MP556

Aquatic Vegetation Control in Arkansas

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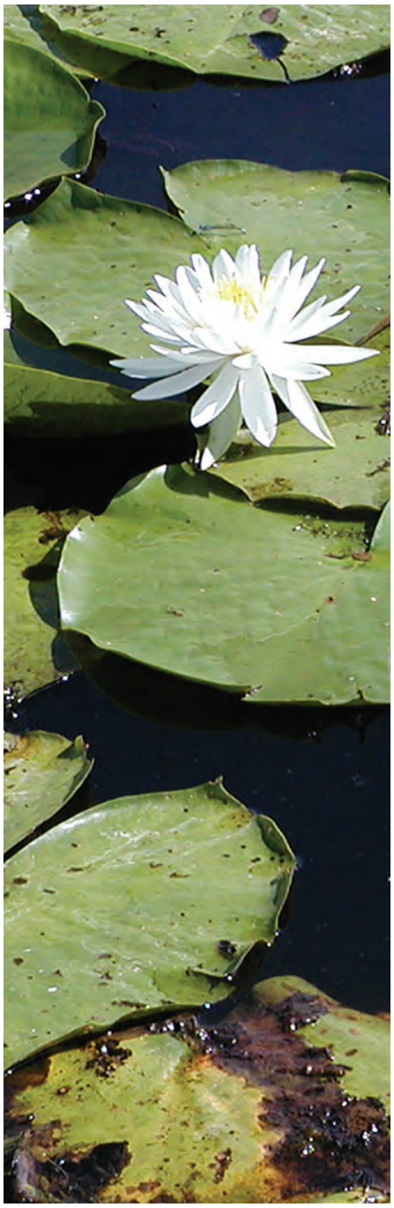

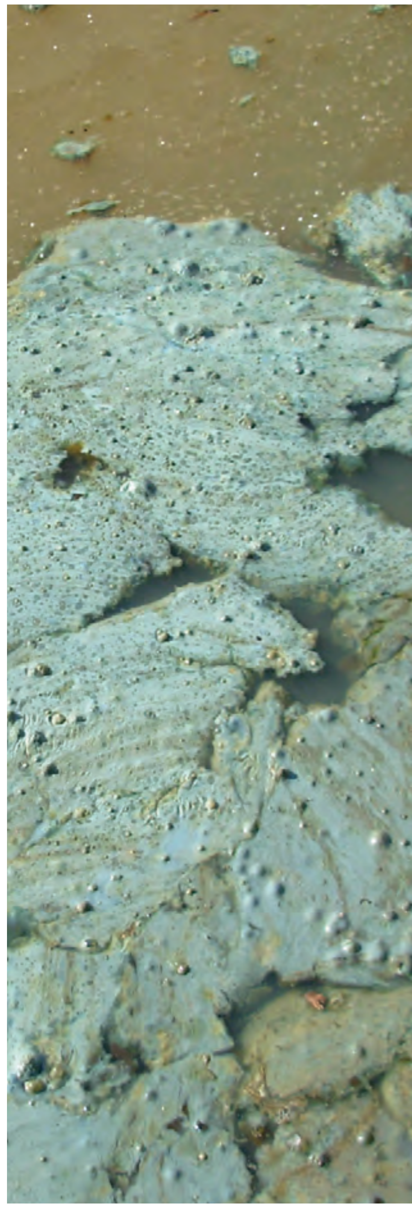

UNIVERSITY of ARKANSAS AT PINE BLUFF
1873
School of Agriculture, Fisheries and Human Sciences
Cooperative Extension Program

University of Arkansas at Pine Bluff, United States Department of Agriculture, and County Governments Cooperating

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INTRODUCTION

The presence of light, water and nutrients will guarantee that a water body, no matter how large or small, will have aquatic vegetation. Some plants can have a positive effect on the lake or pond for multiple reasons. Aquatic plants produce most of the dissolved oxygen in ponds. Microscopic plants (planktonic algae or phytoplankton) represent the base of most pond food chains. Phytoplankton is consumed by animal plankton (zooplankton), which is eaten by small fish that are then eaten by large fish, all the way up the food chain. Rooted plants help increase stability of the pond bottom and shorelines. Plants also improve water quality by absorbing nutrients and filtering pollutants.

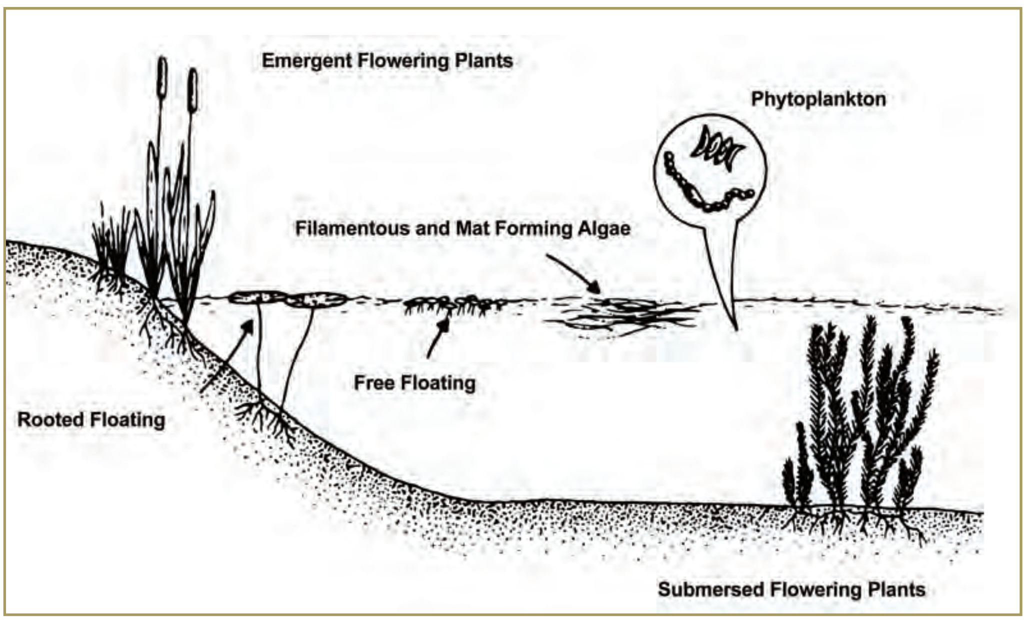
However, uncontrolled aquatic vegetation growth can have far-reaching negative impacts. These impacts can include larger mosquito populations, crop irrigation water loss, decreased fishing enjoyment in the backyard pond and reduced value of waterfront property. If nuisance aquatic vegetation impairs the use or enjoyment of a water body, action needs to be taken to correct the problem. The goal of this publication is to aid water resource managers in the formulation of management plans that allow water resources to be used to their fullest.

AQUATIC PLANT IDENTIFICATION

Correctly identifying the nuisance aquatic plant is the first step to controlling it. Aquatic plants can be divided into two groups: algae and flowering plants.

Algaes and Phytoplankton

Algae generally have simple structures. However, some species such as chara and nitella can be mistaken for flowering plants. Algae can be divided into three categories: Planktonic algae (phytoplankton), filamentous (or colonial) algae (pithophora and others) and macroalgae (chara and nitella). Phytoplankton populations are called blooms and they can make water appear green to yellowish-green in color. These blooms can also leave an oily or scummy appearance on the water surface. If a dense phytoplankton bloom suddenly dies off, oxygen can be consumed so quickly by the decomposing phytoplankton that fish are killed. Dense phytoplankton blooms are caused by excessive nutrients, usually nitrogen or phosphorus. These excessive blooms can sometimes be prevented by limiting nutrient input.

