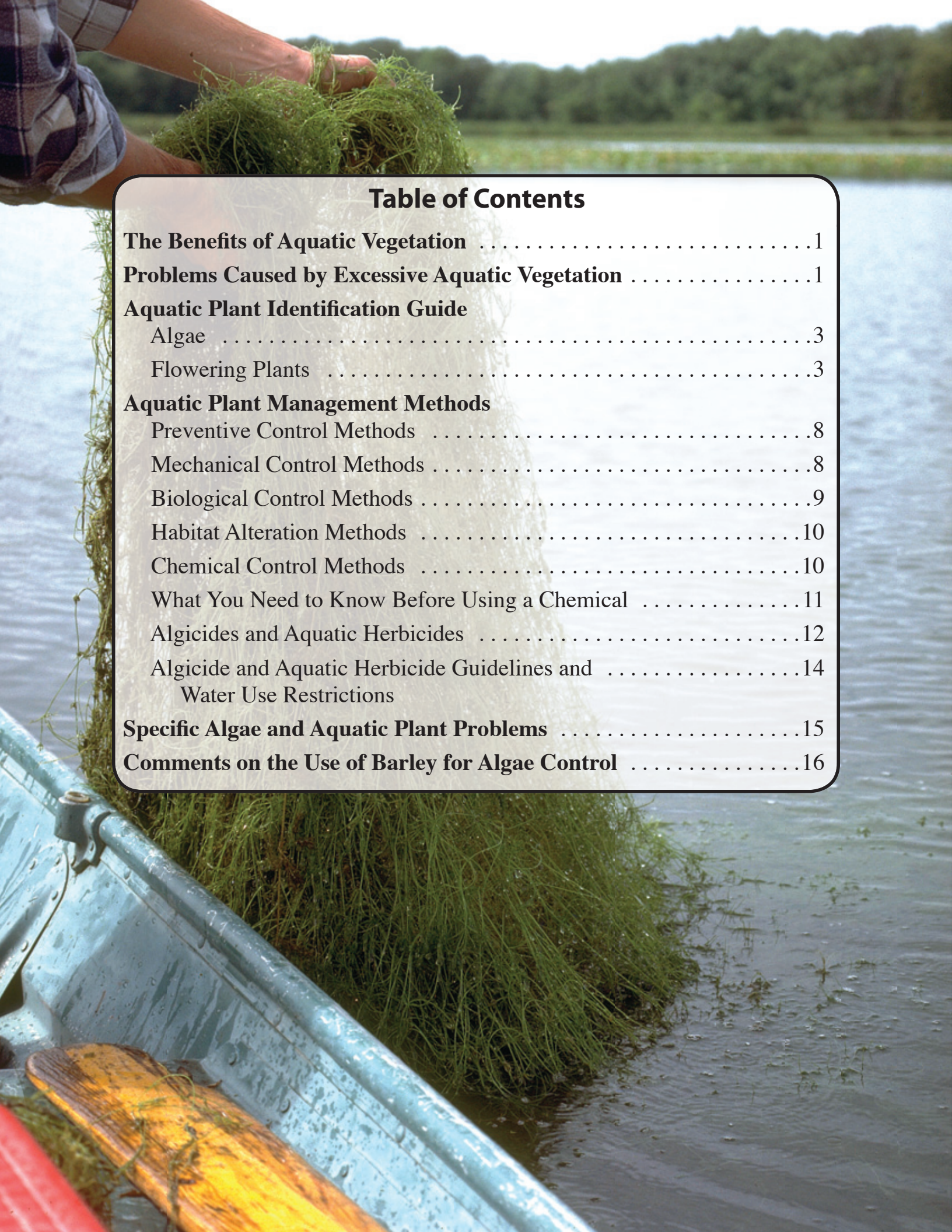

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AQUATIC PLANT MANAGEMENT

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The Benefits of Aquatic Vegetation

Although this guide is primarily devoted to managing or reducing the amount of aquatic vegetation present in a body of water, the reader should be aware that aquatic plants have many important functions in aquatic systems. Just as on land, plants in water are natural and essential components of the environment, and without them, life as we know it could not exist. All plants, whether on land or in the water, utilize sunlight, carbon dioxide, and water to photosynthesize. The process of photosynthesis results in the production of new plant tissue (biomass) and oxygen. In water, new plant biomass takes the form of either microscopic plants or larger plants called macrophytes. Why are these plants so important to the aquatic environment?

1. Microscopic plants (algae) form the base of the aquatic food chain. Another term for these plants is "phytoplankton" or plant plankton. They, in turn, are fed upon by zooplankton, or the microscopic animal plankton. Zooplankton are fed upon by small fish, small fish by larger fish, and so on up the food chain to humans and other top predators.
2. The macrophytes (larger algae and flowering plants) provide habitat and shelter for fish, fish food organisms, waterfowl, and other wildlife.
3. Macrophytes provide food for insects, waterfowl, and mammals such as muskrats and beaver. However, bass, bluegill, and catfish do not, as a rule, eat macrophytic vegetation.
4. All plants produce oxygen as they photosynthesize during the daylight hours. Photosynthesis is the major source of oxygen for aquatic animal life.
5. Rooted plants stabilize shorelines and bottom sediments; uprooting these plants can lead to shoreline erosion and increased turbidity in a body of water.

6. A diversity of aquatic plant life, both around and in the water, can add visual interest and beauty to a water body. One of the largest growing sectors of the home nursery industry is water gardening. Many people now recognize and appreciate the aesthetic and natural qualities of aquatic vegetation, whether in a backyard setting, around a retention pond in an urban area, or along the shoreline of a large lake.