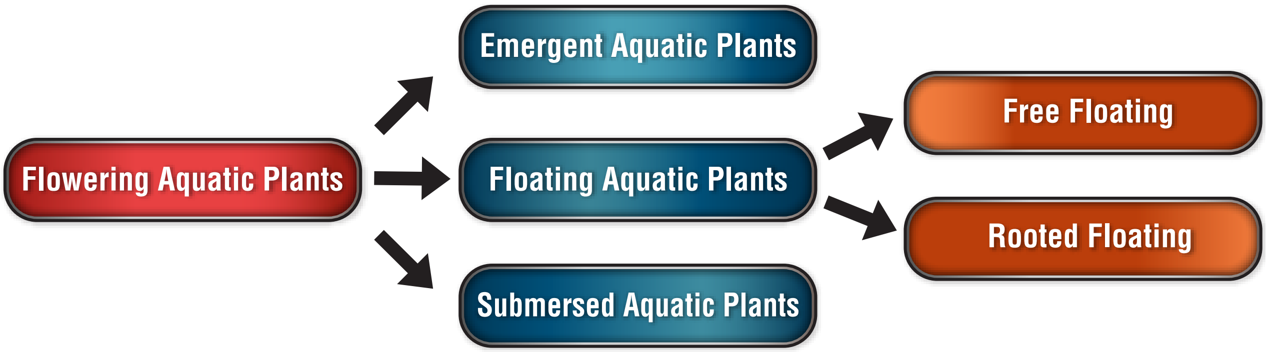


Plant Types Diagram
Illustration Courtesy of Craig Tucker

Flowering Plants

Flowering aqautic plants common to Arkansas can be divided into three categories: emergent, floating and submerged. Floating plants can be further divided into free floating and rooted.

Emergent plants often grow near the shoreline with most of their green vegetation above the water surface. This group includes both grass-like and broadleaf plants. Common Arkansas grass-like plants include cattails, bulrushes, sedges and common reed. Common broadleaf plants include alligator weed, water primrose, water pennywort, smartweed, water willow and lizard's tail.



Floating plants, as their name suggests, float on the surface of the water. Floating plants can either be free floating or rooted to the pond bottom. Free floating species include watermeal, duckweeds, water hyacinth and azolla (mosquito fern). Although these plants do not root into the pond bottom, most have roots that dangle into the water. Free floating plants commonly form dense blankets that cover the surface of calm, stagnant water. Rooted floating plants are anchored to the pond bottom and their stems are attached to floating leaves and flowers. These plants typically grow best in water less than about four to five feet deep. Rooted floating species include frog's bit, American lotus, fragrant water lily, watershield and spatterdock.

Submerged plants are rooted to the pond bottom with most of their green vegetation below the water surface. Species in this category include hydrilla, elodea, coontail, southern naiad, Eurasian milfoil, eelgrass, fanwort, sago pondweed and Illionis pondweed.

CONTROL TECHNIQUES

Aquatic vegetation control techniques can fall into one of four different categories: physical or cultural, mechanical, biological and chemical. Each category has its advantages and disadvantages, and some plants will respond better than others to a particular technique. Below are brief descriptions of each category and some helpful suggestions with control method information.

Physical


Pond Dye

Physical control methods are those strategies that attempt to limit or prevent growth through cultural means. Limiting light penetration is one physical control method. Under certain conditions, adding fertilizer to the water will stimulate a phytoplankton bloom, thereby reducing light penetration and suppressing submersed aquatic plant growth. However, if non-phytoplankton aquatic plants have already become established, fertilization is likely to cause more problems such as stimulating the growth of the undesired plants. Applying an aquatic dye to the water can also limit light penetration. The best time to start this is during the winter. Dye will not kill or prevent plant growth, but it can limit light penetration at a reasonable cost and suppress submersed plant growth. Dye or a plankton bloom will only be effective if the pond is deeper than two and a half to three feet. If the water is shallow, light will penetrate to the bottom, leading to plant growth. At present, while there are many aquatic dyes available for purchase, only two dyes, Aquashade and Admiral, are registered with the EPA for aquatic plant control. As such, they are the only two that can make control claims.

Benthic Barrier
Source: Canadianpond.ca Products

Using a benthic barrier (a burlap, nylon or PVC fabric anchored to the bottom) can provide localized control around a boat dock or swimming area. These can be expensive and difficult to install, but can be effective for small areas. A winter drawdown, or lowering the water level to expose shallow areas, can be used to control some submersed species. This technique is used during the winter to expose bottom sediments to freezing temperatures, which kill plant roots and dormant reproductive structures by freezing and drying. Generally, six to eight weeks is required to provide sufficient exposure. Excessive snow and precipitation can reduce the effectiveness of drawdowns. Winter drawdowns tend to be more effective in the northern parts of Arkansas, due to more days below freezing. The pond owner should keep in mind that a drawdown will result in complete loss of use of the water body during the de-watered period.

The final physical control method to mention is by inactivation of nutrients in the water and/or preventing nutrients from entering the pond. Reducing nutrients available for plant growth can help limit problem weeds. Certain chemicals are available that can render phosphorus unavailable to plants. Phosphorus is usually an important plant nutrient and rendering it unavailable will limit plant growth. Unfortunately, these substances can be expensive and can lead to fish kills if used improperly. Further information is available in SRAC 460 Controlling Clay Turbity in Ponds, (https://srac.tamu.edu/viewCategory/25).

The easiest way to control excess nutrients is to prevent them from entering the pond in the first place. Planting a buffer strip around the pond has proven effective at "catching" nutrients before they wash into a body of water. This also helps stabilize pond banks, reducing erosion and lengthening a pond's lifespan. It is also important to keep livestock from entering a pond. Fencing off the pond and placing a stock tank below the pond will help limit manure from entering the water.

Mechanical

The term mechanical control refers to the removal of undesirable plants by mechanical means. This can be pulling plants by hand, dragging a seine or heavy object through the pond or using a large mechanical harvester. While hand removal is "free," renting a mechanical harvester can be quite costly. Once the plants are removed, some thought will need to be

Pond Mechanical Control
Source: Jay Ferrell, University of Florida Center for Aquatic and Invasive Plants

given to the proper disposal of harvested material. Additionally, many plants can spread by fragmentation, so manual removal has the potential to lead to further plant problems. Due to local regulations or other restrictions, there are situations where mechanical removal is the only option available. In general, while this technique can be quite effective for small areas and can allow you to leave desirable plants in place, it often requires more effort than many pond owners are willing (or able) to invest.

Biological

Biological control (bio-control) is the introduction of an animal or organism that eats, or otherwise kills, aquatic plants. As a general rule, biological control agents require one to two years to control plants and may not control every type of plant. The most common bio-control agent used in Arkansas ponds is the grass carp. They are readily available in various sizes. Smaller fish are less expensive, but if largemouth bass (LMB) are present, fish at least 8-10 inches long will be necessary to limit predation. Typical stocking rates are 5-10 per acre, but more can be used to gain control faster. Grass carp have very specific food preferences and prefer submersed plants that are soft, succulent and not fibrous. After 4-5 years, grass carp will likely be larger than 20 pounds and their plant consumption will decrease, necessitating restocking. They also have a habit of flowing with water currents, so control structures, such as a parallel-bar spillway barrier, will be needed to prevent escape. Many years of experience have proven grass carp to be an effective bio-control agent for some plants. Further information is available in SRAC 3600 *Using Grass Carp in Aquaculture and Private Impoundments* (https://srac.tamu.edu/viewCategory/15).

Goldfish

Watermeal and duckweed are free floating aquatic plants commonly found together in nutrient rich, static waters. Goldfish stocked at a rate of 35-65 pounds per acre have sometimes been effective for control of these plants. Like grass carp, goldfish are very susceptible to LMB predation.

Tilapia are another potential bio-control agent and can be very effective against filamentous algae and sometimes also duckweed and watermeal. Suggested stocking rates are variously given as 60 pounds per acre or 400 fish per acre. Tilapia are also potential LMB forage, and sometimes are stocked for this purpose. Tilapia are a non-native species and their permanent establishment in Arkansas is undesirable. They are also cold intolerant and will die when water temperatures drop below 60°F for an extended period of time. If stocked into most ponds, there will likely be dead fish when water temperatures drop in the fall. The advantages and disadvantages of stocking tilapia have to be weighed on a pond-by-pond basis, and for some ponds with algae problems and no risk of escape or establishment, they might fit into a pond management plan.

Chemical

Chemical control is the use of herbicides and algaecides to manage unwanted vegetation. Using registered herbicides for aquatic plant control is a widely employed technique for both private and public waters. Herbicides can provide quick control of many aquatic plants. Unfortunately, they tend to be very expensive. Treatment objectives include the control of a single invasive plant species or a broad-spectrum control of numerous species.

The University of Arkansas Cooperative Extension publication MP44 Recommended Chemicals for Weed and Brush Control (https://www.uaex.edu/publications/MP-44.aspx) contains a section on aquatic herbicides. For detailed information, this free publication should be consulted. All herbicides listed have undergone EPA review and are approved for aquatic use in Arkansas, when used in accordance with the instructions included on the label. While approximately 300 herbicide active ingredients are registered in the U.S., only 16 of these are labeled for aquatic use. Not every formulation of an active ingredient is labeled for aquatic use, so always ensure that the herbicide selected is approved by the U.S. EPA for use in aquatic habitats.

All herbicides come with a label. Included on the label is the product form and instructions for safe handling and effective use. It cannot be stressed too strongly that the label is the law and not using herbicides according to the labeled directions can have legal ramifications for the applicator.

HERBICIDE SELECTION

Mode of action is the term used to describe how an herbicide works in the plant after it is applied. Each of the herbicide active ingredients legal for aquatic use have a particular mode of action. Some active ingredients work by interrupting a certain biochemical pathway, others stimulate selective growth or cause cell contents to leak out of the cell. As a result, the selected herbicide may control or kill some plants, while not causing harm to others.

Selecting the most effective herbicide begins with proper identification of the nuisance plant. To aid in plant identification, pictures of some common aquatic plants are included in this publication. There are also several online resources available, including *Aquaplant* from the Texas Agricultural Extension Service (http://aquaplant.tamy.edu), and the Center for Aquatic and Invasive Plants at the University of Florida (http://plants.ifas.ufl.edu/).

With the aquatic plant identified, MP44 Recommended Chemicals for Weed and Brush Control has a response rating chart which aids in selecting the herbicide most effective for the plant or plants that need to be controlled. Once the herbicide options are known, a selection can be made based on the water conditions, time of year, spot treatment or whole pond treatment, and any use restrictions.

Herbicide Types

Herbicides can be classified in several ways. One way is by their activity in the plant; systemic or contact. This classification refers to whether the herbicide is translocated, or moves, within the plant. Whether the herbicide moves within a plant or not has implications on its effectiveness, application and how quickly it acts upon the plant.

Contact herbicides do not move within the plant and will cause death only to those parts of the plant they contact. Contact herbicides also tend to cause rapid injury to treated plants but require more complete spray coverage of all plant tissue during application. If a contact herbicide is used on submersed plants, the chemical must remain in the treatment area long enough for the entire plant to be exposed to a lethal concentra-

CONTACT HERBICIDES	SYSTEMIC HERBICIDES
Copper Sulfate (crystals & solution)	2,4-D
Copper Ethanolamine complexes	Glyphosate
Copper Ethylenediamine	Fluridone
Diquat	Triclopyr
Endothall*	Imazapyr
Carfentrazone	Imazamox
Sodium Carbonate Peroxyhydrate	Penoxsulam
Flumioxazin	Bispyribac Sodium
	Topramazone
	Florpyrauxifen-benzyl

*In process of undergoing re-classification with EPA as a systemic herbicide.

Herbicide Types

tion. Since contact herbicides tend to cause rapid plant death, in areas with dense plant populations and warm water, the decomposing plant tissue can lead to a fish kill due to low dissolved oxygen. The way to avoid this problem is to roughly calculate the percent pond coverage by the plant. If the total plant coverage of the pond is less than 30 percent, treat all the plant material. If the plant coverage is above 30 percent of the pond, treat only up to that threshold, and retreat every 7-10 days until you have control of the nuisance plant.

Systemic herbicides are mobile in plant tissue and move through the plant's vascular tissue to their action site. This gives them the ability to affect all parts of the plant, not just those parts they contact. The treatment implications are that they typically take longer before effects on the plant are observed and they may not require complete plant spray coverage to control. If a fall treatment is timed correctly, the herbicide might be stored within the plant's root tissue, and might lead to a second season of control when the following spring, sugars moving upward in the plant carry the herbicide with it.

Why Treatments Fail

Herbicide treatments may not have the desired effect. Sometimes this results from inaccurate plant identification, leading to the incorrect herbicide selection. Another possible cause might be herbicide use under sub-optimal conditions. One example involves diquat and muddy ponds. The label for Reward states that "Application to muddy water may result in reduced control." Diquat binds with suspended particles, rendering it inactive. Water temperature can also negatively impact effectiveness. As a general rule, many herbicides should not be used when the water temperature is below 60°F. While plants will still grow at these lower temperatures, their metabolic rate is very low. As a result, they will not take in sufficient quantities of the herbicide to kill the plant.

However, the most common reason for treatment failure is due to some form of dilution. Every plant and herbicide has a unique concentration and exposure time relationship. If the exposure time is insufficient, the concentration is lower than required, the treatment will fail. Exposure time can be shortened by chemical degradation due to bacteria, sunlight, high water pH or a water current that carries the chemical away, reducing the herbicide contact time. Inaccurately estimating a pond's volume can also reduce the herbicide's target concentration. The end result is plants are not exposed to a concentration of herbicide sufficient to lead to plant control. Please take the time to carefully read the label and correctly estimate the water body's size and conditions prior to an herbicide application.

Currently, none of the aquatic herbicides labeled for use in Arkansas are restricted. This means that a pesticide applicator's license is not required, allowing purchase by the general public.

HERBICIDE FORMULATIONS

Active Ingredients

Herbicides have three names: a trade name, a common name and a chemical name. An example of this is the common herbicide Rodeo. Rodeo is the trade name, the common name is glyphosate and the chemical name is N-(phosphonomethyl) glycine, isopropylamine salt. In this publication, the common name will be used most often.

All herbicides come with a label. Included on the label is the product form and instructions for safe handling and effective use. Again, it cannot be stressed too strongly that the label is the law and not using herbicides according to the labeled directions can have legal ramifications for the applicator. Often included is a listing of species that are controlled by the chemical and sometimes the extent of the control.

Active Ingredient Tips and Known Tank Mixes

Listed below are some use tips for the active ingredients legal for aquatic use in Arkansas. It is also legal to tank mix two or more active ingredients prior to use. It can be more efficient to tank mix herbicides prior to application. The results of tank mixing can be the equivalent to applying the herbicides separately, better than applying each separately (enhancement) or the herbicides could interfere with each other (antagonism), resulting in poor results.

It is highly recommended that a jar test be conducted to determine physical compatibility. This is accomplished by placing small amounts of both herbicides in a jar with some water. The jar is sealed and then shaken vigorously. Incompatible herbicides will form an emulsion, often a mayonnaise-like substance that is very difficult to clean out of spray equipment. If the materials are physically compatible, the jar will be cool to the touch and there will be no separation of materials or forming of clumps or emulsions.

Only those combinations whose results are either equal to each applied separately or enhanced have been listed. These combinations were determined by reading product labels and consulting professionals in the aquatic plant industry. These combinations may not be appropriate for every formulation. Different formulations with the same active ingredient may contain ingredients that may lead to incompatibility. Please read the product labels and perform a jar test prior to use. Some labels will include a warning that "tank mixing the product with any other product not specifically and expressly authorized by the label shall be the exclusive risk of user, applicator and/or application advisor, to the extent of allowed by applicable law."