Because of these many benefits, some aquatic plant growth is always desirable. **The goal of management should never be to totally eliminate aquatic vegetation from a site.**

Problems Caused by Excessive Aquatic Vegetation

Unfortunately, plant growth can get out of hand. Excessive plant growth is usually due to the fact that many of our bodies of water are shallow, which allows sunlight to penetrate to the bottom and support photosynthesis. Also, our bodies of water tend to be rich in nutrients such as nitrogen and phosphorus (substances that are needed by plants for growth). In some cases, exotic species of plants that are extremely aggressive have been introduced and have taken over large areas of aquatic habitat. Some of the problems caused by excessive aquatic plant growth are as follows:

1. Recreational activities such as swimming, fishing, and boating can be impaired and even prevented.
2. Excessive growths can lead to fish stunting and overpopulation. This occurs because the production of too much habitat prevents effective predation of small fish by larger fish.
3. Aquatic plant and algae growths can play a role in causing fish kills. This usually occurs because oxygen is taken out of the water. During the day, plants produce oxygen through photosynthesis; at night (as well as day), they consume oxygen through respiration. If plant growth is excessive, plants at night can use up most of the oxygen in the water. In fact, fish that are stressed for oxygen often die just before dawn when the oxygen content is lowest. Sometimes they can be observed coming to the surface and gasping for air during the early morning hours. This is a sure sign that the fish are oxygen stressed and may die.

Oxygen depletion also occurs when algae and plants die and decompose. When plants die, photosynthetic production of oxygen ceases, and the bacteria and fungi, which break down (decompose) the decaying plant material, use up the oxygen in their own respiration. Unfortunately, it is difficult to predict when a plant die-off will occur under natural conditions. Changes in water temperature, prolonged periods of cloud cover, shifts in wind patterns, and depletion of nutrients are just some of the factors that may trigger a plant or algae die-off. Another cause of plant death and oxygen depletion is the treatment of too much vegetation with a herbicide (see page 11 for more information).

Similarly, it is almost impossible to predict when or if fish are going to die because of vegetation-related oxygen depletion. Fish kills typically occur in the summer or in the winter. Summer fish kills can be caused, as already described, by die-offs and decomposition of algae and plant growth. Another cause can be due to a dense cover of algae or free-floating plants such as duckweed or watermeal on the surface of a body of water. These surface growths reduce light penetration to the deeper waters which in turn inhibits photosynthesis and oxygen production. Anything that stirs or brings these deoxygenated waters to the surface (such as a brisk wind) can result in lowered oxygen levels throughout the water column and cause a fish kill. Even if fish are not immediately killed, prolonged exposure to low oxygen concentrations can lead to greater fish susceptibility to diseases and toxicants.

Fish kills in winter occur when snow accumulates on ice cover. Light is blocked, thus preventing photosynthesis and oxygen production by any living plants or algae. Decomposition of plants that died in the fall causes further oxygen depletion. The fact that a site has undergone a winter fish kill may not even be recognized because the dead fish can decompose and disappear under the ice or as the ice breaks. It may not be until spring or early summer that people notice that fishing is not what it used to be. Other causes of fish kills include natural stresses on fish as they come out of the winter and into the spawning season, insecticide runoff, ammonia leakage from storage tanks, and diseases.

4. Aquatic weed growth provides quiet water areas ideal for mosquito breeding.
5. Certain algae can impart foul tastes and odors to the water.
6. Weeds impede water flow in drainage ditches, irrigation canals, and culverts and cause water to back up.
7. Deposition of weeds, as well as sediment and debris, can cause the gradual filling in of bodies of water.
8. Excessive weed growth can lower property values and decrease aesthetic appeal of a body of water.
9. Exotic aquatic plant species (e.g., Eurasian watermilfoil, purple loosestrife) can invade and completely take over stands of native vegetation. This process upsets the natural balance in an aquatic system and can have adverse effects on the animals that depend on the native vegetation for habitat and food.

What are the aquatic plants that most frequently cause these problems? The following guide is intended to help you identify these plants.

Aquatic Plant Identification Guide

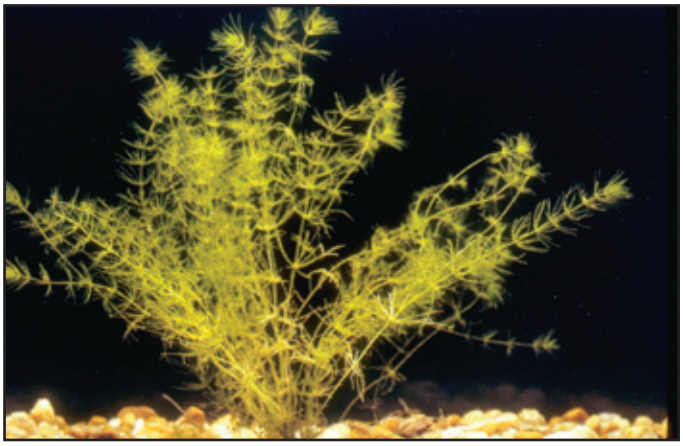
Most aquatic plants can be divided into two botanical groups: algae and flowering plants. Algae are usually very simple in structure, but some (for example, Chara) can resemble flowering plants. For effective management, it is essential that you distinguish between algae and flowering plants.

Algae

There are three general types of algae: microscopic algae, filamentous mat-forming algae, and Chara.

A bloom of microscopic algae causing a surface scum.

Microscopic algae form scums and/or color the water green or yellow-green. Sometimes they can cause red, black, or oily streaks in the water. When in sufficient numbers to color the water they are called "blooms." Die-off of these algae can cause fish kills. Blooms usually occur where abundant nutrients (e.g., nitrogen and phosphorus fertilizers) are reaching the water. The best solution for microscopic algal blooms is to prevent the input of nutrient-laden water.



Chara, an alga.

Chara or stonewort usually grows in very hard water and often is calcified and brittle. The plant is rooted, and leaves are arranged along the stem in whorls. Because of this overall structure, it is often confused with flowering plants, but it is an alga and should be managed as such. The plant is completely underwater and has a very distinctive musky smell. In bodies of water where it is low-growing, it provides valuable habitat for fish and sediment stabilization. Under these conditions it should not be disturbed. In shallow water it can, however, grow up to the surface and be troublesome.