Copper Sulfate and Copper Complexes (Copper Ethanolamine (chelated formulations) and Copper Ethylenediamine)

- No matter the form, free copper ions causes cells to leak
- The effectiveness and safety of copper sulfate treatments are mostly determined by the alkalinity of the water
    - Water alkalinity <40 ppm, copper sulfate treatments can be toxic to fish
    - In water with alkalinity >250-300 ppm, the copper sulfate binds quickly with carbonate, rendering it ineffective
- Copper Sulfate crystals dose calculation = [Total Alkalinity (ppm) /100] x Recommended Dose (ppm) x Volume (in acre*ft) x 2.72
- Copper Complexes were created for use in low alkalinity water (<20 ppm)
- Copper is usually used to treat algae. However, several of the Copper Complex formulations (Captain XTR, Cutrine, KTea, etc.) can be effective for the control of hydrilla and select other submersed flowering aquatic plants. Read individual labels prior to selection.
- When mixed with certain herbicides, adding copper seems to enhance control of some submersed flowering plants
- Copper can be tank mixed with: diquat, endothall or flumioxazin (for algae)

Endothall

- Up to 24-hour exposure needed for maximum effectiveness
- Use in late winter/early spring when plants are present
- Rapid breakdown at water temperature >80°F, through bacterial action
- Aquathol formulations are safe for fish
- Hydrothol formulation can be toxic to fish above 0.3 ppm

- Do not use in brackish or saltwater
- Endothall can be tank mixed with: penoxsulam, imazamox, bispyribac-sodium, 2,4-D and diquat

Diquat

- 12-24-hour contact time for submersed plants depending upon species and herbicide rate
- 30-minutes for floating and emergent plants
- Rapidly absorbed by foliage
- Rainfast in 1-2 hours
- Rapid wilting within several hours
- Water half-life <48 hours
- Don't use in turbid water
  - Active ingredient will bind to suspended particles and become inactivated
- Use whenever plant is actively growing, even in winter
- Submersed plants-faster acting when combined with copper or endothall
- Diquat can be tank mixed with: 2,4-D (emersed), endothall (submersed) or copper (submersed)

Carfentrazone

- Highly effective on broad-leaved weeds
  - Visible results in 24-48 hours
- Rapidly absorbed by foliage
  - Rainfast in 15 minutes
  - 1-2 hours of contact for good activity
- Sensitive to pH:
  - pH7 – half-life is 8.6 days
  - pH9 – half-life is 3.6 hours
- Mixing with systemic herbicides can enhance effectiveness
- Single application will not control plants with high regeneration rates, likely requiring multiple treatments
  - Use with a tank mix may lead to only a single application being needed
- Carfentrazone can be tank mixed with penoxsulam, glyphosate, 2,4-D, triclopyr, imazapyr or imazamox. It is believed to be compatible with most herbicides.

Flumioxazin

- Taken up by roots and foliage
- Foliar contact causes rapid desiccation and necrosis of exposed plant tissue
- Very sensitive to pH
  - at pH9 – the half-life is minutes
- Buffer tank mix so pH is <7
- Apply in early morning
- Floating plants: 1-2 hours contact time required
- Submersed: 4-6 hours contact time required
- More effective during cooler weather
  - in Oct./Nov. and Feb./Mar.

- Reports by professional applicators indicate that duckweed and watermeal are susceptible regardless of pH, if applied to tops of plants, not into the water
- Flumioxazin can be tank mixed with: diquat, 2,4-D, triclopyr, glyphosate, endothall, imazamox, copper, bispyribac-sodium (can use lower rate) or penoxsulam

Sodium Carbonate Peroxyhydrate (SCP)

- SCP is only effective against algae and is better for cyanobacteria control
- SCP converts to hydrogen peroxide when applied to water
- Hydrogen peroxide is a powerful oxidizer and is the compound that causes damage to the plant cells
- Hydrogen peroxide will eventually convert into water, leaving no chemical residue, making it safe for all applications
- It is applied by itself, but can be followed up with other products like copper sulfate, providing more effective algae control

2,4-D

- Only effective against broadleaved plants
  - Will not kill grasses
- Usually foliar applied
- Esters more readily penetrate foliage
- 2,4-D converts to acid form inside plant
- For submersed treatments a 24 hour exposure time is recommended
- Low light intensity reduces ability of submersed plants to recover
- Target and tank water pH > 8 may lead to reduced effectiveness for the ester formulation
- 2,4-D can be tank mixed with: diquat, triclopyr or carfentrazone. 2,4-D is compatible with most herbicides

Glyphosate

- Foliar applied only
- Non-selective
- No root absorption
  - Strongly binds to soil, becoming unavailable to plant
- Not active in water
- 6 hours of contact for maximum effectiveness
- Growth inhibited soon after application
  - Negative affects within 4-7 days
- Glyphosate can be tank mixed with: imazapyr, triclopyr or carfentrazone, 2,4-D etc.

Fluridone

- Absorbed from water by shoots and from hydrosoil (bottom sediments) by roots
- Can be applied to water surface or subsurface
- Requires prolonged contact time (up to 45 days, 30-90 days for control)
- Broken down by sunlight
- Fluridone can be tank mixed with: penoxulam or imazamox
- A bump application may be needed to maintain an effective concentration in the water

Topramazone

- May be applied directly into water, sprayed on foliage or exposed sediment after drawdown
    - Absorbed through leaves, submerged shoots or roots
- Symptoms in 7-10 days, death in 60-120 days

Imazapyr

- Will not work in water (do not try to use on submersed vegetation)
- Typically absorbed by foliage within 24 hours
- Can be absorbed by roots also when ground applied
- Do not mix with diquat or 2,4-D
- Broad spectrum, but can be selectively used to control target vegetation if non-target plants are dormant
- Causes plant starvation, so effects may not be noticeable for 1-2 weeks
- Requires active plant growth to work
- Imazapyr can be tank mixed with glyphosate, triclopyr or carfentrazone

Imazamox

- Absorbed mostly by foliage
- Slow root absorption
- Injury symptoms appear 1-2 weeks after application
- Low light intensity may reduce ability of submersed plants to recover
- Requires active plant growth to work
- Imazamox can be tank mixed with: penoxsulam, carfentrazone, endothall or fluridone

Penoxsulam

- Absorbed by roots and foliage
- Tank mixing with Endothall enhances effectiveness
- Can apply to bare ground, and if activated by water, will act as pre-emergent herbicide
- Requires active plant growth to work
- Penoxsulam can be tank mixed with: imazamox, endothall, fluridone, flumioxazin or carfentrazone

Bispyribac sodium

- Absorbed by roots and foliage
- Clear water and higher light intensity may increase control
- Late winter/early spring better time to apply
- Bispyribac-sodium can be tank mixed with endothall or flumioxazin

Florpyrauxifen-benzyl

- Absorbed through leaves and shoots
- Apply to actively growing plants
- 12-24 hour contact exposure time required for maximum effectiveness

Adjuvants

Herbicide labels will contain information on their use. Often the label will include the addition of an adjuvant, especially if the herbicide is applied as a foliar treatment. Adjuvants are chemicals that are used to enhance the effectiveness of the pesticide when added to a pesticide tank mix. Two of the most common are crop oil concentrates and non-ionic surfactants. Typically, non-ionic surfactants are used for wetting and spreading on the leaf surface, but do not offer much for penetration. Crop oils are penetrants which aid in moving the herbicide into the target plant. A third type of adjuvant acts as a "sinker" when added to a spray solution. When the solution is sprayed onto the water surface, the "sinker" will help carry the herbicide down through the water column, into the weeds growing on the pond bottom. Products which modify the pH of the tank water and stickers are also classified as adjuvants and can be used to improve the performance of a pesticide.

HERBICIDE APPLICATION AND APPLICATION EQUIPMENT

Treating emergent and floating aquatic plants is usually somewhat similar to treating lawn weeds. Treatment most often will consist of spraying plant foliage that is out of the water with an appropriate herbicide. Adding an appropriate adjuvant is also encouraged to increase the absorption of the herbicide into the stems and leaves. Emergent vegetation is also sometimes treated by applying a granular herbicide to the bottom sediment where it can be absorbed by the plant parts underwater. Floating plants may also be treated by "injecting" the herbicide into the water column so it can be absorbed by the subsurface plant structures.


Boat Mounted Sprayer
Source: Kelly Duffy, Helena Chemical

Treating of emergent plant foliage takes place in a two-dimensional realm. Treatment rates are typically listed in terms of ounces per acre, ounces per square foot or the herbicide mix will be expressed as a percent solution (for example a 2 percent solution of glyphosate). Emergent foliage can be treated from either the pond bank or a boat, whichever is easiest for the pond manager. What application equipment is used will depend upon the size of the area to be treated and what equipment is available. For small areas, a hand-held pump sprayer might be adequate. ATV-mounted or boat-mounted tank sprayers are used for larger areas.

The treatment of rooted, submersed plants will differ in significant ways. One example is the whole pond treatment. For this, the pond's volume is calculated and typically expressed in acre-feet. Instructions for pond size and volume determination are found in the next section.

After calculating the pond volume, it is possible to drive around in a boat and pour the herbicide tank mix into the water, but this can be very


Hand-held Sprayer


Tractor-Mounted Sprayer


ATV-Mounted Sprayer
Source: Kelly Duffy, Helena Chemical

wasteful. Most of the submersed aquatic plant biomass will be towards the bottom of the pond. Treating the whole pond might result in the application of more herbicide than is necessary.

A far better way is to deliver the herbicide into, or at minimum just above, the target plants. This will require some specialized equipment in the form of weighted trailing hoses. Without getting into too much detail, a tank with pump is connected to a horizontal boom with weighted hoses attached at spaced intervals. The hose length should be a little shorter than the pond depth so that as the boat moves, they move just over or within the submersed weeds. More detailed instructions can be downloaded from the University of Florida IFAS Extension at http://edis.ifas.ufl.edu/pdffiles/AG/AG36000.pdf.

Diagram of Weighted Trailing Hose System

A big advantage of using weighted trailing hoses is the ability to potentially use less herbicide by only treating the bottom foot or so of the pond. By doing this, only the weeds are treated, not the whole pond.

For larger bodies of water, often the nuisance plants will only grow around the edge, because only at the edges is light able to penetrate to the bottom. Weighted trailing hoses give the pond manager the ability to treat only the "band" of submersed plants. Using specialized equipment also provides the opportunity to "spot treat" patches of weeds.

Weighted Trailing Hose System

Some of the current active ingredients that are legal for aquatic use have a granular formulation. When granular herbicides are applied, they fall to the bottom and begin to release the herbicide. How quickly the active ingredient is released depends on the formulation.

While some of the herbicide will be in the sediment, most of the chemical is absorbed by the plant foliage. Unlike terrestrial plants which absorb nutrients and water from the soil, the root systems of submersed plants are not the main source of nutrients, water and dissolved gases. These materials are absorbed from the foliage.

With accurate application, the herbicide pellets will have landed within the weeds you're trying to control, and the released herbicide is in the right location to be absorbed by the plants. As a result, granular herbicides allow the treatment of smaller areas.

Granular Herbicide Dispersal
Source: Kelly Duffy, Helena Chemical

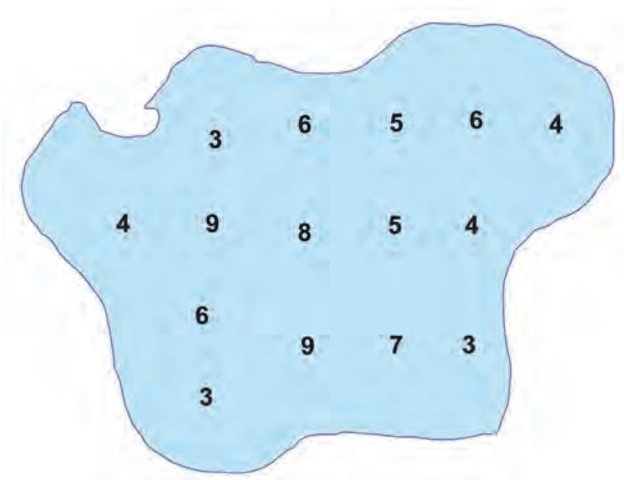
Pond Size and Volume Determination

Calculating pond area can be as simple as multiplying the length by the width. For ponds, this can sometimes be more difficult due to their irregular shape. One way to overcome this is to use an on-line resource which links with Google Earth to allow area calculation. A search term such as "Google Earth area calculator" should bring up one of these online tools. There are also smartphone apps available such as Planimeter and PondCalc.

Pond Area

Pond volume is calculated by multiplying the area by the average depth. There is no easy way to calculate average depth. The most accurate way involves using a boat and a weighted line with depth markings. Depth soundings are taken in a grid pattern. Add up the measurements, divide by the number of measurements and the result is a reasonably accurate estimate of the average depth. More measurements will give greater accuracy.

For further information on pond area and volume calculation, consult Southern Regional Aquaculture Center (SRAC) publication 103 Calculating Area and Volume of Ponds and Tanks (https://srac.tamu.edu/viewCategory/1).



Irregular Pond: Average Pond Depth

AQUATIC PLANTS THAT COMMONLY BECOME PROBLEMS IN ARKANSAS PONDS

ALGAE

Filamentous Algae

Description: Filamentous algae are single algae cells that form long visible chains, threads or filaments. These filaments intertwine forming a mat that resembles wet wool. Filamentous algae starts growing along the bottom in shallow water or attached to structures in the water (like rocks or other aquatic plants). Filamentous algae will often detach from the pond bottom and float to the surface, forming large mats, which are commonly referred to as "pond scums." There are many species of filamentous algae and often more than one species will be present at the same time in the pond.

Filamentous Algae

Filamentous Algae

Mechanical Control: Raking out the vegetation is possible but burdensome, time consuming and disposal can be difficult.

Physical Control: To help control aquatic plant growth, attempts should be made to limit the amount of phosphorus entering any water body. Livestock should be prevented from entering the pond if possible. If desired, excess phosphorus can be inactivated by using alum, Phoslock®, or other similar product.

For pond areas below three feet, the use of an aquatic dye (Admiral, Aquashade), applied during the winter or early spring, could limit growth by reducing light penetration.

Biological Control: Tilapia stocked at a rate of 60 pounds per acre can sometimes control filamentous algae. The negatives associated with stocking tilapia include availability, predation due to Largemouth Bass and eventual mortality due to cold temperatures in the fall.

Tilapia are also a non-native species. Since permanent establishment of non-native plant and animal species is undesirable, care should be taken to ensure that the intended water body does not have areas that stay warm enough (such as a thermal spring) during the winter which could allow some fish to survive.

Chemical Control:
Excellent – Copper sulfate and copper complexes*
Good to Excellent – Sodium Carbonate Peroxyhydrate, Flumioxazin
Good – Diquat*, Endothall (Hydrothol formulation)
*control can be sometimes enhanced by combining diquat with copper sulfate/copper complexes


Blue-Green Algae

Blue-Green Algae

Description: Blue-green algae are cyanobacteria that can be single-celled, filamentous or colonial. They can be buoyant and form a "scum" layer or large floating mats. They occur in fresh water and marine water, typically water that is very nutrient rich. Single celled or colonial genera, such as Microcystis, can sometimes produce harmful algal blooms (HAB's), with toxic or harmful effects to people, mammals and marine life. This can range from a bad taste and/or odor in drinking water to death of fish and other marine animals. Some floating mats may be several inches thick and can cover large areas of the water surface, sometimes entire coves and small ponds, or benthic (bottom) sediments. Mats can impede navigation and recreation, cover and smother submersed plants and clog water intakes. Benthic Lyngbya mats are usually dark blue to black and may float to the surface due to trapped gases. In addition, they may emit a strong and unpleasant earthy or musk-like odor.