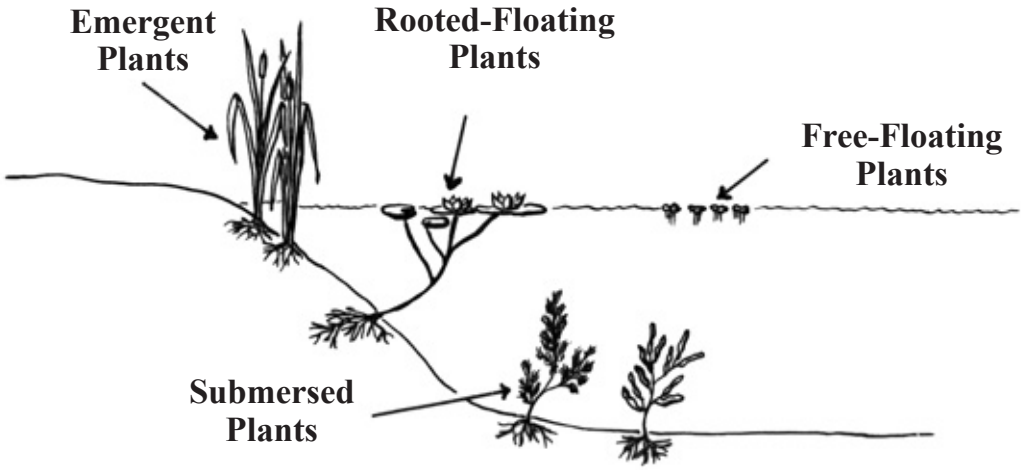
Mat-forming algae.

Mat-forming algae.

Filamentous, or mat-forming algae (often incorrectly called moss) form floating, mat-like growths that usually begin around the edges and bottoms of bodies of water in the spring. This type of growth is probably the most common in ponds in the Midwest.

Flowering Plants

Flowering plants are more complex in their structure than algae. In addition to producing flowers, they have an internal conducting system which algae lack. Flowering plants can be grouped into broad categories according to where they are found in a body of water.



Submersed Plants

Submersed plants are rooted in the bottom sediments and grow up through the water. Flowers or flowering spikes sometimes emerge above the water surface. Some of the pondweeds, such as American pondweed, have both underwater leaves and leaves that float on the water surface. The main criteria for identification are leaf arrangement and leaf shape. The plants shown here are some of the most common underwater plants with weedy characteristics. However, within almost every group there are species that have value for fish and/or wildfowl habitat. For example, curly-leaf pondweed is an invasive weed, but beds of large-leaf pondweed provide good shelter for game fish. Eurasian watermilfoil also is a very aggressive, introduced weed, but other milfoil species are native and have less potential as weeds. Information beyond what this bulletin can provide is necessary for complete aquatic plant identification.

Curly-leaf pondweed

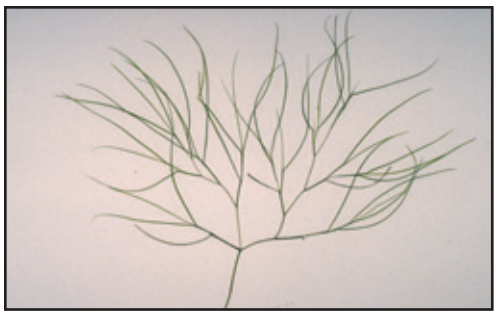
Alternate leaf arrangement (one leaf per node). Grows best in the spring and tends to die out in the summer. Found in both lakes and ponds.

Leafy pondweed

Very narrow leaves – alternate leaf arrangement. Extremely common in farm ponds in the summer.

American elodea

Three leaves at a node. Very common in lakes and ponds.



Sago pondweed

Leaves are almost thread-like. Individual leaves tend to be slightly curved. Although a weed in some situations, the seeds and underground tubers are valuable as food for waterfowl.

American pondweed

Leaves that float on top of the water surface are about 1 to 4 inches long. Usually restricted to shallow water.

Brittle naiad

Opposite (two leaves per node) leaf arrangement; sometimes three leaves appear at a node. Leaves slightly spined. More common in southern portions of the north central region.

Southern naiad

Opposite leaf arrangement, sometimes appearing as three leaves at a node. Very common in lakes and ponds.

Coontail

Whorled leaf arrangement (more than two leaves at a node); leaves branched and spined. Very lightly rooted or floating in the water column. Very common in shallow, marsh-like areas. Diagram: an individual leaf.

Eurasian watermilfoil

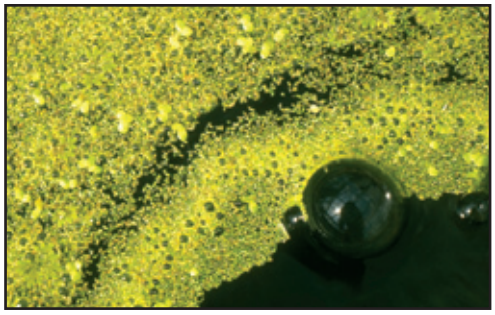
Four leaves at a node. Each leaf is feather-like. A serious and rapidly spreading invader. Eurasian watermilfoil typically has more than 10 leaflet pairs per leaf whereas native milfoils have fewer than 10. Diagram: an individual leaf.

Free-floating Plants

Free-floating plants such as duckweed and watermeal can completely cover the surface of a pond. Complete surface coverage by these plants shades out underwater plants, thus causing oxygen depletion in the deeper water. These plants are extremely small. Duckweed is no more than 1/4 to 1/2 inch in diameter; each plant has a small root that hangs into the water. Watermeal plants have no roots and look like tiny green seeds or green cornmeal. Both plants are found in nutrient-rich waters; therefore, restricting nutrient inputs can be helpful in management.

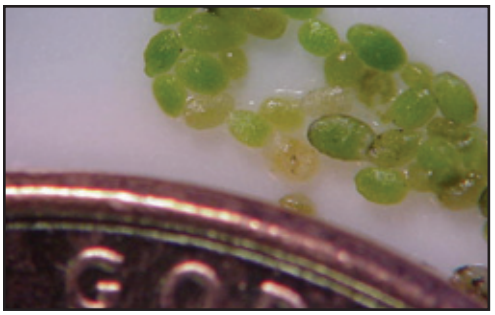
Duckweed

Note the roots hanging from the plants.



Watermeal

Most of these very tiny plants are watermeal. There are also some duckweed plants and an air bubble.



Watermeal plants look like tiny green seeds.

A pond totally covered with watermeal.

Rooted-floating Plants

Rooted-floating plants include waterlily, spatterdock, and watershield. These plants are generally found in shallow water less than 4 to 5 feet deep. Spatterdock has a massive underground rhizome from which new plants can sprout. It differs from waterlily in having a heart-shaped rather than round leaf, and the leaves come above the surface of the water rather than float. Spatterdock has yellow flowers and is sometimes called yellow cow lily. This group of plants provides valuable wildlife habitat and should be protected in natural lake and wetland areas.

Spatterdock

Waterlily

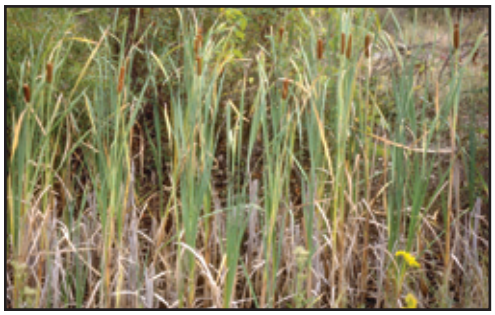
Watershield

The leaves are only 2 to 5 inches in length. The petioles and undersides of the leaves tend to be slimy. Note how the petiole joins the leaf at the middle of the leaf.

Watershield leaves floating on the water surface.

Emergent Plants

Emergent (shoreline or marginal) plants include grass-like and broadleaved plants. Grass-like plants commonly include cattails, bulrushes, spikerushes, and reed canarygrass. Broadleaves include willow trees, creeping water primrose, and purple loosestrife. Purple loosestrife is an invader of wetland areas, has no wildlife value, and is considered a serious weed. Many of these plants spread rapidly by underground systems as well as by seed.



Cattail

Plants 5 - 7 ft. tall.

Spikerush

Plants usually no more than 1 ft. tall.

Bulrush

Plants 3 - 7 ft. tall.

Creeping water primrose

Plants low growing in shallow water.

Purple loosestrife

A serious wetland invader. Flowers are purple.

Phragmites

Also called common reed. An aggressive grass; plants typically 10 to 12 ft. tall. Rapidly spreading along roadsides, ditches, and into wetlands.

Aquatic Plant Management Methods

The goal for a person managing a body of water is to achieve a balance. As discussed earlier, some vegetation, particularly native species, is highly desirable and adds interest and appeal. **A sterile, swimming pool effect for a natural body of water should be avoided.** How do we achieve this balance between too much vegetation and too little? We attempt to do it by careful use of one or several management methods. These are preventive, mechanical, biological, habitat alteration, and chemical methods.

Preventive Control Methods

Many aquatic plants or their seeds are carried into a body of water by wind, birds, fish introduction, boat trailers, fishermen, etc. Plant fragments, even less than an inch long, that do not completely dry out during transfer can survive and produce new plants. It is quite possible that the recent proliferation of Canada geese has resulted in the increased spread of algae and certain aquatic plants. Prevention starts with eliminating or reducing these causes of spread; e.g., discourage geese from visiting your water body, wash plant fragments off of boat trailers and boats before moving to a new site, and remove plant fragments from live wells and when moving fish or fish bait from one site to another.

Newly introduced plants become infestations only if the water conditions are just right. Good growing conditions usually mean that the body of water is shallow or has shallow areas with good light penetration, and has an available source of nutrients (nitrogen and phosphorus), either in the water or stored in the sediment. Often nutrients enter a body of water from runoff or stream flow. Nutrient inputs can be reduced by initiating a good management plan for the watershed (the area that drains into the body of water). In addition to surveying the watershed and reducing or eliminating obvious nutrient or sediment sources, you can do the following things:

1. Do not fertilize your pond or lake. Most Midwestern waters are sufficiently rich in plankton and other food organisms to support large fish without being fertilized.
2. Maintain a good sod and grass cover around the body of water or areas that drain into the water. The planting of native perennial species such as sweetflag, water iris, and certain types of sedges is also effective in absorbing nutrients that might flow into a body of water and in reducing soil erosion. These plants can give a body of water a more natural look, and it is thought that taller vegetation reduces the chances of Canada geese colonizing a water site. Consult with the plant supplier to make sure the species you choose are not overly invasive. For example, some suppliers sell Phragmites and common cattail. These plants can be difficult to keep from spreading. However, dwarf species of each are available and should be less aggressive.
3. Do not apply lawn fertilizers any closer than 10-20 feet from the shoreline.
4. Do not allow livestock access to a pond except under conditions of extreme heat stress. If the water is used for livestock, fence the pond. Water the animals from a stock tank below and outside the fence. Animals in the water will increase turbidity and fertility and tear down the banks.
5. Check septic tanks for possible leakage or seepage into the water. New septic drainage fields should be directed away from the body of water.
6. Do not permit runoff from chicken coops, feedlots, etc. to enter the body of water. If this kind of runoff is occurring upstream from your water site, you should check with your county board of health to see if anything can be done about it.
7. Establish a settling or retention pond or wetland area to receive and settle out nutrients before the flow reaches the main body of water.

All of these measures will help prevent weed growth, particularly in a newly constructed body of water. In older bodies, these measures will aid in gradually reducing infestations of free-floating plants such as microscopic algae and duckweed.

Mechanical Control Methods

Even with preventive measures, many bodies of water still have severe plant infestations. Hand-pulling or raking plants is a possible method of control. Since most aquatic plants are perennial,

with underground portions that can resprout new shoots, it is essential that below-ground growth also be harvested. In the case of larger plants such as cattails, this is difficult to do. Hand-held devices for cutting or pulling plants in small areas are available from dealers that specialize in aquatic/fisheries supplies.

For larger bodies of water, motor-driven underwater weed harvesters are available. This equipment usually is a major investment and may have to be operated several times during the season to effectively keep the vegetation cut back. The premise is the same as mowing a lawn. The plants will not be eliminated, but they can be prevented from growing to the surface and becoming a nuisance. Mechanical harvesters have been used successfully to cut channels through vegetation, which allows boat traffic to move out to open water. The cut vegetation should be harvested and dumped where it cannot reenter the water. Plant fragments left to float in the water can produce a new plant. The harvested material can be satisfactorily used as a fertilizer or mulch in gardens or as land fill.

Some states require permits for harvesting on natural lakes; check with your state regulatory agencies to determine if such permits are required. **Indiana residents:** A permit from the Indiana Department of Natural Resources is required for the mechanical harvesting of vegetation in public waters that are more than 25 feet along the shoreline, greater than a water depth of 6 feet, and greater in area than 625 square feet. A permit is **not required** for privately owned lakes, ponds, or drainage ditches.