Single cells are all that is required to start growth and can be transferred from one water body to another by boat hulls and bilge water, and by many animal species (e.g. birds, turtles, alligators, raccoons, insects, etc.) This can involve cells attached to the surface of the organism, or via viable cells in fecal material. Cells can also be transported by wind events such as storms and hurricanes that can transport water droplets or particulate matter over large distances.

This description of the blue-green algae's forms and potential problems is extremely brief. It is in no way meant to be complete.

Mechanical Control: Raking out these mats is technically possible, but burdensome, time consuming and unlikely to be effective.

Physical Control: Excess phosphorous can lead to blue-green algae growth. Attempts should be made to limit the amount of phosphorus entering any water body. Livestock should be prevented from entering the pond if possible. If desired, excess phosphorus can be inactivated by using alum, Phoslock® or other similar product.

For pond areas below three feet, the use of an aquatic dye, applied during the winter or early spring, could limit growth of benthic mats by reducing light penetration.

Biological Control: There are no biological control agents for these organisms.

Chemical Control:
Excellent – Copper sulfate and copper complexes
Good to Excellent – Sodium Carbonate Peroxyhydrate
Good – Endothall (Hydrothol formulation)


Lyngbya Species


Blue-Green Algae

FLOATING PLANTS

Duckweed (*Lemna* spp.)

Duckweed

y-

Description: Common duckweed is a very small light green, free-floating, seed bearing plant. Duckweed has one to three leaves, or fronds, of 1/16 to 1/8 inch in length. A single root (or root-hair) protrudes from each frond. Duckweeds tend to grow in dense colonies in quiet water, undisturbed by wave action. Often more than one species of duckweed will be together in these colonies. Duckweeds can be aggressive invaders of ponds and are often found mixed in with mosquito fern or watermeal. If colonies cover the surface of the water, then oxygen depletions and fish kills can occur. Duckweed will sink to the bottom during the fall and reemerge on the surface with an increase in photosynthetic activity during the spring. Early treatment is urged.

Mechanical Control: It is possible to use a small mesh seine to collect duckweed and remove it from the pond. This will be very labor intensive and tends to be of limited long-term effectiveness.

Physical Control: To help control aquatic plant growth, attempts should be made to limit the amount to phosphorus entering any water body. Livestock should be prevented from entering the pond if possible. If desired, excess phosphorus can be inactivated by using alum, Phoslock® or other similar product.

Biological Control: Grass carp will consume duckweed, but never control it.

Tilapia stocked at a rate 15-20 pounds per acre, of mixed sex fish, can sometimes control duckweed. The negatives associated with stocking tilapia include availability, predation due to Largemouth Bass, and eventual mortality due to cold temperatures in the fall.

Tilapia are also a non-native species. Since permanent establishment of non-native plant and animal species is undesirable, care should be taken to ensure that the intended water body does not have areas that stay warm enough (such as a thermal spring) during the winter which could allow some fish to survive.

Chemical Control:
Excellent – Diquat, Fluridone, Penoxsulam, Flumioxazin, Bispyribac sodium
Good – Carfentrazone, Imazapyr

Watermeal (*Wolffia* spp.)

Watermeal

Description: Watermeals are the smallest flowering plant, often less than 1 millimeter in diameter. Watermeal is light green, free-floating and rootless. Watermeal tend to grow in dense colonies in quiet water, undisturbed by wave action. Watermeal can be an aggressive invader of ponds and are often found mixed in with duckweeds or mosquito fern. If colonies cover the surface of the water, then oxygen depletions and fish kills can occur. These plants should be controlled before they cover the entire surface of the pond. Watermeal will sink to the bottom during the fall, and reemerge on the surface with an increase in photosynthetic activity during the spring. Early treatment is urged.

Mechanical Control: It is possible to use a small mesh seine to collect watermeal and remove it from the pond. This will be very labor intensive and tends to be of limited long-term effectiveness.

Physical Control: To help control aquatic plant growth, attempts should be made to limit the amount of phosphorus entering any water body. Livestock should be prevented from entering the pond if possible. If desired, excess phosphorus can be inactivated by using alum, Phoslock®, or other similar product.

Biological Control: Goldfish can be an effective bio-control agent, if Largemouth Bass are either small or not present. The stocking rate is 35-65 pounds per acre.

Tilapia stocked at a rate 15-20 pounds per acre, of mixed sex fish, can sometimes control watermeal. The negatives associated with stocking tilapia include availability, predation due to Largemouth Bass and eventual mortality due to cold temperatures in the fall.

Tilapia are also a non-native species. Since permanent establishment of non-native plant and animal species is undesirable, care should be taken to ensure that the intended water body does not have areas that stay warm enough (such as a thermal spring) during the winter which could allow some fish to survive.

Chemical Control:
Excellent – Flumioxazin and Fluridone
Good – Carfentrazone, Penoxsulam, Diquat and Bispyribac Sodium

SUBMERSED PLANTS

Coontail

Description: Coontail (sometimes called hornwort) is a dark olive-green, rootless submerged perennial plant that often forms dense colonies. Leaves are relatively stiff, whorled with many forks and small teeth along one edge. The tips of branches are crowded with leaves giving it a "coontail" resemblance. Coontail reproduces by seeds and fragmentation.

Coontail

Mechanical Control: Raking out plant material is possible but burdensome. Fragmentation from harvesting can also spread the plant.

Physical Control: For pond areas below 3 feet, the use of an aquatic dye (Admiral, Aquashade), applied during the winter or early spring, could limit growth by reducing light penetration.

Biological Control: Grass carp will consume coontail but are only rated as a good-fair control agent.

Chemical Control:
Excellent – Diquat, Endothall, Fluridone, Flumioxazin, Florpyrauxifen
Good – 2,4-D (the ester formulations are more effective than the amine formulations

Sago Pondweed

Description: Sago pondweed is a perennial plant that arises from thickly matted rhizomes and has no floating leaves. The plant grows entirely under the water, except for the reproductive stalk that peaks above the water when it flowers. The stems are thin, long and highly branching, with alternating leaves that are very thin and filament-like, about 1/16 inch wide and 2 to 12 inches long, tapering to a point. The leaves grow in thick layers and originate from a sheath. The fruit is nut-like 1/8 to 1/4 inch long and 1/10 to 1/8 inch wide.

Sage Pondweed

Mechanical Control: Raking out plant material is possible, but burdensome.

Physical Control: For pond areas below 3 feet, the use of an aquatic dye (Admiral, Aquashade), applied during the winter or early spring, could limit growth by reducing light penetration.

Biological Control: Grass carp will consume this plant. Typical stocking rates are 5-10 per acre, restocked every 5-7 years.

Chemical Control:
Excellent – Endothall, Fluridone, Imazamox, Penoxsulam, Flumioxazin, Bispyribac Sodium, Topramazone
Good – Copper ethanolamine complexes, Copper ethylinediamine and diquat

Hydrilla

Description: Hydrilla is a non-native perennial plant that forms very dense colonies or mats and can grow to the surface in water over 20 feet deep. Hydrilla branches grow profusely and after reaching the surface it extends across it forming thick mats. Hydrilla can reproduce by fragmentation, from seeds, from turions (axilary buds) and from tubers.

Hydrilla is often confused with the native Elodea or the non-native Egeria. The leaves of hydrilla are blade-like about 1/8 inch wide and 3/8 inch long with small tooth margins and spines on the underside of the midrib which make them feel rough when drawn through your hand from base to tip, where neither Elodea nor Egeria have these midrib teeth.