More information on mechanical harvesters can be obtained at the following Web sites: United Marine International <www.trashskimmer.com>, Aquarius Systems <www.aquarius-systems.com>, and Aquamarine Aquatic Plant Harvesters <www.aquamarine.ca>. These are only three of several companies; their listing does not imply an endorsement of their products.

Biological Control Methods

Biological controls (organisms that control pest organisms) have received considerable publicity. Bacteria, fungi, and insects currently are being tested for their ability to reduce aquatic plant infestations. Certain insects appear to have potential for the control of Eurasian watermilfoil and purple loosestrife. Insects have been released at selected sites in the Midwest for the control of both plants, but it is too early to know whether they will be effective on a widespread scale. Waterfowl such as swans can keep small ponds weed-free, but they require husbandry and protection from predators. They also are extremely aggressive during and following the breeding season.

Check with the appropriate state regulatory agency or fish and game agency to determine if a biological control agent is legal in your state and for permitting information and restrictions if it is. **Indiana residents:** A permit from the Indiana Department of Natural Resources is required for the introduction of a biological control agent in all public waters. A permit is **not required** for privately owned lakes, ponds, or drainage ditches (however, note restrictions below on use of grass carp in private waters).

The most widely used biological control agent to date is a herbivorous fish, the grass carp (also known as the white amur).

The grass carp is native to China and Russia. It can live 15-20 years. This fish consumes some filamentous algae and most submersed plants. Since it has the potential to denude a body of water of its underwater vegetation, **it must not be released in natural lakes and wetland areas** where vegetation is critical to fish and wildlife. In Indiana the land surrounding the pond or lake must be totally in private ownership and all precautions must be taken to prevent escape of the fish from the stocked area. Barriers should be erected at the spillway or outflows.

The type of grass carp that is most commonly legal is the triploid grass carp, a form that will not reproduce itself. In Indiana, fish must be purchased from a holder of an Aquaculture Permit. The permit holder must deliver and stock the fish and present the purchaser with a bill of sale and copy of triploid certification. It is the responsibility of the purchaser to retain these documents for at least two years.

In Indiana, stocking rates are 15 or 30 fish per vegetated acre. Fish should be 8-12 inches long. Vegetation can be thinned with as few as five fish per vegetated acre. Smaller fish will be rapidly removed by predators such as bass. The lower stocking rate is recommended for most ponds so that some vegetation remains. Where total vegetation

control is desired (e.g., in ponds on golf courses), the higher stocking rate can be used. Vegetation control may not be observed for a year or more; after about five years, the grass carp slows its feeding rate, so that more fish may be needed to maintain adequate vegetation control.

Although the grass carp has provided good control of aquatic vegetation in some situations, it is not the solution for all ponds. Since its effects on vegetation may not be noticed for a year or more, it may be difficult to determine if enough fish are still present in the pond to be effective. In addition, the grass carp prefers certain plant species over others. For example, it will consume native species such as pondweeds before it will feed on truly troublesome weeds such as Eurasian watermilfoil or mat-forming algae. It is not effective on duckweed or watermeal.

Triploid grass carp are legal for use in Indiana, Illinois, and Ohio. They have not been approved for use in Michigan, Minnesota, and Wisconsin.

Habitat Alteration Methods

Certain methods of manipulating or altering the aquatic environment can be effective in aquatic plant management. One of the more successful methods is the drawdown technique in which water levels are lowered over the winter. Exposure of the sediments in the shallow areas of a lake or pond to alternate freezing and thawing action will kill the underground structures of many aquatic plants. This method has been successful for the control of Eurasian watermilfoil and waterlilies, although the degree of control depends on the severity of the winter.

Other types of habitat manipulation include riprapping shorelines or anchoring black plastic sheeting on the bottom sediments to prevent rooted plant growth. Dyes such as Aquashade® are used to inhibit light penetration throughout the water. This blue dye can be applied right out of the bottle along the shoreline. It mixes throughout the body of water within 24 hours. The dye intercepts light normally used for photosynthesis by underwater plants. The dye can only be effective if its concentration is maintained. Some general rules for using Aquashade® or other dye products are as follows:

1. Do not apply where water outflow will reduce the dye concentration.
2. Apply in March or April before plants reach the water surface. Midsummer reapplication is usually necessary.
3. Dyes are effective only on rooted underwater plants growing at depths greater than 2 to 3 feet. Supplemental treatments of copper sulfate are often needed for algae control.
4. Do not use in muddy water.

Aeration has been publicized as another method of weed control. Although aeration is definitely beneficial for fish life and can help prevent fish kills, there is no evidence that aeration inhibits weed growth. If you do install an aerator to provide oxygen for fish, make sure that you purchase a unit that introduces air to the bottom of the pond, not just a fountain that sprays surface water. **Indiana residents**: A permit from the Indiana Department of Natural Resources is required for habitat alteration methods such as bottom barriers and dyes in public waters that are more than 25 feet along a shoreline, greater than a water depth of 6 feet, and greater in area than 625 square feet. A permit is **not required** for privately owned lakes, ponds, and drainage ditches.

Chemical Control Methods

When properly applied, certain herbicides can control aquatic vegetation without harming the fish and other wildlife. In some instances, herbicides can be used selectively, that is, to control certain plant species without killing others. Aquatic herbicides also can fit into an aquatic plant management plan when it is desirable to treat some vegetated areas and leave others untreated. They can be particularly effective for controlling certain aggressive weed species such as Eurasian watermilfoil.

However, it should be noted that, in most cases, aquatic herbicides offer only temporary solutions. The target species usually will reappear, and retreatment or application of another control method usually will be necessary.

All of the herbicides discussed in this publication are registered with the federal Environmental Protection Agency (EPA) and, when used in water as directed, pose no significant threat to the environment or to public health. Most herbicides, however, ARE TOXIC IF TAKEN INTERNALLY, and direct contact with the chemical should be avoided. Protective clothing, gloves, and a face mask or respirator should be worn during mixing

and application. If a herbicide comes in contact with the skin, it should be washed off immediately with water. If a herbicide is accidentally swallowed, go to a physician immediately and consult the container label for first aid information.

Because these chemicals are toxins and require special precautions, the remainder of this bulletin is devoted to the proper use of aquatic herbicides.