The leaves of Hydrilla usually occur in a whorl of five, Egeria leaves are usually in a whorl of four, and Elodea leaves usually occur in a whorl of three. This rule in not universal, so other factors should also be used for identification.


Hydrilla

Hydrilla are small, typically only 1/4 inch in diameter.

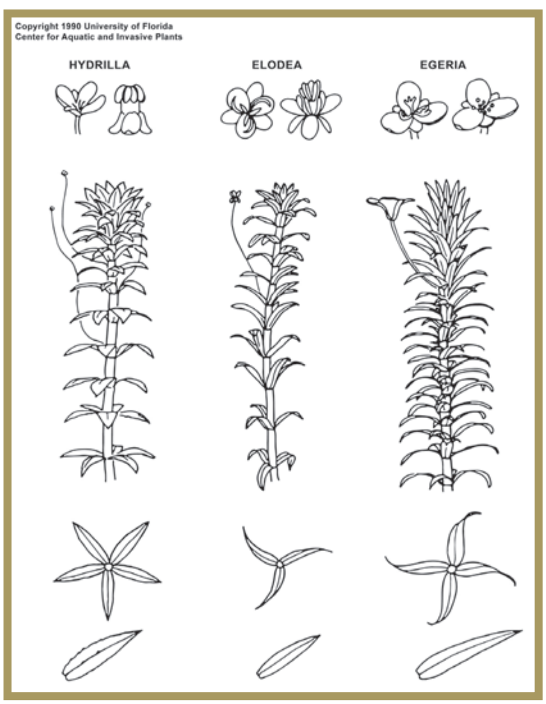


Diagram of Hydrilla
Source: Jay Ferrell, University of Florida Center for Aquatic and Invasive Plants

Mechanical Control: Raking out plant material is possible but will be burdensome. Hydrilla also can spread due to fragmentation, so mechanical harvesting can lead colonization in more pond areas.

Physical Control: For pond areas below 3 feet, the use of an aquatic dye (Admiral, Aquashade), applied during the winter or early spring, could limit growth by reducing light penetration.

Biological Control: Grass carp have a preference for this plant. Typical stocking rates are 5-10 per acre, restocked every 5-7 years.

Chemical Control:

Excellent – Diquat, Endothall, Copper ethylinediamine, Fluridone, Penoxsulam, Flumioxazin, Bispyribac Sodium, Topramazone, Florpyrauxifen

Southern Naiad


Southern Naiad

Description: Southern naiad (sometime called bushy pondweed) is an annual plant that branches profusely and forms very dense stands of rooted submerged vegetation. Leaves are dark green to greenish-purple, ribbon-like, opposite or in a whorl of three, mostly less than 1/2 inch long and 1/8 inch wide. Single seeds are found encased in the leaf sheath. Southern naiad reproduces by seeds and fragmentation. Flowers are at the base of the leaves but so small that they can only be observed with magnification. Southern naiad is often confused with sago pondweed and widegeongrass.

Mechanical Control: Raking out plant material is possible, but burdensome.

Physical Control: For pond areas below 3 feet, the use of an aquatic dye (Admiral, Aquashade), applied during the winter or early spring, could limit growth by reducing light penetration.

Biological Control: Grass carp have a definite preference for this plant. Typical stocking rates are 5-10 per acre, restocked every 5-7 years.

Chemical Control:
Excellent – Diquat, Endothall, Fluridone, Flumioxazin
Good – Penoxsulam, Topramazone

EMERGENT PLANTS

Water Primrose

Water Primrose

Description: Water primrose is a perennial plant that stands erect along the shoreline but also forms long runners (up to 16 feet) that creep across wet soil or floats out across the water surface. The runners form roots at their nodes. Leaves range from lance-shaped, 2 inches long by 1/2 - 1 inch wide, on the erect stems, to round or oval, 1-2 inches in diameter, on the floating stems. Leaves can be green to reddish, depending on the species. Plants in the primrose family have distinct, single yellow flowers, with four or five petals depending on the species. Flowers vary in size from 1-2 inches in diameter.

Mechanical Control: For plants along the shoreline, cutting with a string trimmer, rotary cutter, side cutter or similar device might be practical and provide the desired control.

Physical Control: A benthic barrier placed on the bottom sediment prior to spring growth could be effective. If conditions are right, a winter drawdown might kill roots (for best conditions, please refer to page 4).

Biological Control: There are no biological control agents for this plant.

Chemical Control:
Excellent – 2,4-D, Glyphosate, Triclopyr, Imazapyr, Imazamox, Florpyrauxifen
Good – Diquat

Alligator Weed

Alligator Weed

Description: Alligator weed is a non-native perennial plant. It often forms very dense mats along the shore, making access difficult. The stems are hollow and can be single or branched. Leaves are opposite, long, elliptical or lance-shaped up to 3/4 inch wide and 5 inches long with a prominent midrib. Roots often develop at leaf nodes. Soft, whitish hairs are found in the leaf axis. Flowers resemble those of white clover, and are singular, small (about 1/2 inch in diameter), white, fragrant clusters of 6 to 10 florets, borne on long branches (to 3 inches). A single seed develops within the fruit.

Mechanical Control: For plants along the shoreline, cutting with a string trimmer, Rotary cutter, side cutter or similar device might be practical and provide the desired control.

Physical Control: A benthic barrier placed on the bottom sediment prior to spring growth could be effective. If conditions are right, a winter drawdown might kill roots (please see page 4 for further information).

Biological Control: There are no biological control agents for this plant in Arkansas.

Chemical Control:
Excellent – 2,4-D, Glyphosate, Triclopyr, Imazapyr, Flumioxazin, Bispyribac Sodium, Florpyrauxifen
Good – Fluridone, Imazamox, Penoxsulam, Diquat, Carfentrazone

Smartweed (Water Pepper)

Description: Smartweed is a perennial plant that forms dense colonies in shallow water or moist soils and can grow to three feet tall. Stems are jointed or have swollen leaf nodes that are surrounded by a tubular sheath. Roots can develop from the leaf nodes. Leaves are alternate, lance-shaped up to four inches long but usually less than 1/2 inch wide. Flowers are on spikes at the end of stems. There are often numerous spikes on the same plant. Flowers begin greenish then turn whitish or light pink as they mature. Fruits are flat, triangular (1/8 inch), dark brown to black.

Smartweed

Smartweed

Mechanical Control: For plants along the shoreline, cutting with a string trimmer, rotary cutter, side cutter, or similar device might be practical and provide the desired control.

Physical Control: A benthic barrier placed on the bottom sediment prior to spring growth could be effective. If conditions are right, a winter drawdown might kill roots (please see page 4 for further information).

Biological Control: There are no biological control agents for this plant in Arkansas.

Chemical Control:
Excellent – Glyphosate, Triclopyr, Imazapyr, Imazamox
Good – 2,4-D, Penoxsulam, Diquat

Spatterdock (Cow Lily)

Description: Spatterdock is a perennial plant with leaves that arise from a large spongy rhizome. The leaves have a slit that makes them roughly heart-shaped, 8-16 inches long by 10 inches wide, and can float on the surface or stand above the surface on thick round stalks. Flowers are spherical with six to nine green sepals and yellow petals. Flowers may float on the water or stand above it. Fruits are oval with a flat top and green or yellow in color. Spatterdock can spread from seeds or the rhizomes. Floating leaves may provide a habitat for fish.

Spatterdock

Mechanical Control: Mechanically removing plants is only likely to be effective for small areas.

Physical Control: Spatterdock can possibly be shaded out with the addition of an aquatic dye if the pond is deep enough (three feet or deeper) and the dye is added before plant growth begins. Food reserves stored in roots will probably be enough to allow the plant to grow to the surface. A benthic barrier placed on the bottom sediment prior to spring growth could be effective. If conditions are right, a winter drawdown might kill roots (please see page 4 for further information).

Biological Control: There are no biological control agents for this plant in Arkansas.

Chemical Control:
Excellent – 2,4-D, Fluridone
Good - Glyphosate, Imazapyr

Water Lily


Water Lily

Description: The white water lily is a perennial plant that often forms dense colonies on the surface. Leaves usually float on the water's surface, attached to flexible stalks growing from large, thick rhizomes. The leaves are more round than heart-shaped, bright green, 6-12 inches in diameter, with the slit about 1/3 the length of the leaf. Flowers arise on separate stalks, have brilliant white petals (25 or more per flower) with yellow centers. The flowers may float or stick above the water, and each opens in the morning and closes in the afternoon. The flowers are very fragrant. White water lily can spread from seeds or the rhizomes. While appearing thick on the surface, underneath there is room for fish.

Mechanical Control: Mechanically removing plants is only likely to be practical or effective for small areas.

Physical Control: Water Lilies can possibly be shaded out with the addition of an aquatic dye if the pond is deep enough (three feet or deeper) and the dye is added before plant growth begins. Unfortunately, food reserves stored in roots will probably be enough to allow the plant to grow to the surface. A benthic barrier placed on the bottom sediment prior to spring growth could be effective. If conditions are right, a winter drawdown might kill roots (please see page 4 for further information).

Biological Control: There are no biological control agents for this plant in Arkansas.

Chemical Control:
Excellent – 2,4-D (ester formulations will be more effective than the amine formulations), Fluridone, Glyphosate, Triclopyr, Imazapyr
Good – Imazamox

American Lotus

American Lotus

Description: American Lotus is a perennial plant that is often confused with water lilies. Rhizomes are slender, branched and rooted in mud. Leaves are simple, round, bluish-green in color, up to 2' in diameter, attached to the stem in center (no slit like water lilies). Leaves are flat if floating or conical if emergent and can stand above the water's surface as high as 3½ feet on the rigid stem. Flowers are large (up to 10 inches across) yellowish-white to yellow with more than 20 petals. The seed structure in center of the flower is cone-shaped (see picture), and has openings in which the large, acorn-like seeds develop. Lotus can form large colonies and spreads by seeds and large fleshy rhizomes.

Mechanical Control: Mechanically removing plants is unlikely to be practical.

Physical Control: American Lotus can possibly be shaded out with the addition of an aquatic dye if the pond is deep enough (3 feet or deeper) and the dye is added before plant growth begins. Unfortunately, food reserves stored in roots will probably be enough to allow the plant to grow to the surface. A benthic barrier placed on the bottom sediment prior to spring growth could be effective. If conditions are right, a winter drawdown might kill roots (please see page 4 for further information).

Biological Control: There are no bio-control agents for this plant.

American Lotus

Chemical Control:

Excellent – 2,4-D, Triclopyr, Florpyrauxifen

Good – Glyphosate, Imazapyr, Imazamox, Topramazone

Sagittaria spp. (Narrow-leaf arrowhead, bull-tongue, duck potato, broad-leaf arrowhead, common arrowhead)


Arrowhead


Arrowhead


Arrowhead

Description: There are many species of Sagittaria but all are perennial plants that have arrowhead-shaped leaves. Usually, leaves have three points giving it the arrowhead shape but some are narrow and almost grass-like. Arrowheads can grow in shallow water or in wet areas. Leaves grow in clusters from the base and can be from less than a foot tall to over four feet. Leaf petioles are long, often spongy and have a milky-like fluid if crushed. Rhizomes can be extensive and some species have large tubers off the roots. Flowers are borne on separate stalks above the water in whorls of three and are usually white to light pink with three petals. Arrowheads spread rapidly by seeds and extensive rhizomes.

The tubers of arrowheads are prized foods by ducks, geese, muskrats and nutria. Seeds are sometimes consumed by ducks.

Mechanical Control: For plants along the shoreline, cutting with a string trimmer, Rotary cutter, side cutter or similar device might be practical and provide the desired control.

Physical Control: A benthic barrier placed on the bottom sediment prior to spring growth could be effective. If conditions are right, a winter drawdown might kill roots (please see page 4 for further information).

Biological Control: There are no bio-control agents for this plant.

Chemical Control:

Excellent – 2,4-D, Imazapyr, Imazamox, Topramazone

Good – Diquat, Endothall, Penoxsulam

American Water Willow

Water Willow

Description: Water-willow is a perennial that may be found along stream and lake margins. Water-willow grows to 3 feet tall and often forms dense colonies that help stabilize shorelines. The stems do not usually branch and have prominent whitish lines. The leaves are opposite, long and narrowly tapered (up to 6 inches long by 1/2 inch wide) with smooth margins and a distinctive, whitish mid-vein. The leaves look very much like those of the willow tree. Water-Willow flowers from May through October. The flowers are on long stems originating from the base of the leaves. Flowers are five-petaled orchid-like (3/4 inch in diameter), white with purple/violet streaks on the lower petals. Water-willow can spread from seeds and forms extensive rhizomes by which it forms colonies and spreads rapidly.

Mechanical Control: Cutting with a string trimmer might be practical for small areas. It can quickly propagate from seeds and roots.

Physical Control: A benthic barrier placed on the bottom sediment prior to spring growth could be effective.

Biological Control: There are no bio-control agents for this plant.

Chemical Control

Excellent – 2,4-D, Glyphosate, Triclopyr, Imazapyr
Good – Fluridone

Water Willow

ADDITIONAL RESOURCES

University of Arkansas Cooperative Extension Fact Sheets

Farm Pond Management for Recreational Fishing http://www.uaex.edu/publications/PDF/MP360.pdf

Recommended Chemicals for Weed and Brush Control for Arkansas 2019 http://www.uaex.edu/publications/MP-44.aspx

Weeds of Arkansas: Aquatic, Lawn, Pasture and Roadside http://www.uaex.edu/publications/pdf/MP169.pdf

Algal Blooms, Scums and Mats in Ponds http://www.uaex.edu/publications/PDF/FSA-9094.pdf

Arkansas Farm Pond Management Calendar http://www.uaex.edu/publications/PDF/FSA-9093.pdf

Southern Regional Aquaculture Center

SRAC 103 Calculating Area and Volume of Ponds and Tanks https://srac.tamu.edu/serveFactSheet/4

SRAC 0360: Aquatic Weed Management: Control Methods https://srac.tamu.edu/serveFactSheet/65

SRAC 0361: Aquatic Weed Management: Herbicides https://srac.tamu.edu/serveFactSheet/66

SRAC 3600: Using Grass Carp in Aquaculture and in Private Impoundments https://srac.tamu.edu/serveFactSheet/160

SRAC 3601: Aquatic Weed Management: Herbicide Safety, Technology and Application Techniques https://srac.tamu.edu/serveFactSheet/161

SRAC 3602: Aquatic Herbicide Mode of Action and Use Implications https://srac.tamu.edu/serveFactSheet/285

SRAC 460 Controlling Clay Turbity in Ponds https://srac.tamu.edu/viewCategory/25

University of Florida/IFAS Extension Publications

https://plants.ifas.ufl.edu/publications/extension-publications

Constructing Weighted Trailing Hoses for Submersed Aquatic Herbicide Applications http://edis.ifas.ufl.edu/pdffiles/AG/AG36000.pdf

Aquaplant from the Texas Agricultural Extension Service http://aquaplant.tamy.edu

Center for Aquatic and Invasive Plants at the University of Florida http://plants.ifas.ufl.edu

Aquatic Plants: Their Identification and Management https://www.ifishillinois.org/publications/aquatic_plants.pdf

Purdue University Extension- Aquatic Plant Management: Identifying and Managing Aquatic Vegetation https://www.extension.purdue.edu/extmedia/APM/APM_3_W.pdf

Journal of Aquatic Plant Management http://www.apms.org/japm/japmindex.html

Printed by the University of Arkansas Cooperative Extension Service Print Media Center, Little Rock, Arkansas.

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