Check with the appropriate state regulatory agency for a list of the herbicides approved for use in your state, and for other restrictions and important information. **Indiana residents:** A permit from the Indiana Department of Natural Resources is required for the chemical treatment of vegetation in public waters that are more than 25 feet along the shoreline, greater than a water depth of 6 feet, and greater in area than 625 square feet. A permit is **not required** for privately owned lakes, ponds, or drainage ditches.

What You Need to Know Before Using a Chemical

Before buying and applying a herbicide it is essential that you READ THE LABEL to determine whether the product will meet your needs. Important considerations in choosing a herbicide include:

1. **Identity of the plant**. This can save you a lot of money because certain chemicals will work only on some plants and not on others. Identification help can be obtained from your county or university Cooperative Extension Service, pest diagnostic services, fisheries biologists, or dealers of aquatic herbicides. Always transport or mail the plant in a plastic bag without extra water.
2. **Restrictions on use of water treated with herbicides**. Although most aquatic herbicides break down readily and rapidly in water and pose no threat to human or animal health, there are waiting periods on the use of water treated with most herbicides. These restrictions—mostly on fishing, domestic use, livestock watering, or irrigation—dictate which herbicides will be appropriate for your lake or pond. At the current time there are no swimming restrictions on the herbicides listed in this publication. However, it is always wise to encourage at least a 24 hour period before swimmers are allowed back into treated water. Always check the herbicide label for possible restrictions.

   If you are interested in learning more about the environmental and human health impacts of aquatic herbicides, you can go to a Web site entitled "Why Aquatic Herbicides Affect Aquatic Plants and Not You!" at <www.btny.purdue.edu/aquatic/>. The three major factors that protect us from harmful effects are that currently EPA-registered algicides and aquatic herbicides 1) are used at extremely low doses in water, 2) do not persist very long in water (usually only a few days), and 3) do not bioaccumulate in fatty tissues of humans or animals. **Chemicals that are not EPA-registered for aquatic use may not have these characteristics and therefore should never be used in or around water. Read the herbicide label. If it does not provide information for aquatic use, its application to water is illegal and can cause environmental or human health problems. An example of a herbicide that is not cleared for aquatic use is Karmex.**
3. **Dosage**. Calculate the dosage carefully and do not apply more chemical than is needed. Some aquatic herbicide labels give dosages on the basis of acre-feet (a volume measurement). Acre-feet are calculated by multiplying the surface area by the average depth. For example, a pond with a surface area of 1/2 acre and an average depth of 4 feet contains (1/2 acre X 4 ft) 2 acre-feet. The herbicide label can then be consulted for the amount of chemical to apply per acre-foot.
4. **Timing**. Late spring is usually the best time to apply aquatic herbicides (exceptions are noted under the individual chemicals). The plants are young and actively growing and most susceptible to herbicides. **Do not wait until July or August!** If you wait until late summer to treat, you are running a serious risk of killing fish. By that time, the vegetation is usually extensive and thick. Also the water is warm and still. Killing all vegetation at once under these conditions could seriously deplete the water of its oxygen and cause a fish kill. **If you must treat this late in the summer, treat only a portion of the weed growth at a time.**
5. **Temperature**. Aquatic plants are not affected by herbicides when the water is too cold. The water temperature should be in the 60's, preferably

the upper 60s (in the area to be treated). These temperatures usually occur from late April to early June in Indiana. This means that as soon as the plants are up and actively growing, and if the water temperature is right, the herbicide should be applied.

6. **Contact versus translocated herbicides**. Some herbicides (contacts) work very quickly by killing the plant tissue that they come into contact with. These herbicides can be used for "spot" treatments; that is, treatments of selected patches of vegetation. These chemicals include the copper algicides, endothall, and diquat. Other herbicides (translocated) move into the plant and work on other parts of the plant (e.g., underground rhizomes or tubers) rather than just the leaf tissue. They tend to work more slowly than contact herbicides. One of these, fluridone, cannot be used as a spot treatment because it may move away from the treated area before it can have an effect. The other translocated herbicides (2,4-D, triclopyr, and glyphosate) can be used as spot treatments, but again, they work slowly.
7. **Retreatment**. More than one treatment a season (e.g., copper sulfate on algae) may be required for adequate control. Retreatment is usually required in succeeding years. Plants can regenerate each spring from seeds, spores, and underground structures. Seeds and underground structures that lie dormant over the winter are not affected by most aquatic herbicides.

Algicides and Aquatic Herbicides

1. **Copper sulfate**. Trade names are various. Available as granular crystals, diamond form, and powder.

   Copper sulfate is used only for algae control; it is not effective on other types of weeds. When purchased as copper sulfate pentahydrate (25% metallic copper), the recommended dosage is 2.7 pounds per acre-foot of water. Concentrate the treatment in the area of growth.

   The granular form is best applied by putting it in a burlap sack and towing it by boat around the pond until it is dissolved. Tossing the granules into the water is not very effective because those that land on the sediment may be rapidly adsorbed by soil particles and will not be available for uptake into the algae.

   The powder form is best used by dissolving it in water and spraying directly onto the algae mats and into the water around the mats.

   Copper sulfate is highly corrosive to metals so plastic, enameled, or copper-lined containers and fittings are needed for mixing and applying the algicide. Sprayers should be thoroughly cleaned and rinsed out after every operation to prevent corrosion damage.

2. **Copper chelates**. Trade names include Cutrine Plus, Algae Pro, Captain, K-Tea, and others. Available as liquids; Cutrine Plus is also available as a granule.

   The copper chelates are used primarily for algae control, particularly at sites where hard water may cause copper sulfate to precipitate out of the water and reduce its effectiveness. These products tend to be less corrosive to metals than copper sulfate. Mix the liquid formulations with water in a container and spray or inject into the infested area. Granular formulations can be broadcast into the water using a seeder. Both liquid and granular formulations can be used as spot treatments.

3. **Endothall**. Trade names include Aquathol and Hydrothol. Both are available as liquids and granules.

   Aquathol is used for submersed plant control and, along with diquat, is a standard treatment for these plants. Mix the liquid formulations with water in a container and spray or inject into the infested area. Granular formulations can be broadcast into the water using a seeder. Both liquid and granular formulations can be used as spot treatments.

   Hydrothol liquid can control both algae and submersed plants, but it is recommended for use only by certified applicators who have had special training in handling aquatic pesticides. It can cause fish kills and severe skin burns to the applicator.

4. **Diquat**. Trade name is Reward. It is available only as a liquid.

   Diquat is used for submersed plant control and, along with Aquathol, is a standard treatment for these plants. It can also be used for burndown

treatments of duckweed and watermeal, although these plants will usually recover. Mix the Reward with water in a container and spray or inject into the infested area. The herbicide can be used as a spot treatment. Do not use when water is muddy because the soil particles will remove the diquat from the water.

5. **Fluridone**. Trade names are Sonar and Avast! Sonar is available as A.S. (aqueous solution), SRP (slow release pellet), PR (precision release), and Q (quick release).

   Fluridone is used primarily for the control of submersed plants and duckweed. Mix Sonar A.S. and Avast! with water in a container and spray or inject into the infested area. The pelleted forms can be dispersed with a seeder. Fluridone is not effective as a spot treatment, therefore, it must be applied to the entire surface area of ponds. In lakes and reservoirs it should be applied to areas greater than 5 acres to prevent dilution. Since the chemical must stay in contact with target plants for several weeks, it is not recommended for sites where there is a lot of water exchange. The chemical is slow acting, and it may take 30-90 days to see results. However, under optimal conditions, target plants may be controlled for up to 2 or more years. This chemical is particularly effective at removing the invasive species Eurasian watermilfoil without affecting native species.

6. **2,4-D**. Trade names are Navigate and Aquakleen. Both are granular formulations.

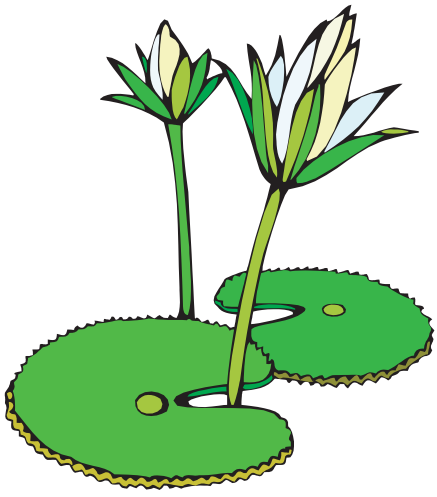
   2,4-D granules are used for specific plant species such as Eurasian watermilfoil, coontail, and waterlilies. Since 2,4-D is a broadleaved weed killer, it can be used selectively to remove these target species and retain grasses and grass-like species (many of which are native species). The granules should be distributed evenly over the infested area. 2,4-D liquid formulations are not currently registered for in-water use. Only amine formulations of 2,4-D liquid should be used for vegetation control around water (for example, vegetation along drainage ditchbanks) but check the label to make sure the product is registered for that use; liquid ester formulations are highly toxic to fish and should not be used around water.

7. **Triclopyr**. Trade name is Renovate 3. It is available only as a liquid.

   Triclopyr is used to control many of the same plant species as 2,4-D and has the same selectivity; in other words, it controls broadleaved plants but does not affect grasses or grass-like plants such as cattails. One of its advantages is that it is a liquid formulation whereas 2,4-D is approved for in-water use only as a granule formulation. Therefore, triclopyr offers additional flexibility for the control of Eurasian watermilfoil. Its other major use is for the control of broadleaved emergent plants such as purple loosestrife and creeping water primrose. Use of a non-ionic surfactant in the spray mixture is recommended for emergent plant control.

8. **Glyphosate**. Trade names are Rodeo, Aqua Neat, and Eagre. These products are available only as liquids.

   Glyphosate is used for the control of emergent vegetation such as cattails. It is not selective; therefore, it can kill any emergent plant that it comes into contact with. **It does not work on plants that are under the water surface**. All of the current formulations require the addition of a nonionic surfactant (wetting agent) to the glyphosate-water mix. The solution is sprayed directly on the foliage. The best time for treatment is late summer or early fall, before the first hard freeze. The solution can be used as a spot treatment or as a wipe-on application (wear protective gloves to apply the chemical with a sponge directly on the foliage of the target species) to kill only specific plants.



Algicide and Aquatic Herbicide Guidelines and Water Use Restrictions

Aquatic weed	Herbicide	Typical product dose[1]	Restrictions[2]
Algae (microscopic, filamentous, Chara)	Copper sulfate (25% Cu)	2.7 lb/A-ft.	Do not use in trout-bearing waters
	Copper chelates	Rate varies with formulation	Do not use in trout-bearing waters
	Endothall (Hydrothal 191) Liquid Granular	 0.6 to 8.8 pt/A-ft. 2.2 to 13.2 lbs/A-ft.	F= 3 days; I, L, D = 7-25 days Recommended for use by certified applicators only.
Submersed plants (pondweeds, naiads, elodea)	Endothall (Aquathol K liquid) (Aquathol Super K granular)	0.6 to 1.3 gal/A-ft. 27 to 54 lbs/A-ft.	F= 3 days; I[3], L, D = 7-25 days
	Diquat (Reward)	1 to 2 gal/SA	I = 1-5 days; D= 1-3 days; L = 1 day
	Fluridone (Sonar, Avast!)	Dose varies with formulation	I = 7-30 days: do not apply within 1/4 mile of potable water intakes
Submersed plants (Eurasian watermilfoil, coontail)	2,4-D (Navigate)	100 to 200 lbs/SA	Do not apply to waters for I, D
	Fluridone (Sonar, Avast!)	As above	As above
Submersed plants (Eurasian watermilfoil)	Triclopyr (Renovate 3)	0.7 to 2.3 gal/A for each ft. of depth (see label)	See label for required setback distances from potable water intakes
Free-floating plants (duckweed, watermeal)	Diquat (Reward)	1 gal/SA; add surfactant	As above
	Fluridone (Sonar AS, Avast!)	1 to 1.5 qt/SA	As above
Rooted-floating plants (waterlilies, spatterdock)	Glyphosate (Rodeo, Aqua Neat, Eagre) **plus surfactant**	Consult label.	Do not apply within 1/2 mile upstream of potable water intake

	Triclopyr (Renovate 3) **plus surfactant**	2 to 8 qt/SA	As above
Emergent plants (Most plants including cattails, grasses, purple loosestrife, willows)	Glyphosate (Rodeo, Aqua Neat, Eagre) **plus surfactant**	Consult label.	As above
Emergent plants (Purple loosestrife, creeping water primrose)	Triclopyr (Renovate 3) **plus surfactant**	6 to 8 qt/SA	Minimize overspray to open water

Footnotes

[1]SA= surface acre; A-ft = acre-feet. These dosages are given only as an indication of amount to use and will vary according to target species, state restrictions, etc. **Please read the label to determine actual dosage for the target plant.**

[2]F = fishing; I = irrigation; L = drinking water for livestock; D = drinking water for humans. Where range of days is given (e.g., 7-25 days), the waiting time depends on dose used. These restrictions apply to Indiana. If you wish to use these chemicals outside of Indiana, be aware that additional restrictions can be imposed by other states. Check with local and state regulatory agencies.

[3]Liquid formulation only: treated water can be used for sprinkling bent grass immediately.

Specific Algae and Aquatic Plant Problems

Algae Control

The first step in algae control is to reduce the runoff of nutrients (nitrogen and phosphorus) into a body of water. This is particularly true for the management of green water blooms caused by microscopic algae. If chemical treatment is needed, the algae should be treated with chemicals **before** they cause a noticeable color in order to prevent a fish kill.

Microscopic algae are not consumed by grass carp. Mat-forming algae may be eaten when grass carp are young, but generally the fish will eat submersed flowering plants in preference to algae. The blue dye products are not particularly effective on algae, particularly in shallow water. However, it may be useful to add dye after a copper treatment to prevent new growth from rising to the surface.

Control of mat-forming algae and Chara is mostly accomplished with a copper-based product. The standard product is copper sulfate. Sometimes copper sulfate is not very effective. Copper sulfate tends to be inactivated in very hard (alkaline) waters. Also, some types of algae are not very well controlled with copper sulfate. If copper sulfate is ineffective, it may well be worthwhile to try a chelated copper product. Both copper sulfate and copper chelates are best applied by mixing in water and spraying directly on and around the algae mats. Good coverage of the mats is critical to good control. For some extremely copper-tolerant algae, repeated copper treatments over the summer season may be necessary to keep the mats to a minimum.

Chara can be difficult to control once it has become established and has a heavy coating of calcium carbonate (limestone) around its body. Copper compounds should be used when the plants are still young and not heavily calcified. The granular form of Cutrine, which is dropped into the vegetation, can be an effective control.

There are no water use restrictions after the use of the copper products (although they should never be used in trout-bearing waters). Even so, it is wise to restrict swimming, fishing, using the water for irrigation or drinking, and other activities for 24 hours after application

Although Hydrothol is labeled for algae control, it must be used with caution, and preferably by certified aquatic applicators, to avoid killing fish. Hydrothol should only be used as a spot treatment so that ample untreated, fresh water is available for fish to move into. Sometimes small fish will not move away from the treated area quickly enough and can be killed.

Submersed Plant Control

Submersed plants can be controlled with a variety of methods, including the grass carp, mechanical harvesting, and dyes. However, the grass carp is not very effective in controlling Eurasian watermilfoil.

Aquathol and Reward are the most commonly used chemicals for submersed plant control. They can be tank mixed with copper products to control both algae and submersed plants. They are effective as spot treatments; therefore, they can be used to control vegetation in one area while leaving other areas untreated. They act quickly, and burn-down should be visible within a week of treatment. They are extremely short-lived in water; therefore, waiting periods to use the water for various purposes are short (see table).

Although burn-down of Eurasian watermilfoil can be achieved with Aquathol and Reward, this invasive species is more effectively controlled with 2,4-D (Navigate or Aquakleen), triclopyr (Renovate 3) or fluridone (Sonar or Avast!). Although the fluridone products are quite expensive, they can be used at extremely low dosages (parts per billion) to remove Eurasian watermilfoil from native plant stands.

Free-floating Plant Control

Duckweed and watermeal are difficult to control. They are not consumed by grass carp, and mechanical removal is very difficult. Surface applications of Reward primarily burn the plants, but they tend to come back within a week or two. Therefore, continual treatments with Reward are required throughout the season, starting as soon as the plants appear on the water surface. Furidone (Sonar or Avast!) can be more effective on duckweed than Reward and if used correctly can sometimes provide more than one year of control. Pond outflow must be blocked for at least 30 days or longer because the plant has to be exposed to the chemical for at least this long in order to be effectively controlled. The dose for duckweed (1 quart per acre) should be split and applied in two applications about 10-14 days apart. SePRO, the company that sells Sonar, guarantees the results on duckweed if its published procedures are followed. For a copy of those procedures, call 1-800-419-7779.

Watermeal is typically harder to control than duckweed. A higher dose of fluridone (1.5 quarts per acre) in a split application is suggested. Although fluridone usually provides successful control, there can also be failures. A Web site on watermeal and duckweed control is available at <www.btny.purdue.edu/pubs/APM/APM-2-W.pdf>.

Rooted-floating and Emergent Plant Control

Cutting or digging these plants can be extremely laborious because the underground rhizomes must also be removed for effective control. Grass carp do not feed on these plants.

The glyphosate products (Rodeo, Aqua Neat, Eagre) **plus a nonionic surfactant** are effective as foliar spray or wipe-on treatments on almost all vegetation that stands above the water surface. Surfactants (wetting agents) can usually be purchased at the same place as the glyphosate. Although Reward also is labelled for emergent plant control, it primarily burns the foliage and does not move into the underground parts of the plant. Glyphosate, on the other hand, does move downward and effectively kills underground structures. This movement is essential for long-term control of the plant. Glyphosate acts slowly; therefore, effects on the vegetation may not be seen for several weeks after treatment.

Although glyphosate applications can be made as soon as vegetation appears in the spring, it is most effectively applied in the late summer or early fall before the first hard freeze. If the underground structures are successfully killed, the vegetation should not reappear in the spring.

Triclopyr (Renovate 3) and some 2,4-D products can be used selectively to remove purple loosestrife and other broadleaved weeds from grasses or grass-like plants such as cattails and bulrushes.

Comments on the Use of Barley for Algae Control

Barley straw has been promoted as a means of controlling algae. Although widely used in England and other countries, research results in the United States have been inconsistent. For information on barley for algae control, go to <www.btny.purdue.edu/pubs/APM/APM-1-W>.

Notes

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